

GLSIO CONFERENCE

JUNE 10-13, 2014 | MADISON, WI

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CONFERENCE PROCEEDINGS

Edited by : Amanda Ochsner, Jeremy Dietmeier, Caroline C. Williams, & Constance Steinkuehler

PROCEEDINGS
GLS 10
GAMES + LEARNING + SOCIETY CONFERENCE

MADISON, WISCONSIN
JUNE 10 - 13, 2014

Editors

Amanda Ochsner
Jeremy Dietmeier
Caroline C. Williams
Constance Steinkuehler

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Letter from the Co-Chair

For the 10th time, the annual GLS Conference is over. And, also for the 10th time, it was the best one ever! We had an incredible group of sponsors and volunteers, and our pre-conference events and the conference itself broke our attendance records. It was a wonderful ride, folks - thanks for coming with us!

Some of the new GLS Conference content this year:

For the first time, the GLS Conference hosted the NSF Cyberlearning Summit - we enjoyed sharing our space with this prestigious and delightful event, and we look forward to doing it again!

We had the first annual Games in Libraries Day as one of our pre-conference events, and - as usual - having librarians around was wonderful. They are the original managers of information and freely accessible educational spaces. RESPECT.

The Educational Game Arcade was renamed the GLS Showcase, and then we added a GLS Showcase award ceremony with an MC, pitches by the game designers, and critical judges. Shiny.

The GLS Quest was handed out to all of our attendees, and boy howdy, some played it harder than others! But turns out that an old-fashioned paper-based activity game is a wonderful complement to the GLS experience. #FTW

We introduced special Fireside Chats with keynote speakers, immediately following their keynotes, as well as special networking lunches with specific themes. Small and cosy conversations can make big differences!

Some of our attendees got to LARP for the very first time, with a concluding battle that involved nerf guns, nerf swords, and a nine-foot-tall vampire bat costume with stilts. Holy awesome, vampire-batman!

Last, but not least, we unveiled our new version of pechu kucha: Speed Runs. GLS has never been so fast.

Unexpected Stories from the Conference

- the epic adventure of the lost box
- the comedic tale of the HDMI to mini-HDMI convertor
- Stanley Parable Phil ("Did you *plan* for that to happen?!")
- the "game" of finding the sessions hiding behind construction doors

And remember to keep your eyes peeled for the special issue of the Well Played journal with GLS and DiGRA Well Played - coming soon to an internet near you!

Thanks for a wonderful ten years, folks - here's hoping for ten more!

Constance Steinkuehler, Chair, and Caroline "Caro" Williams, Co-Chair

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GLS 10 Award Winners

Poster Session

Chair: Gabriella Anton

Judge's Choice: *Socioeconomic Pong: A Social Impact Game about Inequality*

Naomi Rockler-Gladen, Matt Taylor, Estelle Domingos

Best of Show: *"Raid the fridge!": Promoting Healthy Eating Habits Through the Game Monster Appetite*

Maria Hwang, Pantiphar Chantes, Mark Santolucito

Most Original Research: *Improving Learning and Assessment Outcomes through Automated Detection of Engaged and Disengaged Behavior in Game Based Assessments*

Shonte Stephenson, Ryan Baker, Seth Corrigan

Most Inspirational: *Arctic Saga: A Game of Negotiation and Environmental Conscientiousness*

Christian de Luna, Chris Vicari, Tom Toynton, Joey Lee

GLS Showcase Award Ceremony

Chair: Dennis Ramirez

Judges Panel: Erin Hoffman, Colleen Macklin, James Paul Gee, Scott Price

1st Place: *Reach for the Sun (Filament Games)*

Ellen Jameson, Fiona Zimmer, Marshall Behringer

2nd Place: *Turn Up the Heat!*

Michael Horn, Amartya Banerjee, Sarah D'Angelo, Pei-Yi Kuo, D. Harmon Pollock, Reed Stevens

3rd Place: *Quest2Teach*

Anna Arici, Sasha Barab, Brenden Sewell

Finalists: *The Gravity Ether* (Kevin Miklasz) & *NELL* (Bert Snow)

GLS Quest

Designers: Courtney Francis, Jolene Zywica, Gabriella Anton, Caro Williams

1st Place: Donna Sinclair

2nd Place: David Leach

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LONG PAPERS

Panels

***Gone Home*, Playful Narratives and Classroom (de)Constructions of Contemporary Culture**

Discussant: David Simkins, Rochester Institute of Technology
Kelly Bergstrom, York University
Negin Dahya, York University
Paul Darvasi, Royal St. George's College
Jennifer Jenson, York University

Gone Home is a first person exploration game that unearths a compelling family drama by means of discovering documents, artifacts and personal possessions. Players unravel a family's history that includes a queer young person "coming out", a depressed and alcoholic parent, and another implicated in infidelity as well as spousal neglect. It is a highly visual, interactive and non-linear narrative that unfolds through user exploration of a family's home. Lauded by critics as breaking new ground, *Gone Home* is an ideal example of a game's power to relate a compelling story. In this panel discussion, the presenters explore intriguing directions for the future of games and learning in formal and informal schooling through narrative-based play.

Panel Overview

This panel provides a unique opportunity to bring together three perspectives relating to games and learning: the developers of *Gone Home*, a teacher who used the game as part of a high school English class, and a team of university researchers with a focus on learning through play who observed the classroom where *Gone Home* was played and deconstructed as text. Using this particular game as our touchstone, we hope this panel will foster a lively discussion between both panelists and audience about the role of narrative driven games in education.

Making *Gone Home*

Gone Home was created on a tight budget by a small team led by Steve Gaynor and Karla Zimanji. The creators met while working on *Bioshock 2* from which they imported many elements of the mainstream title to the narrower precincts of this indie enterprise. Whenever possible, they shaped their financial and technological limitations to their advantage by focusing on storytelling above all else. They strategically set the game in the 90's to encourage interaction with diverse objects and documents, as modern gadgets might be seen to collapse revelatory gameplay into scrolling through text messages and emails. Action was limited to a single home in real time, producing a focused and realistic experience of discovery. Making the old mansion gloomy, and the dark rural night stormy, masked graphic limitations and invoked elements of the horror genre to keep players on edge and unsettled. Where players expect ghosts, they discover skeletons in the closet and a family haunted by its past.

***Gone Home* as a Classroom Text**

Gone Home was selected as a substitute for a traditional English text and implemented as such without modification to the game and with a particular focus on developing a curriculum that framed the game as a narrative text. It was apt for classroom use in terms of both functionality and content. Unlike many long-form narrative games, it has a user-friendly interface and can be comfortably played in less than three hours. *Gone Home* does not progress on a reward schedule of levels, points and achievements and, as a result, creates a fluid and non-competitive gameplay experience. It is void of gratuitous sex and violence, and its basic premise of environmental storytelling yields ample opportunity to discuss setting, character, and a consideration of linear and non-linear narrative – fundamental concepts in any secondary school literature class. Its reliance on a diverse and realistic assortment of historically situated documents also expose students to a variety of more traditional written voices and forms.

The teacher implemented response strategies included an "annotation" of a single room, individual tracking assignments based on prominent themes recurrent in the game, considerations of tone and mood, game review writing and publication, and group presentations. A combination of screenshots and notes were employed to unpack the first room they entered, which acquainted them with all the main characters, basic gameplay and the ability to take in-game screenshots. Students selected tracking topics and, as they played, took relevant notes and screenshots. Topics included gathering information on specific character arcs; 1995 Archeology, objects from the game space set in 1995; Riot Girl pop culture which informs the main storyline; and the multimedia layering of other videogame references subtly woven throughout the house.

These directed activities encouraged purposeful and deliberate exploration, without restricting player agency. After

the gameplay phase, players were grouped together according to topic and collaborated on presentations that were delivered to the rest of the class. Finally, they read examples of game reviews, and wrote their own which they then published in video game websites such as Metacritic, Gamespot and IGN.

Researching *Gone Home*

Among the earliest forms of computer-supported games are RPGs (Bartle, 2010). Central to this genre is the ability to follow and to tell a compelling story (Murray, 1999; Jenkins, 2004; Heliö, 2004). Our interest in studying RPGs relates to the development of narrative and story writing competencies, the primary learning outcomes for literature, language and expressive arts, and communications, by examining the pedagogical affordances of the uniquely narrative experiences these games provide (Heliö, 2004). However, these narrative experiences can be overshadowed by a game's mechanics, as was the experience of Dickey (2011) who found that some of her students overly focused on finding the "game" elements of *Murder on Grimm Isle*, rather piecing together a story. While critics have lauded *Gone Home* for its ability to tell a compelling story, players have criticized it for being *not* a game. In our classroom observations, a very similar debate played out and in this panel discussion we will address the relationship between game procedures (Bogost, 2007), learning (Gee, 2007), and narrative play (Jenkins, 2004).

Considering the increasing importance of multimodal discourse in 21st century learning (Kress & Van Leeuwen, 2001), the authors focus on the interpretation of multimodal discourse as a narrative form in gameplay. Based on participant observations collected by four researchers over two weeks, the authors discuss how students in this all male private school engaged in critical discussions about feminism, popular culture and social activism, the recent history of technology, character development, the importance of home/place, and sexuality through their gaming experience with *Gone Home*. In particular, the focus of this discussion will be on explorative capabilities embedded in narrative play and the reconstructive possibilities associated with a textual deconstruction (in the form of literary analysis) of videogame narratives. How do players engage with the life history of the lead game character in *Gone Home*? How is the game's non-linear narrative experienced by players, and how do they relate their experiences of that narrative?

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Tuning the Knobs and Dials: Empirically Maximizing Features for Serious Games

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Carl Symborski, Leidos
Rosa Mikeal Martey, Colorado State University
Emilie T. Saulnier, 1st Playable Productions
Elizabeth S. Veinott, Applied Research Associates (ARA)

Games research has often treated the game as a black box; we introduce the game into a situation, observe the effects, and declare success. But we don't know *why* the game worked. What was it about the game that made it a powerful tool for learning? Can games be used to teach not just concepts and knowledge, but to also spark changes in reasoning, judgment, and decision-making? This panel will address these questions.

Five game development and research teams were charged with creating 5 games to teach intelligence analysts to learn to recognize and mitigate 3 cognitive biases: Confirmation Bias (CB), Fundamental Attribution Error (FAE) and Bias Blind Spot (BBS). Cognitive biases occur in situations where evidence is incomplete or uncertain and time pressures rise. Heuristics provide a quick solution to the problem under consideration, but "heuristics gone astray" result in biases may lead to errors in judgment. The judgment and decision-making literature has shown that overcoming biases is difficult (Kahneman, 2011).

Each of the teams went through 3 rounds of prototyping and testing their games over an 18-month period. Each round varied one or more game features that were used in a controlled experiment to determine the effectiveness of the particular feature to teach players to recognize and mitigate their own cognitive biases. For example, one version of a game examined the use of a student model to guide game play, which was compared to a second version of the game without a student model. Participants in the experiments were randomly assigned to play one version of the game or to watch a 30-minute training video, which served as the control condition. Game variables examined by the teams included student models, priming, visual fidelity, and repetition.

Three of those games are discussed here. The 3 games employed a variety of narratives and gameplay styles; we had no preconceived notions about what would make a successful game. Thus the game spectrum ranged from casual, puzzle-style games with minimal narrative structure, to immersive, 3D game environments with strong storylines. We now describe the 3 games in more detail, the game features examined, and the results of the empirical tests of game effectiveness on recognizing and mitigating cognitive bias.

Heuristica (ARA) is a 3D immersive video game developed using Unreal3. Designed with a space station narrative, Heuristica's gameplay is driven by exploration, problem solving, and includes two phases for learning, a training phase and an action phase. The player assumes the role of a human astronaut on a space station where a new starship crewed by a team of androids is about to launch their first expedition. A small team of humans must compete to win command over the androids on-board and the player is competing for one of these spots. There is a core difference between the minds of androids and humans. Humans use heuristics, leaving them vulnerable to biases, while androids do not. To be successful leading the androids, the player must demonstrate his or her ability to recognize and mitigate several cognitive biases.

Over the course of 3 experiment cycles, we examined the effects of 10 different game variables (e.g., real time reward, time pressure, session duration, repeated sessions of game play, 3rd person perspective, student model/intelligent tutoring) on learning and retention with Heuristica (Veinott et al, 2013). We found that certain versions of the video game improved participants' immediate knowledge of the cognitive biases and their ability to mitigate them. The size of the improvement depended on the game variable being examined. Two game conditions that showed the greatest improvement in learning, and significantly more than the training video, were the repeated session game (2 sessions over 3 days) and the single session game using a student model for intelligent tutoring. Furthermore, these learning improvements were retained after an 8-week delay.

The **CYCLES** game (Albany Team) is a 2D casual game in which players navigate an avatar through a slightly sinister "Bias Training Center" comprised of a series of rooms with puzzles that teach about the three biases and how to mitigate them. A humorous storyline involving an evil genius provides a basic story and context for the player's predicament. Players receive infographics before each room to define and describe biases and mitigation strategies as well as short quizzes after each room to reinforce each lesson and transfer to real-world scenarios. Our team studied the effects of three game variables (Martey et al., forthcoming). First, we examined avatar customization by varying whether the player could choose their avatar's shape and uniform. We found no

significant differences in learning between the game versions. Our next experiment looked at the effects of visual and narrative detail. To do so, we used two art styles: a detailed condition with full-color, rich texture and shading, and realistic detailing; and a minimalistic condition that was largely monochrome with minimal shading and almost no textures. We also used two narrative styles for the game text: a light narrative in which the player was only told they were in a training center; and a rich narrative that explained a plot with backstory and specific character motivations, as well as an opening cut scene. Because narrative is often conveyed via visual details in commercial games and thus closely associated with each other, we combined these variables to create four versions of the game. This allowed us to examine the impact of art and narrative combinations as well as individually using statistical analyses.

Our finding was that the minimalistic art conditions did result in greater bias mitigation than a detailed art game. Somewhat similarly, adding more narrative through text did not improve mitigation. Our experiments also show the final *CYCLES* game trains players well in bias recognition and mitigation, outperforming the training video control condition. In a final round of experiments, we also found that replaying the game 5-7 days later greatly improves learning retention 8 weeks later. We found this repetition was far more effective than a longer version of the game with additional levels.

Missing: The Pursuit of Terry Hughes (Leidos Team) is designed in the style of an adventure game that combines the rich immersive qualities of entertainment software with a host of training activities on cognitive bias recognition and mitigation. The story develops over the course of three episodes, during which the player completes a series of tasks and interactions with game characters, all in pursuit of resolving the mystery at the center of the story. The player is exposed to specific bias-invoking situations in the form of “bias vignettes,” where cognitive biases exhibited by the player are measured. After each episode there is an After Action Review that teaches about specific biases and offers feedback on player performance. The features examined include session duration, either 30 or 90 minutes; type of narrative, varied by including or excluding cognitive reinforcing stories; point of view, either first or third person; and communication style, varied by providing or not providing hints during the game.

Results obtained by the Leidos team showed that the game *Missing* improved participants’ ability to recognize and mitigate the targeted cognitive biases. Studies of the individual game variables showed they had varying effects on the game efficacy to teach bias recognition and mitigation, depending on the bias. The session duration game variable had a significant effect, particularly for the mitigation of Confirmation Bias, when it was set to 90 minutes. The inclusion of cognitive reinforcing stories had a positive effect for the mitigation of both Confirmation Bias and the Bias Blind Spot. First person point of view had a large mitigation effect on Confirmation Bias. Finally, providing hints during the game had a mitigation effect on all three biases. These studies resulted in the final game variable selection of 90 minute duration, providing reinforcing stories, first person point of view, and providing hints.

At the conclusion of the 3 rounds of prototyping and experimentation, the 5 teams sent the “best and final version” of their games to a third party, for independent validation and verification of game effectiveness. Participants were randomly assigned to play one of the 5 games or to watch the educational video. Two studies were conducted; one with college students and one with practicing intelligence analysts. Clear differences in game effectiveness emerged from these studies.

The independent validation showed that 3 of the 5 games resulted in participants with significant improvement in *knowledge* about biases, even after a delay of 8 weeks (Figure 1). We also assessed *behavior change*, that is, did the participant show less biased decision-making when presented with a series of judgment and decision-making tasks? Participants who played one of the 5 of the games, or who watched the video, showed immediate improvement in bias mitigation; for the games (but not the video) this improvement persisted even after a delay of 8 weeks (Figure 2). Four of the 5 games beat the video in the amount of participant bias mitigation.

This research program has shown the value of having game developers and researchers conducting more systematic examination and testing of game features. Some of the game variables that we expected to be effective were not. Some of the game storylines, which intuitively should have worked very well, did not. The heuristic judgments of the game designers were sometimes off-target; empirical testing revealed these flaws and showed us what did work well in accomplishing the goals of the games. Game designers and researchers must beware of their own biases!

Student Recognition and Discrimination Test Score by Performer

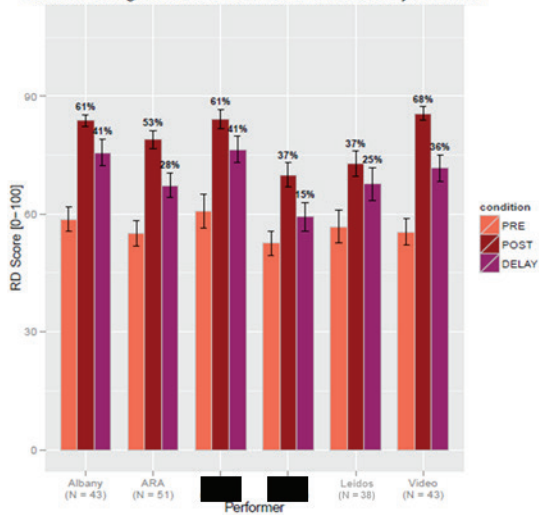


Figure 1: Recognition/ Discrimination (Knowledge) Scores.

Student Average Pre/Post/Delay Test Score by Performer

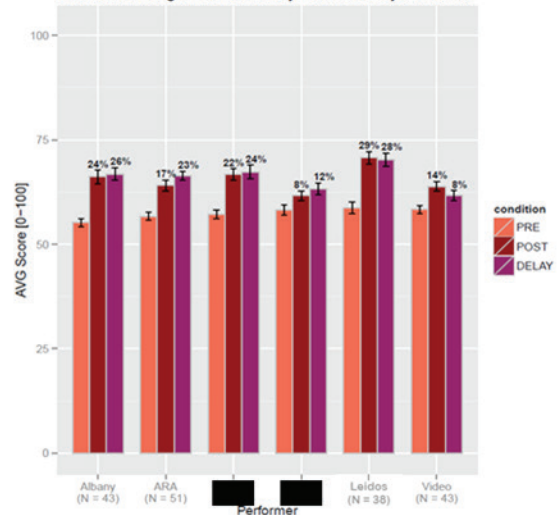


Figure 2: Bias Mitigation (Behavior Change) Scores.

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The State of the Surveys: Framing and Informing Research on Games and Learning

Moderator: Barry Fishman, University of Michigan
Seeta Pai, Common Sense Media
Lori Takeuchi & Sarah Vaala, Joan Ganz Cooney Center at Sesame Workshop
Michelle Riconscente, New York University

Introduction: Why Use Surveys?

As the field of games and learning grows, the need for varied research approaches to inform and shape ongoing work in the areas of policy, design, development, and implementation grows as well. What do we know about the context(s) for games in formal and informal learning settings? What are the attitudes, beliefs, and practices of players, learners, educators, parents, policy-makers, and designers? How do these factors interact to create complex settings for game-use? These kinds of questions are relevant to any learning and design endeavor. But as a distinct subfield, games and learning needs its own research designs and its own answers to these questions to inform our work.

Surveys are a methodology designed to frame a big-picture view of a question, topic, or area. There have been many recent surveys on topics such as: teacher attitudes and practices around games and learning (e.g., VeraQuest, 2012); how teachers view student informal game play and media use (Common Sense Media, 2012), as well as surveys on more general attitudes about technology conducted by Pew (e.g., Purcell, Heaps, Buchanan, & Friedrich, 2013) and others. Surveys allow for questions to be asked of a broad sample of respondents in order to “take the pulse” of practitioners, surface issues, and indicate relationships between various factors that might be pursued further in follow-up research. But surveys face a range of challenges as well. Sampling issues are foremost; how do you know if your sample is representative? Surveys primarily yield either descriptive data, or correlations among variables, as opposed to identifying causal or predictive relationships. Definitions of constructs can be challenging: How do you know if survey respondents interpret questions the way they were intended? Surveys often provide a starting point for deeper investigation.

This panel highlighted research questions addressed by recent surveys about games and learning, briefly shared what has been learned from these surveys, and invited discussion among both panelists and the audience to identify high-need areas for further research.

Common Sense Media: Teacher and Parent Attitudes, and Game Use

Common Sense Media tracks national (U.S.) patterns in media use among youth 0-18. In addition, we conduct landscape surveys of parents and teachers regarding technology, learning, and education to inform our ratings and reviews of games, mobile apps, and web-based products for learning potential.

The presentation drew from various Common Sense studies to frame implications for surveys as a methodology for games in learning. First, we inquired *why* surveys are a useful research tool, pointing to their importance for outlining broad contours or trends about a field or topic, for describing a landscape, and identifying areas worthy of deeper examination. We presented examples of broad data trends from our (1) Zero to Eight surveys (2011, 2013) and (2) National Study of Educators (2013, 2014 - also known as “Teaching with Technology”) that documented, respectively, (1) an explosive growth in mobile use at home among U.S. kids 0-8, and (2) consistency in shared, centralized use of devices in U.S. schools over time.

Second, the presentation asked *what types* of topics are appropriate to survey, using the example of key construct definitions for “video game”, “learning”, and “educational”. Data from various Common Sense studies (View from the Classroom, 2012; Digital Media and Learning Attitudes, 2011; Zero to Eight, 2013) indicate that survey respondents (parents and teachers) may be stereotyping video games negatively and considering them in a narrow light, and may be interpreting “learning” and “educational” in similarly narrow, traditional, academically-focused ways relative to the field’s definition of them. The presentation encouraged discussion among the audience around how best to approach definitions of fundamental concepts for use in surveys. Finally, drawing on examples (e.g., “thinking about just yesterday, how many minutes...” and “in this school year, how often...”) from our surveys, the presentation summarized the importance of using specific behavioral anchors in survey questions to improve the reliability and validity of responses.

Joan Ganz Cooney Center: Game-using Teachers – Practices & Perceptions

Digital game-based teaching requires fundamental shifts in one's pedagogical approaches to content (Mishra & Koehler, 2006), even among the younger teachers who may have grown up playing games (Lei, 2009). Where are U.S. teachers today with respect to integrating digital games into instruction? What kinds of teachers teach with games? What results do they see, and with which students? What do they struggle with most? To answer these questions, the Joan Ganz Cooney Center surveyed 694 K-8 teachers from across the U.S. on how they're using games in their classrooms; professional development (PD) around and barriers to integrating games in instruction; and perceptions of the effectiveness of games in delivering content, assessing, and motivating students. The survey also included the responses of *non*-game-using teachers, a population that could provide greater insight into why games are not being integrated into classroom instruction. VeraQuest, a professional survey firm, fielded the study in fall of 2013 with an omnibus survey panel, which comprised over 2 million members enrolled through a number of different online panels in the U.S. Respondents receive points for the surveys they complete, which can be redeemed for a variety of products. VeraQuest randomly selected 694 adult respondents from a targeted panel of K-8 classroom teachers such that the sample would be generally proportional of the demographic and geographic strata of U.S. teachers.

The Cooney Center's presentation focused on a set of analyses aimed at understanding the different types of teachers who use digital games to teach. To generate these profiles, we conducted a cluster analysis, which involved running a select set of variables (particular characteristics gathered on each survey respondent) through a statistical model, and allowing subgroups within the larger population to emerge based on their similarities and differences around these variables. The four resulting profiles reflect the varying levels of *support* that teachers receive around these practices, and their varying *dispositions* toward using games to teach. Although exploratory in nature, we believe these profiles serve as a starting point for designing games, tools, resources, and training programs that can better support teachers with diverse needs and experiences in their use of games to teach.

A-GAMES: How do Teachers Use Games for Formative Assessment?

The Analyzing Games for Assessment in Math, ELA/Social Studies, and Science Project (A-GAMES) is designed to investigate how features of educational video games intended to support classroom formative assessment are understood and used by teachers. Formative assessment can be a valuable classroom practice, when used well (Black & William, 2009). Game designers include features they hope are useful to support formative assessment, including student progress reports, leaderboards, and tools to allow students to reflect and self-report learning. But what do we know about how these features are used? What do we know about how game-using teachers think about formative assessment and look to games as part of their formative assessment toolkit?

To investigate these questions, A-GAMES surveyed K-12 teachers in the U.S. in fall of 2012. The survey asked about formative assessment practices, classroom game use, and game use for formative assessment. The goal of the survey was to identify how game-using teachers conceive of the goals of formative assessment, what they think it is good for (with or without games), and how they currently use games for formative assessment. The survey is a backdrop to a series of case studies of teachers using educational video games, accessed through BrainPOP's GameUp platform (<http://brainpop.com/games>), that represent a range of formative assessment design features. Our goal is to use the survey and the case studies to inform the design of future video games, curriculum and PD to increase teachers' capability to use games for formative assessment.

What Happened in the Panel Session?

The session was well attended by an audience that was eager to think together about a range of methodological issues related to the use of surveys. All panelists played key roles in the design of recent prominent surveys in games and learning. Each discussed the objectives and findings of their surveys, as well as the limitations. After the brief presentations, the floor was opened for questions.

The questions opened with an inquiry about how each presenter dealt with issues of sampling and selectivity. Panelists described various approaches to sampling. For instance, the Joan Ganz Cooney Center hired a professional survey firm with a standing panel of respondents. The A-GAMES project used a convenience sample, placing their survey online and inviting responses. In both cases, researchers compared the overall response demographics to national databases such as the Schools and Staffing Survey (<http://nces.ed.gov/surveys/sass/>). Common Sense Media used a more comprehensive approach to sampling, seeking representativeness along multiple dimensions. This was both time-consuming and expensive, involving, for instance, providing laptop computers to families for purposes of completing the survey. Selection bias was also considered. For instance, the A-GAMES survey was announced to potential respondents through games and education web sites and social

media feeds. Did this result in a response population biased towards games? The most important consideration is the claims one can make with the survey data. For instance, if issues of equity/social justice were the point of the survey, it would be critical to make sure your response population was balanced in terms of socio-economic status, race, and similar factors. In such a case, the more expensive approach taken by Common Sense Media is warranted. In the case of A-GAMES, where the surveys are meant to provide a back-drop to case studies, the convenience sampling approach was warranted, even if the claims that can be made from the data are limited.

Another question dealt with potential challenges in gaining Institutional Review Board or Human Subjects approval. None of the panelists found this to be challenging, in large part due to the non-identifiable nature of their survey data collection. The A-GAMES project reported that surveys are usually granted “exempt” status by their institutions, especially when they are designed to be anonymous. Furthermore, taking the survey is usually construed as giving consent to participate in research, so separate consent processes are not required.

A final area of questioning focused on the design of items/questions for surveys. How do you gain confidence that survey respondents perceive questions they way they were intended? The A-GAMES panelist pointed to a particular approach known as “cognitive interviewing” (Desimone, 2009), an approach that employs interviews and think-alouds while piloting the survey. All panelists stressed the importance of providing definitions and examples of what the question is looking for. For instance, the A-GAMES survey included a definition of formative assessment. Socially-desirable responses are also problematic – when teachers give the answer they think is *better*, as opposed to what is actually true of them. Panelists stressed that emphasizing anonymity is one approach to minimizing this issue. Another is to keep survey items focused on *behaviors* instead of on *feelings* or *opinions*.

Final Thoughts

This panel was one of the first sessions at GLS to be focused exclusively on research methodology, and we were pleased both with the large turnout and with the spirited and engaged discussion among panelists and audience members. The session ended with a statement of the importance of having methodological discussions as the field of games and learning continues to evolve.

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Mobile History Games: Challenges, Frameworks, and Design Principles

Owen Gottlieb, New York University/ConverJent
Jim Mathews, Clark Street Community School/Placework Studios
Karen Schrier, Marist College
Jennifer Sly, Minnesota Historical Society

Introduction and Overview

This panel covered nearly a decade of work in mobile and location-based history games, and reflects on the key questions, learnings, and challenges in this emergent field. Using location-based mobile technologies to explore historic moments can be powerful: designers and educators can access narratives from the past, in the places that they occurred, and can potentially disrupt those narratives to create new versions of the past. Historical narratives have always been “constructed,” and so, history is, in essence, rewritten through the experience of these games. This is a significant responsibility for designers and educators. How do we characterize the interplay of fiction and non-fiction in the mobile history game, since players’ own narratives are mixed with the historical narrative? How do we appropriately show sentiments and biases that were representative historically, but perhaps not considered ethical by today’s standards, or in some cases, by any standard?

Mobile environments can also allow for place-based, *in-situ* exploration of historical moments, debates, and interpretations. They can help simulate historical systems of production, trade, commerce, or environmental impact, and they can augment reality through the use of historical media and the digital reproduction of primary sources. Mobile history games can situate play within local communities, such as those at historic sites, allowing learners to participate more tangibly with the past. These games can also provide an historical context for contemporary events and issues by facilitating interactions with contemporary community members on location.

How can genres, such as the situated documentary or resource management game, guide or limit a designer, educator, or learners’ choices? How might we further mobilize mobile history games toward civic engagement and critical thinking?

The panel explored these questions in relation to specific mobile history games, with Schrier’s *Reliving the Revolution* (created at M.I.T. in 2004-5) and Mathews’ development of *Dow Day*, to current place-based and museum-based mobile history games: Gottlieb’s *Jewish Time Jump: New York*, and *Play the Past* at the Minnesota Historical Society (Sly).

As we investigated this “history” of mobile history games, we considered how mobile history gaming has evolved over the past ten years, its failures and successes, and how we might collectively conceive its future.

Reliving *Reliving the Revolution*

Almost a decade ago, Schrier designed a location-based game to teach children historical thinking skills. The game, *Reliving the Revolution* (2005), invited participants to explore the physical location of the Battle of Lexington (Lexington, Massachusetts) and access virtual information about the Battle using GPS-enabled Palm Pilots. The game was tailored to students in middle and high school, and provided numerous first-person narratives (based on historic testimonials), which would automatically appear on the players’ phones depending on where they were standing at the physical Battle of Lexington site. To complete the game, students needed to interpret the narratives about the historic moment of the Battle to create a meta-narrative about who fired the first shot at the Battle. Each participant played as one role: a white male Minuteman soldier, female white loyalist, African American male Minuteman soldier, or British regular (white/male) soldier, each of whom were based on real people involved in the battle. Depending on which role you played, the NPCs (non-playing characters) would provide slightly different testimonials. In this panel, Schrier discussed and revisited the design principles used to create what ended up being the first location-based history game of its kind, and how she would adjust it, now almost 10 years later. In particular, Schrier discussed the ethical considerations and historiographic ramifications of this game.

Dow Day: Unpacking the Genre of Situated Documentary

Mathews presented *Dow Day*, a situated documentary designed to promote local historical inquiry and help players make connections between the past and present. He discussed the questions, challenges, tensions

and opportunities that arose during the production, implementation, and evaluation of *Dow Day*. He also applied frameworks and questions from history education and documentary studies to frame his design decisions and reflect on the relative success of *Dow Day*. Some of the questions he presented for consideration included: How might we classify these types of mobile-based designs (and should it matter)? What types of learning outcomes should we be concerned about? What dilemmas and opportunities arise when we use situated documentaries within an educational context?

Surrogates, Suturing, and Supra-reveals: Developing Narrative Design Principles for Mobile History Games

Dynamic interactive approaches to teaching history can catalyze the development of an active citizenry through teaching aspects of citizen journalism and the power of issue-based advocacy. The exploration of such topics can promote a sense of ownership of community challenges. What design elements for place-based mobile history gaming may better achieve the kinds of history learning goals that could lead to deeper civic engagement? Gottlieb uses mixed methods and design-based research in the process of developing mobile augmented reality gaming for teaching history. Design-based research employs iterative cycles of design and development paired with field study to arrive at new design knowledge. In these cases, the knowledge is in the form of design principles for the genre of the “situated documentary.” Gottlieb shared design principles and best practices from *Jewish Time Jump: New York*, a game centering on immigrant, women’s, and labor history in early 20th Century America. The newly derived design principles address learning goals including perspective-taking and learner investigation, as well as offering approaches for historically grounding contemporary civic concerns from within the game environment.

Play the Past: Weaving Critical Thinking and Problem Solving into Immersive History Exhibits

Play the Past is a new and student-directed, mobile technology-supported, field trip experience at the Minnesota Historical Society. Students use iPods loaded with a mobile game to explore the *Then Now Wow* exhibit at the Minnesota History Center. They enter historical situations and, through critical thinking and collaboration, earn badges and collect digital items for later use. Students meet historic characters and solve challenges emulating those that actual Minnesotans faced. Back at school, the interaction continues as educators and students build upon the experience through further research and classroom activities. Drawing from the development of *Play the Past*, including the iterative design with over 1,500 students and formal evaluation, Sly explored design questions, such as: How does narrative fit in or balance with game play/mechanics? How does role-play complement or compete with historic narrative? How can designers represent historic characters for which there exist no media artifacts?

Key Discussion Questions

A number of key questions emerged through the presentations and Q&A. They included: What design principles have you found useful in producing these games? What opportunities and dilemmas arise when you invite players to take on roles as part of historical games? What data are you collecting and how are you analyzing it? What is the future of mobile history games? The panelists and audience discussed these questions, and such questions can be useful in shaping future design and research.

Emergent Themes

Themes that emerged included balancing content needs with constraints. For example, how does a designer balance a complexity of rich, layered content, and multiple perspectives with constraints such as small screens, technical issues, and time.

Another theme related to the opportunities, challenges, and need for balancing associated with narrativizing historical moments, and the historiographic questions that are important to foreground (see Marcus & Stoddard, 2009; Stoddard, 2010).

All media experiences (including those in a textbook) are designed, which means that there is someone designing it, and their values, sociocultural context, and other perspectives will affect the design. It is important to make those design decisions as transparent as possible, such that the learner is made aware of how these designs may be affecting their learning. The problem remains: how to make a game’s design as transparent as possible while enabling players to immerse themselves in the game, and have the “suspension of disbelief” that is necessary to fully embrace the experience. Finding a balance between one’s meta-understanding of the game and immersion in the game should be considered.

Looking Ahead to the Next Generation of Mobile History Games

Some of the trends, goals, hopes, and suggestions for the next generation of mobile history game design include:

- Cultivating more learner-designed history games as a means for exploring places and historical moments
- Promoting the development of games that engage players in producing new content, such as games in which players collect oral histories or document historical places.
- Taking advantage of the newest functionality of mobile devices, such as evolving augmented reality technology for just-in-time location based history, or using “heads up” games development to allows users to not have to stare at a screen (Soute, Lagerström, & Markopoulos, 2013).
- Creating templates for educators and designers to be able to quickly generate location-based games for various use cases (such as the “classroom case,” the “museum case” or the “battle site” case.

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Massiveness in Educational Games

Eric Klopfer, MIT Scheller Teacher Education Program
Scot Osterweil, MIT Education Arcade
Dan Norton, Filament Games
Joel Levin, Minecraft Edu

Many genres of commercial games have social elements where many players play at once and have various types of interactions. A few projects have integrated this type of massiveness into educational games as well. There are many benefits to this design element such as the ability to collect large amounts of data, access to large pools of collaborators, potential to find mentors, and a “live” feel to the game world. However, there are also drawbacks in the amount of infrastructure and resources needed to get massive games up and running. This panel will discuss the value of massiveness in educational games and whether it’s worth the resources to build them, drawing on current examples of educational projects.

Benefits of Massive Games

There are a number of ways in which large numbers of players playing a game simultaneously and interacting in various ways can support both the engagement and curriculum goals of a learning game. Massive games leverage persistence and community in ways that other forms of gaming don’t. Participating in a world you can come back to and meeting friends that greet you when you come back are powerful elements of engagement. In addition, a game that creates a community of hundreds or thousands of players can feel more important and more authentic, and in the process motivate them to work harder at rising to the game’s challenges. Some players may respond to the sociability of playing with others, which can result in collaboration and mentorship – both of which help build skills and solidify content knowledge. Other players may be more motivated by the possibility of demonstrating their talents on a larger stage. Massive games can enable this by providing a place to display achievements and creations, which can then lead to further peer feedback and connection building. In addition to the engagement and learning benefits, massive games can be a valuable research tool. Data tracking metrics that are built in to collect data from many players working on a range of personalizable activities result in a large data set and the opportunity to learn about a wide variety of play and learning styles.

Drawbacks of Massive Games

Despite the value added by the design of massive, social mechanics, there are drawbacks as well, mainly stemming from the game development piece. The intrinsic massiveness means it is necessary to integrate many play systems together into one space, for example tools, NPCs, health, social elements, the environment, etc. Creating a constellation of activities that are relevant to each other but can also be utilized independently is no simple task. While it is not impossible to overcome, it does mean that massively multiplayer games are inherently more costly to design and develop. In addition, for learning games targeting children there is an added complexity of creating social spaces for players who may be protected by laws (COPPA), or who at the very least have less fully developed self-regulation when it comes to online interaction. For an educational game whose goal is to get into the hands of students as quickly and smoothly as possible, increasing the complexity and scale of any project presents a certain amount of risk.

Are Massive Games Worth Building?

Given the resources necessary for building massive educational games, we can see that the social component must be well thought out, and of significant value to justify the added expense. It certainly can be a worthwhile undertaking, however. The explosive growth of ubiquitous internet connectivity is creating an expectation that one can be linked to a very large network of friends and acquaintances at all times. In this environment there will be growing demand for more and more synchronous play, and synchronous social learning experiences. To ignore this genre of games and their potential for education would be a mistake. Moreover, some of the challenges of commercial MMOs, particularly community management and time coordination, are actually supported rather than hindered by integration of the games into classrooms. For example, a class turned into a guild comes with a lot of interesting perks and ramifications and is an interesting pedagogical concept to explore. There is another option though, which is to identify the most relevant existing commercial or mainstream games and put resources into making them work for educational purposes. This is already being done by many teachers who modify games or implement companion curriculum around a relevant topic. Capitalizing on existing games that can fit into an educational setting requires fewer resources than developing them from scratch, but may not deliver the content in quite the same way. Given these options the question remains: is it worth building massive educational games

from the ground up?

Panel of Experts

The panel will consist of four experts in the field of educational games who have designed, developed, and implemented a variety of massive learning games. **Eric Klopfer** is currently carrying out research on The Radix Endeavor, an MMOG for STEM learning co-designed by the Scheller Teacher Education Program lab, and he is also designing MOOCs that incorporate game creation. **Scot Osterweil** from the MIT Education Arcade designed Lure of the Labyrinth, a middle school math game that incorporates social elements to help students complete math puzzles. As one of the lead designers on The Radix Endeavor, **Dan Norton** from Filament Games has explored many of the social systems that can work in a multiplayer game. Finally, **Joel Levin** is the co-creator of MinecraftEdu and teaches using Minecraft in his classroom. The games created and used by the panelists are shown in Figure 1.

The panelists have identified the issue of massive educational games as an engaging question, and one that the GLS community would have an interest in exploring. The panel will consist of 5-minute “speed introductions” from each panelist in which they will describe their background with massive learning games, and present their position on the question at hand. Next the panelists will have an opportunity to respond to each other’s positions and engage in some friendly debate. Finally, the floor will be open for questions so that attendees can probe the panel further, as well as offer their own opinions on the topic. The session will be largely discussion-driven to give everyone a chance to participate and gain a deeper understanding of the emerging issues around massive social interaction in educational games.

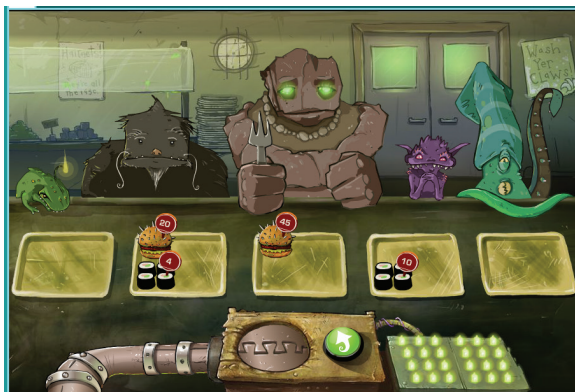
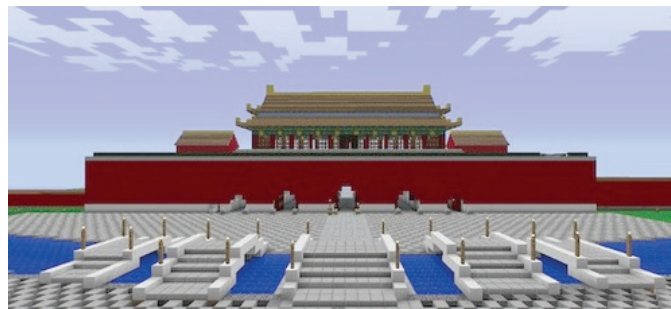


Figure 1: Screen shots from Minecraft, Lure of the Labyrinth, and The Radix Endeavor.

Resulting Discussion

After introductions by the panelists the session focused on questions and a discussion with the attendees. Much of the discussion centered around the importance of the social aspects of multiplayer games, both massive games and games that work on a smaller scale. One goal of the panel was to explore the idea of massiveness and what that means, including MMOs but not limited to games in that genre. However, the conversation grew out of that and turned more toward the social aspects of all types of games. This included not only typical multiplayer video games, but also social or team-based non-digital games. Additionally, it included communities that grow out of either multiplayer or single player games. Those communities may be purposefully designed or emerge organically

from the player base, but are also an important massively multiplayer factor to consider. The session went well due largely to the participation and contributions of the attendees, who helped identify many different types of games that were relevant to the discussion.

Advancing STEM Learning with Games in Civic and Cultural Institutions: A Play, Critique, and Discussion Session

Edge Quintanilla, The Field Museum of Natural History
Barry Joseph, American Museum of Natural History
Margaret Chmiel, Smithsonian Science Education Center
David Ng, Michael Smith Laboratories, University of British Columbia

Designing Games to Advance STEM Learning

STEM (Science, Technology, Engineering, and Math) education has recently garnered much national attention. According to the National Science Board (2010), The United States lags behind its counterparts in STEM; only 16% of U.S. undergraduates declared natural sciences and engineering as their primary field of study compared to higher rates in China- 47%, South Korea- 38%, and the European Union- 25%. Science is seemingly not interesting to young people in the U.S.

Out-of-school, or informal learning is crucial for engaging youth and helps connect learning that happens in school settings to learning that occurs in other areas of their lives. In order to engage with science, youth need connection and translation between in-school and out-of-school learning through “ecologies” of learning. These ecologies can provide pathways of engagement across the spaces where young people develop (Ito, 2013). Cultural and civic institutions like the American Museum of Natural History (AMNH), The Field Museum of Natural History (FMNH), the Smithsonian Science Education Center (SSEC), and University of British Columbia comprise a handful of institutions that have contributed to creating these learning pathways through the development and implementation of innovative STEM games. Games, as part of a well-designed learning system, have an important role in advancing learning by providing deeper modes of engagement and providing a context for thinking through problems (Gee, 2008).

The members of this panel represent civic and cultural institutions using games to encourage, excite, and engage learners of all ages in STEM. Although the broad goals of STEM learning are similar across institutions, the methods, development and delivery of these games differ significantly. These diverse approaches of game development illustrate the multiple pathways available to STEM game development. This panel will explore what the driving ideas are for using and developing science games. What common themes arise? How are outcomes affected given different audiences, resources and limitations? Panelists will foster discussion with the audience and with each other on how games are being used, and how they might be used, to advance STEM learning using civic and cultural institutions as case studies.

Science Games for Learning: Play, Critique, and Discussion

Panel participants came from a range of backgrounds, including public programs in museums, game development, and research. The variety of the panelists’ experiences illustrated the different approaches to STEM game development complete with demos of playable experiences. At the start of the session, audience members were given the chance to play each institution’s games and were invited to engage in conversation with panel members and each other by sharing comments and asking questions. Questions tended to be project specific as each panel member demoed their STEM games at small stations within the room. In this first half, most of the questions asked were logistical (“*how do you play the game?*”) and pragmatic in nature (“*how can I bring this into my classroom.*”). The only problem with this format was that participants were able to hear about only one of four projects. To allow for the panel to talk more broadly, the session convened into a larger group discussion.

The discussion continued exploring themes of STEM game design, informal innovation in STEM education, and pros and cons of STEM learning in informal versus formal learning environments. The general narrative centered on where informal science education institutions fit in the broader educational landscape. In other words, since informal programs aren’t required to be directly applicable or formally tied to school systems how might this interesting dynamic play out? Another question asked touched on the idea of evaluating and measuring students’ learning in informal settings. Thought there are some possible methods of evaluation (badges, external evaluation, etc..) the bigger question was asked back to the audience, “*are there ways for informal learning institutions to collaborate in order to better evaluate and measure student learning?*”

The discussion here led to an emphasis that having less “formality” in informal programming could be thought of as both a good or bad thing. Good because it’s arguably easier for informal science education to be different, unconventional, risky, and innovative. In a way, there is less at stake when compared to designing learning

experiences for direct inclusion into school curriculum. A comment was made in the panel that science museums might be the perfect place to try out these sorts of initiatives where engagement via artistic work and new media are being explored. On the other hand, one way to look at informal science education is to see it at a disadvantage. Because this informality doesn't fit as nicely in the usual science education grant/funding culture (though it was brought up that the NSF has been good at having a go here) - discussion here led to the fact that this potential innovativeness is tricky. Determining the metrics to rigorously measure effectiveness is justifiably more challenging.

Overall, the organizations represented in this panel (and beyond), because of the special place in the culture of education represent a great collaborative opportunity. Logistically and strategically, informal learning spaces are a great place for the gaming academic and the education academic communities to pilot or baby step into new and innovative projects.

Games that were available for play were *Phylo the Trading Card Game* (University of British Columbia), *Pterosaur: The Card Game* (AMNH), *Shutterbugs: Wiggle and Stomp* (SSEC), and youth-designed ARIS games on soil science (FMNH). Following are descriptions of panel participants' games:

Phylo: The Trading Card Game (<http://www.phylogame.org>) is a crowdsourced game that is inspired by the premise "...children know more about Pokemon, than they do about the plants and animals in their neighborhood." (Balmford, A., *Science*. 2002, 295, pp2367). Since 2010, the project has built itself from the incremental contributions of thousands of individuals with different backgrounds; most notably those in the disciplines of life science research, graphic design, education, game development, computer programming, museum outreach, and intellectual property law. Currently, this has manifested itself as an online hub where moderated cards/decks and DIY cards/decks can be selected and printed; as well as a growing collection of "physically" purchasable decks, often sold in a revenue neutral (or outreach fundraising) manner, and generally hosted by an organization with a vested interest in biodiversity outreach. The core game mechanic is essentially an ecosystem building game, where players compete by building and modifying trophic (food chain) networks using playable decks of cards.

Pterosaurs: The Card Game. #scienceFTW was a 20-session after school program held at AMNH which used card games to teach high school students about science and prepare them to co-develop their own science learning game based on assets produced for a recent exhibition on pterosaurs. Using the open nature of an existing game, *Phylo*, the youth modded the core mechanics of *Phylo* for use during the Mesozoic period. The youth selected which pterosaurs to use in the game, designed the color scheme, created new cards with new features, selected the text for the cards, playtested to achieve a good game play balance, and created spreadsheets to ensure all of the cards worked and had the right values. By the end of the program, professional cards were developed for each youth to take home. A few months later, they were made available for free download for educators at amnh.org/pterosaursgame, for sale in the Museum store, and for sale online at shop.amnh.org.

Shutterbugs: Wiggle and Stomp (<http://www.ssec.si.edu/games/shutterbugs-wiggle-and-stomp>) is a free game aimed at children ages 3-7 available on the web, iPad, and Android devices. Smithsonian Science Education Center has been developing research-based science education curriculum for over 25 years. In 2013, SSEC added kindergarten to its standard-aligned curricular offering. *Shutterbugs* was designed to co-launch with the new kindergarten curriculum. Several goals and questions went into designing the game. First, SSEC sought to fulfill the goal of "broadening access" to Smithsonian collections and exhibits. In other words, how can SSEC, itself not a museum with its own collections, make the treasures of Smithsonian accessible to children across the globe? Secondly, how might a game accommodate the wide range of learning needs and abilities found in children at the kindergarten age. Finally, How can science concepts be introduced to kindergarten classrooms, where science teaching isn't always a priority? Careful user testing and agile design and development methods yielded an October 2013 launch that has since been featured in the iTunes education store and has won praise from teachers and parents alike.

Mobile Game Design with ARIS: This one-week pilot experience was meant to facilitate STEM learning for middle school youth through game design. Youth, ages 12-14, were tasked with creating ARIS games that translate soil science. A combination of game-like learning methodology, The Field Museum's integrative research approach, and professional game designers were used in this summer camp. The workshop started with modding ancient games found in the museum's collections. Youth were put in the shoes of an archaeologist, given information about the cultural context of these games and asked to make an educated guess on how they thought the game might be played. This taught the students about game theory and prepared them to work with game design experts to understand, analyze and share key scientific concepts through an ARIS game. Program participants worked in teams to produce mobile games that were played by museum staff, family and friends at the conclusion of the

program. These youth-designed ARIS games were also posted onto The Field Museum web pages (<http://www.fieldmuseum.org/schools/mobile-planet-2013-0>) and are publically available for play through the ARIS platform.

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Ghost Stories from Learning Game Design: Surprises: Good outcomes we weren't expecting and things we'll know to worry about next time.

Bert Snow, Muzzy Lane Software
Scot Osterweil, The MIT Education Arcade, The Learning Game Network
Jason Mathew Haas, The MIT Education Arcade
Peter Stidwell, The Learning Games Network
David Gagnon

A Spirited Discussion among Practitioners

The aim of this Fireside Chat proposal is to spark a lively discussion among the many wizened (and scarred) designers of learning-games who will be at the conference. The intent is to focus the discussion interesting discoveries that occur in the design process: both serendipitous and things that the designers wish they had foreseen and possibly avoided. . The goal is to talk about the experience and the lessons of the work itself, the surprises and what we've learned from them

Given this focus, this proposal will not include references to learning research, design theory, or specific processes, though the authors and other participants certainly work with all of these.

The Authors (Ghost story tellers..)

The authors are designers who between them have many years and many games on their resumes, and in particular a lot of work and thinking about learning games. While we generally share an interest in working forward from core learning or practice objectives, our work and approaches have tended to vary quite widely.

The authors' work has ranged from ingenious puzzles to complex strategy games to open games-as game-building-systems to radical MMOs and mobile collaborations, language-learning-through games, and much more.

In addition to learning-game design and development, the author variously have written extensively on game design and learning, have helped invent game genres, and have worked with educators in many different disciplines.

We don't expect to always agree – and hope for several good arguments and also to draw out experiences and ideas from everybody who joins us.

The Focus

Playing a game involves attention to the goal a player is trying to reach, the role being played, and to the tools, actions, and strategies the player can use to reach the goal. To succeed, the player must learn about all of these elements – what tools make sense when, what strategies worked – and didn't, what the responsibilities of a role really mean.

To design a game with the ambition of inspiring learning in a particular area, it can make sense to look for goals, tools, actions, and strategies that relate to that area – that are intrinsic to it. Hopefully then, play will naturally lead the player to engage with and learn about those elements – and the topic area itself.

To accomplish this, the authors have different processes and favored approaches that we start with....but in game design things don't usually go as planned – and that's what we want to focus on – how the curves and lessons of design and development inform and change the starting point – and how to take advantage of the creative opportunities in the process while not losing our way.

Some Questions to fuel the Discussion

We will bring to the discussion a set of questions to fuel the Chat. Below is an initial list, which will be added to and refined over the course of the spring. We don't expect to include all of these questions, but hopefully many.

- What are some things that you worried about at the start of a design project – and later found you didn't need to have worried?

- What are examples of things that you didn't worry about but later found you should have? Has that experience affected how you approach things now? How?
- Do you have an example of a surprise that led you to change the game design in a fundamental way? Why did you make that change?
- The development process often pushes the design off of its presumed track: Was it a surprise that gave the push, or something subtler?
- How do you take advantage of surprises?
- What elements of a design are most liable providing surprises?
- How can we prepare to respond to surprises, both good and bad?" Often our design is pretty well advanced when the surprise comes up, and it can be hard to change direction in response.

Including the Audience

We intend to make this an interactive discussion – not a panel talk. The questions will be batted around to all attendees, with an aim of bringing to light interesting experiences and lessons from the rich group of designers who will be at GLS. Within the session we will ask questions, and seek answers and examples from the audience as well as from each other.

Designing Game Elements into the Chat Itself

In the spirit of our topic, we will look for a few ways in which we might find inspiration for the mechanics of the Fireside Chat in our objectives, our objectives roughly being:

- To draw interested and interesting designers (with tales to tell) to the Fireside Chat
- To create a spirited discussion amongst all, as if gathered around a fire
- To avoid having the chat dominated by one or a few – to hear many experiences.
- To reward the telling of especially interesting (but hopefully true) tales – of heroic success or defeat.

In advance of the conference, the authors will work out roles, actions, and mechanics based on these objectives, and will put a select set into practice as part of the Fireside Chat.

Conclusion and Post-mortem

Although the tone of this proposal is light-hearted, and we aim to have a lively and entertaining discussion, our true aim is serious. A discussion of these aspects of learning-game design, with the authors and the GLS audience, should bring out ideas and strategies that will be of benefit to many of those involved in creating learning through games.

The session was full and lively, with discussions ranging from design and production roles to a number of spirited discussions about differences between game and “real-world” models. We were able to record all of the stories told by the audience (in addition to the stories told by our core group. We will be transcribing the stories and will create a way to share them. If you would like more information on that please email Bert Snow (bert@muzzylane.com)

Presentations

Multiple Paths, Same Goal: Exploring the Motivational Pathways of Two Distinct Game-Inspired University Course Designs

Stephen Aguilar, University of Michigan
Caitlin Holman, University of Michigan
Barry Fishman, University of Michigan

Introduction

In his seminal work, James Gee (2003) elucidated many of the mechanisms behind what makes video games engaging. In the decade since his book was published there have been many attempts to further explore and apply his principles in both digital and face-to-face environments (see

Aguilar, Holman, & Fishman, 2013; Fishman & Aguilar, 2012; Deterding, S., Dixon, D., Khaled, R., & Nacke, L., 2011; Huotari, & Hamari, 2011; and Thom, Millen, & DiMicco, 2012, for examples). These efforts have ranged from designing “gamified” digital environments, to courses and entire schools with “gameful” structures (e.g., Sheldon, 2012; Salen, Torres, Wolozin, Rufo-Tepper, & Shapiro, 2011).

Our work explores gameful approaches, which typically involve deliberately increasing student autonomy—and mitigating the impact of failure—so that students are encouraged to put forth effort in academic areas that they might have otherwise shied away from. To that end, we report on the latest progression of a larger design-based research project that seeks to both understand and support gameful course designs. This latest iteration represents an examination of two gameful courses within the same institution, but with varying designs. Both courses were undergraduate, high-enrollment, gateway courses, were designed with an eye towards gamefulness to support student engagement, and were supported by “GradeCraft”, an in-house Learning Management System (LMS) designed specifically to support gameful instruction and pedagogy (Holman, Aguilar, & Fishman, 2013). The nature of the course’s gameful grading systems, however, differed substantially. We examine if the divergent design decisions made by the instructors resulted in similar or different outcomes in terms of the motivational pathways associated with adaptive student outcomes (e.g., reporting feeling “in control” of their learning).

Specifically, we examined the following research questions:

- (RQ1) How strongly is assignment choice associated with student effort, assignment exploration, and control over their learning pathways (key affordances of gameful designs)?
- (RQ2) What are the direct and mediating roles of students’ perceptions of the following grading system features: regard for the grading system, perceived fairness of the grading system, ease to earn one’s desired grade, and control over one’s grade?

In so doing, we had the following working hypotheses:

- (H1) Students’ assessment of being given choices over which assignments to pursue will strongly and positively predict perceptions of gameful grading system features.
- (H2) Students’ assessment of being given control over assignment weighting will strongly and positively predict perceptions of gameful grading system features.
- (H3) Students’ assessment of competitive community activities (i.e., leaderboards) will likely be negatively associated with perceptions of gameful grading system features, while perceptions of non-competitive activities (i.e., house points) will be positively associated with gameful grading system features.
- (H4) Overall, the gameful grading system features and students’ associated interpretations of them will be positively associated with adaptive academic behaviors.

Gameful Course Designs and their Players

Each course used videogames as a design metaphor to encourage student engagement, support student autonomy, and explain the grading system to students—neither course was *about* games or used off the shelf games in instruction. Both course instructors also utilized GradeCraft to support their course’s gameful features; students, for example, were able to engage in a modest level of “play” through use of a grade prediction tool

and interactive syllabus tool designed to help students manage various components of the course. The following sections briefly describe the major gameful mechanics of each course.

Introduction to Political Theory Course

The grading system in the political theory course supported student autonomy and students' feelings of competence in two distinct ways. First, students chose which two out of four assignment "types" to complete throughout the term. The assignments consisted of "boss battles" (short in-class exams), academic essays, blogging, or a group project. Second, students were given the freedom to determine how their assignments would be weighted within a 60% allotment. The remaining 40% of a student's grade was more "traditional" and consisted of a core set of requirements: lecture attendance (5%), weekly reading quizzes (15%), and participation in a weekly discussion section (20%).

Introduction to Information Studies Course

The grading system in the introduction to information course also supported student autonomy and students' feelings of competence in two ways. First, course assignments were framed as a series of "quests," through which students earned points ("XP"). These quests were either "adventures" (akin to regular assignments on a standard syllabus), or "pick up quests" which included a wide range of activities, such as exploring campus resources and participating in class "events" like "Laptop Liberation Day". Students began with zero points, and had the potential of earning over 1,000,000. A grade of "A" was achieved once students earned more than 950,000 points. The instructor ensured that there was an overabundance of choices so that students could make mistakes, avoid assignments, and have a sense of control over their experience.

The instructor also established structures to encourage students' feelings of belonging to a larger learning community by instituting "leaderboards". These boards were optional and anonymous; students who opted in were able to pick pseudonyms that would be displayed in GradeCraft. To further encourage students' sense of belonging in the course community, students were also put into "houses" led by graduate student instructors, and awarded house points for various challenges throughout the term (e.g., the Digital Content Playlist Challenge, where all house members worked together to design and build a website of online resources around one of the primary themes of the course).

Design Guidelines Informed by Self-Determination Theory (SDT)

SDT emphasizes the importance of self-determined action, which is a precondition to intrinsic motivation—an adaptive frame of mind for students to have. The gameful approaches used in each course are rooted (albeit implicitly) in the desire to promote students' intrinsic motivation by designing grading systems that leverage the "ABCs" of Self-Determination Theory (SDT; Ryan & Deci, 2000). Support for autonomy (A) is defined as a person seeing him-or-herself as the primary locus of control in a learning environment. A sense of belonging (B) serves as a pathway from extrinsic motivation to intrinsic motivation; as students enter a new learning environment they participate in it partially as a function of how connected they feel to other learners. Support for competence (C), serves to motivate learners towards engaging with course content by asking students to accomplish tasks that have the capability to complete successfully. Table 1 summarizes each of the gameful elements described above as well as their link to SDT.

Course	Term Taught	Game-inspired Elements	SDT Component
Political Theory	Fall 2013	Flexible Assignment options, Assignment weighting, Power-Ups	Autonomy, Competence
Information Studies	Fall 2013	Flexible Assignment options, Leaderboards, House points	Autonomy, Belonging, Competence,

Table 1: Summary of the two course designs as they relate to SDT.

Methodology

Data from both courses was gathered using online surveys administered at the end of the term. All but one item were measured on a 1-5-point Likert scale. In the political theory course "assignment choice" and "assignment weighting" were both measured on a 0-100 sliding scale, with 0 indicating "no control" and 100 equaling "total control". The entire survey took about 15 minutes to complete in each course.

Sample

There were 292 students enrolled in the political theory course, and 268 completed the survey for a response rate of 91%; there were 231 students enrolled in the introduction to information course, and 205 of them completed the survey for a response rate of 89%. Table 2 summarizes students' grade point averages for the term, final course grade (both on a 4 point scale), and ratings concerning how similar each grading system was to video games and other courses they were enrolled in (both measured on a 1-4 Likert scale).

Variables	Political Theory (N = 268)	Information (N = 205)
<i>Academic information</i>		
Cumulative GPA	3.3 (0.5)	3.3 (0.5)
Final course grade	3.5 (0.5)	3.9 (0.4)
<i>Grading System...</i>		
Similar to other courses	1.6 (1.1)	1.7 (1.1)
Similar to videogames	3.7 (1.0)	3.5 (1.1)

Table 2. Means and Standard Deviations of Academic Achievement and Grading System Similarity Judgments

Measures

We measured political theory students' interpretation of their grading system's features by asking them to rate how much control they believed being able to choose which assignments they committed to gave them (assignment choice) and how much control being able to choose how the two assignments they committed to were weighted (assignment weight). Both choices were measured on a 0-100 scale, with 0 = "no control", 50 = "some control", and 100 = "total control" serving as anchors. We measured information students' interpretation of their grading system's features by asking them how motivating it was for them to: 1) rank high on the leaderboard 2) earn house points, and 3) have flexible assignment options. The three options were measured on 1-5 Likert scale, with "very motivating" and "very unmotivating" serving as the endpoints. We operationalized the variables measuring students' perception of the affordances granted by each grading system on 1-5 Likert scale (see Table 2 for means and standard deviations of measured variables, and endnotes for survey items).

Variables	Political Theory (N = 268)	Information (N = 205)
<i>Grading System Feature</i>		
House points	--	3.3 (1.2)
Leaderboards	--	3.1 (1.2)
Flexible assignment options	--	3.8 (1.2)
Assignment choice*	80.5 (22.2)	--
Assignment weighting*	78.4 (24.2)	--
<i>Perception of Grading System Feature</i>		
Ease (1) [†]	3.5 (1.2)	3.2 (1.3)
Fairness (2)	4.0 (1.1)	3.7 (1.1)
Control over grade (3)	3.7 (1.2)	3.5 (1.3)
Regard for grading system (4)	3.8 (1.2)	3.4 (1.3)
<i>Result of engaging with Grading System</i>		
Exploration (5)	3.2 (1.2)	3.3 (1.2)
Control over learning (6)	3.9 (1.1)	3.6 (1.2)
Effort (7)	3.4 (1.1)	3.1 (1.2)
* = measured on a 0-100 scale; with 0 = "no control", 50 = "some control" and 100 = "total control" serving as anchors		
† = see endnotes for (1) - (7) for exact wordings of items.		

Table 2. Means and Standard Deviations of Measured Variables

Results

We used path analysis to better understand how assignment choice was associated with student effort, assignment exploration, and control over their learning (RQ1), and the direct and mediating roles of students' perceptions of grading system features (RQ2). Working hypotheses are examined and path analysis results are described below.

Introduction to Political Theory Course

Using Figure 2 as a guide (and reading from left to right) we can infer a strong direct relationship between assignment choice and assignment weighting, yet assignment weighting did not prove to play a further role in the rest of the path model, which suggests that once students chose their weights, they did not see the ability to make the choice as motivating them one way or another. Modest direct relationships between assignment choice, and grading system fairness and ease were found, which in turn were moderately predictive of overall regard for the grading system and control over final course grade. Regard for the grading system also predicted effort and control over learning, while control over course grade moderately predicted effort, exploration, and control over learning.

In short, students' ability to control their grade and their overall regard for the grading system were found to have positive direct and mediation relationships with adaptive student outcomes of effortful work, exploration of new assignment types, as well as how much control they felt over their overall learning.

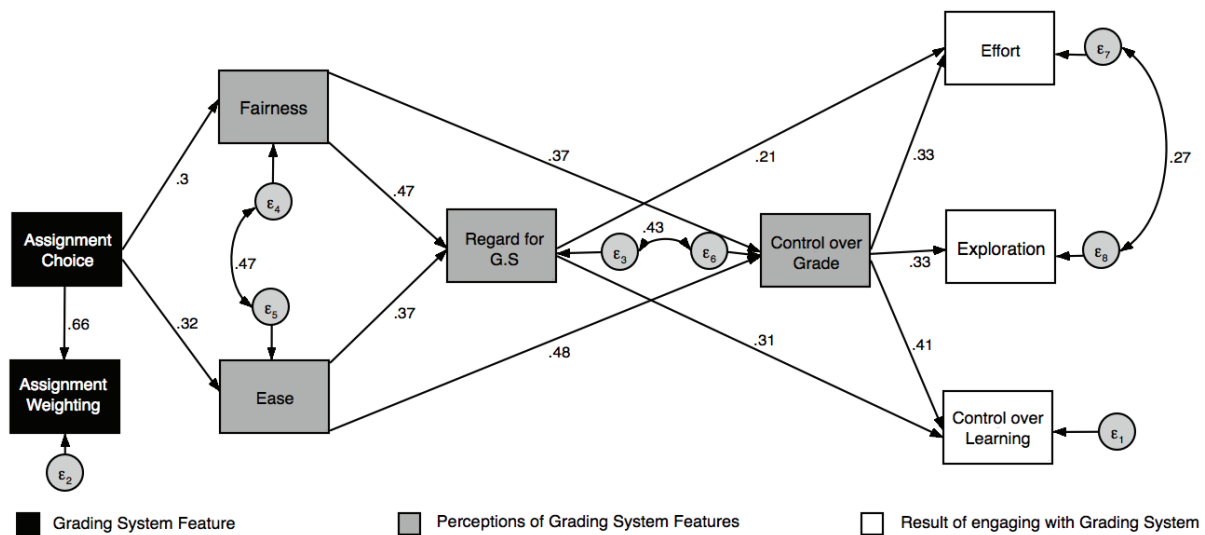


Figure 1: Path analysis for political theory course indicates good fit [$\chi^2(21, N = 268) = 57, p < .001, CFI = .97, RMSEA = .08, SRMR = .05$] and fit better than alternative models. All paths were statistically significant with $p < .01$.

Introduction to Information Studies Course

Using Figure 3 as a guide we can infer a positive and direct relationship between how motivating house points and leaderboards were in predicting how motivating assignment options were to students. House points and leaderboards were also positively correlated. This was in line with our expectations since both house points and leaderboards are course mechanics that relate to the course community. They did not, however, play a further role in the model. Moderate direct relationships between assignment options, ease, fairness, and regard for the grading system were found. This makes sense, given that students' choice of assignments was the primary gameful mechanic in the course, and would influence their regard for the grading system, as well as assessing its ease and fairness. Ease and fairness also moderately predicted control over grade, and regard for grading system. As with the political theory course, both regard for grading system and control over grade were positively related to the adaptive outcomes of effortful work, exploration of new assignment types, as well as how much control they felt over their overall learning.

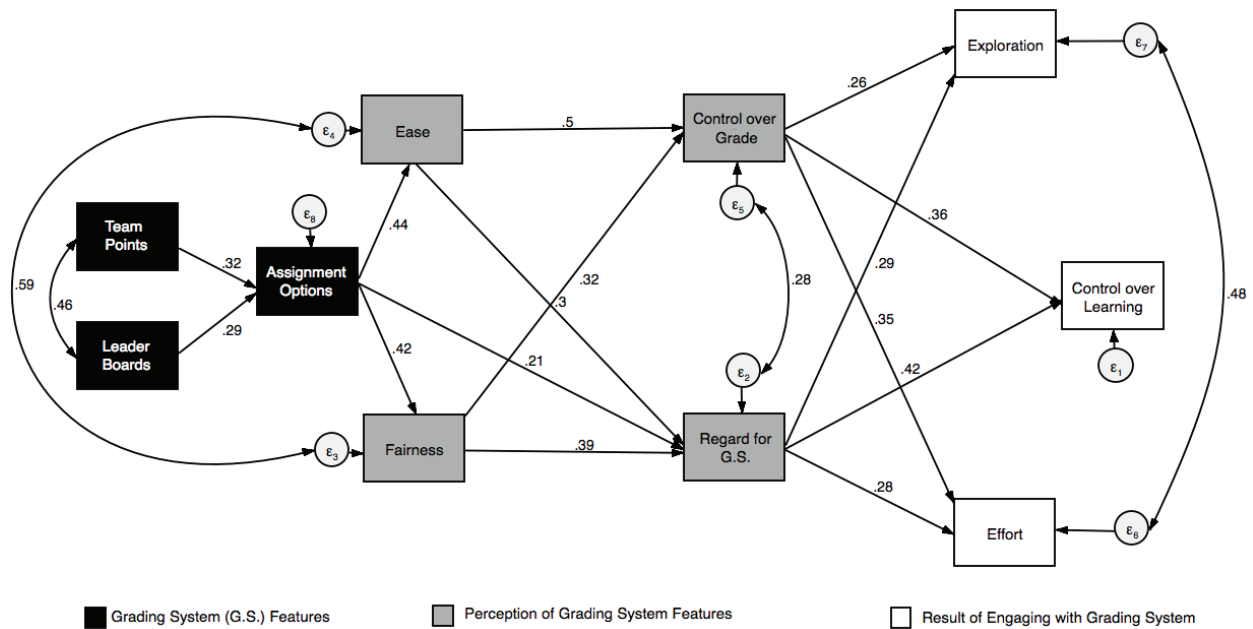


Figure 2. Path analysis for information course [$\chi^2(36, N = 205) = 62.2, p = .001, CFI = .97, RMSEA = .06, SRMR = .05$] and fit better than alternative models. All paths were statistically significant with $p < .01$.

Implications

The above analysis lends some support to working hypotheses one and four, which posit that the affordances of gameful grading systems lead to positive perceptions of the grading system themselves as well as predict adaptive student outcomes (i.e., students working harder and feeling in more control over the learning process). While each of the models are slightly different in their respective path structures, both show that gameful mechanics were positively predictive of students' assessment of various aspects of the course, which in turn predicted positive non-cognitive motivational outcomes. This was expected, since it seems likely that a well-designed course structure will lead to positive assessments of that structure, which in turn influences student engagement. It is important to note, however, that this is the first time *gameful* course structures have been analyzed in this way, so we interpret the fact that students reacted well to a consequential shift in the traditional—and near-ubiquitous—course structure (i.e., where 100% divided up between assignments and aggregated later on) as a positive sign.

Hypothesis two (the central role of assignment weighting) and three (the negative association of leaderboards to various student motivation measures and positive association of house points to outcomes of interest), were not supported. This is interesting, because we believed assignment weighting to be more central to the positive outcomes associated with gameful grading systems. We speculate that weights did not have the predicted effect because of the generally “static” nature of the assignment weighting mechanic; once students decided how their assignments would be weighted there was no need to further dwell on assignment weights. In this way the mechanic may be analogous to triggered videogame “events” (i.e., where an in-game event forces a player to make a decision that impacts the rest of the game), which are important in shaping the narrative arch, but subsequently less important once over.

Leaderboards were also a surprise—results indicated that they were a net *positive*. This is perhaps the case because students who participated in leaderboards adopted a performance-approach motivation orientation towards leaderboards, which may have enabled them to be driven by competition in a positive way. Research shows this approach to be a more adaptive form of the performance motivation construct (see Elliot, 2005 for a historical review of the achievement goal constructs). Indeed, further analysis may show that students with a more performance-avoid orientation to the course (i.e., students who did not wish to be seen as incompetent compared to their peers) may have opted out. This would further support the need for gameful systems to allow for student autonomy. As “players” in the course game, students are well suited to avoid engaging in the course in ways that would not motivate them.

Limitations and Further Study

While our results are promising, we understand that there are key limitations. First, there is a need for better baseline measures of student effort and motivation around *gameful* courses. While many measures exist, they

often presuppose the standard and ubiquitous course designs and do not take into account the peculiarity of gameful designs. So, there is a need for better measures that predict student's proclivity towards gamefulness.

As with much of this work, we are also limited by our context. This work represents an important step in exploring and comparing two gameful courses, but more contexts need to be examined. It is also important to use similar measures in "normal" courses to establish a baseline for how students may interpret our scales in more ubiquitous course settings. Overall, our evidence indicates that gameful courses can take many shapes, so long as they support student autonomy, competence, and a sense of belonging. Future designers of such courses are welcome to use either course as inspiration for their own course, or develop a hybrid course that uses elements from both. We do not assume, however, that these two courses represent all of the possibilities and opportunities for gameful course designs. There are many possible gameful designs each with multiple paths driven by similar goals.

Endnotes

- (1) "Compared with my other classes, it was much easier to earn the grade I wanted because of the grading system."
- (2) "I believe the grading system is fair to students."
- (3) "I have more control over my final course grade because of the grading system"
- (4) "I liked the grading system"
- (5) "The grading system encourages me to work on assignment types I would normally avoid."
- (6) "Compared with my other classes, the grading system gave me more control over my own learning."
- (7) "The grading system encourages me to work harder than I would in a different kind of grading system."

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Citizen Science in the Classroom: An Analysis of Teacher-Student Discourse

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Teacher roles in the learning environment

Just as video games for education function as *designed experiences* that affirm certain ways of acting (Squire, 2006), classroom environments also supply rules, values, and contexts that shape student learning experiences (Gaydos, 2013). Naturally, teachers play a significant role in the development of that context. They select and organize course content, develop in-class activities and other curricular elements, and they structure classroom discourse in order to emphasize certain points, perspectives, or pieces of information.

Teacher involvement can profoundly shape student learning experiences. Teacher-influenced elements of classroom context such as instructional quality, student-teacher relationship quality, and the socioemotional climate of the classroom have all been shown to have lasting effects on the development of student engagement and academic achievement (Dotterer & Lowe, 2011). Teacher-student relationships are also linked to student feelings of support and connectedness (Connell, 1990).

The conversational discourse in a designed classroom experience also plays a role in shaping students' learning experiences. Teachers can choose to employ varying degrees of authoritative (teacher-led and controlled) or dialogic (student-led and teacher facilitated) discourse styles to suit the needs of the students, the activity and the content (DeWitt & Hohenstein, 2010). The use of questions in teacher-student dialogue can serve a variety of functions and establish differing levels of teacher control as well (DeWitt & Hohenstein, 2009). Types and methods of teacher-student interaction vary by classroom and by teacher, and certain styles and methods of discourse can potentially support or fail to support academic performance (Applebee, Langer, Nystrand, & Gamoran, 2003).

As classroom learning interventions, educational video games are subject to the same contextual influences as other designed classroom experiences. However, video games for education show particular potential as tools for learning, particularly in domains of science, technology, engineering, and mathematics (National Research Council, 2011). The educational game *Citizen Science*, used in our research, is a potential foray into the development of games for learning.

Citizen Science

As both a video game and a classroom learning activity, *Citizen Science* was designed with principles of engagement (Gaydos & Squire, 2012) and playful learning (Squire, Barnett, Grant, & Higginbotham, 2004) in mind. *Citizen Science*, an educational adventure game, has been found to facilitate learning about issues in lake ecology and has been implemented in classrooms as both a stand-alone experience and as a curricular component (Gaydos, 2013). The game was designed with the intention that it could serve as a "springboard" that inspires students to develop interest in lake ecology content, both within the game and in supporting curricula (Squire, 2004), while prompting students to model active civic participation in the virtual Madison community (Gaydos, 2013).

In the game, players travel through time as the "steward" of the lake, collecting scientific evidence about the health of Lake Mendota in Madison, Wisconsin, and using it to formulate compelling arguments in support of environmentally beneficial practices. Players progress through the game narrative and unlock new evidence, areas of exploration, and other game components, with the overall goal of convincing non-player characters to make choices that benefit the lake, and helping to enact change that positively affects lake health over time. The game ends when the player has successfully completed each of the nine in-game arguments.

Previous research suggests that as a stand-alone intervention, *Citizen Science* can elicit player engagement and interest in in-game topics (Barany, Gaydos, & Squire, 2013). Establishing internal efficacy of the game as an intervention is an important step for assessment, yet a deeper scrutiny of how the game is situated in the classroom setting is a vital step toward making meaningful claims about the game's real-world efficacy (cf. Brown, Collins, & Duguid, 1989). This contextualized setting includes both the spatial environment and the physical and verbal interactions between students and educators. During its first exploratory phase, our research focuses on interactional elements of the classroom context.

Data Collection

A 7th grade teacher from a public middle school in rural Wisconsin implemented the game *Citizen Science* (accompanied by her own curriculum) in each of her six 45-minute life science classes over the span of a two-day unit. The *Citizen Science* unit served as one section of this teacher's larger ecology unit that spanned the several weeks before and after *Citizen Science*. 90 students from Mrs. Robertson's class, equipped with school-issued PC laptops, agreed to participate in the research. A visiting field researcher attended class during the *Citizen Science* unit, and used audio and video recording devices to capture student interactions with Mrs. Robertson, other students, teacher aides, and the field researcher. The video recorder was set up in the rear of the classroom in an attempt to capture a broad range of classroom interactions. The audio recorder was carried to various parts of the room to capture individual conversations with greater clarity. In addition, the visiting field researcher created personal field notes on classroom interactions, and obtained copies of classroom artifacts such as PowerPoint slides, student assignments, and student feedback cards. During class in the week following the *Citizen Science* unit, students completed an online, 15-item survey designed to measure student interest in in-game topics (Barany, Gaydos, & Squire, 2013).

Spoken interactions in the recorded video data were transcribed using simplified Jeffersonian standards (Jefferson, 2004). After the full transcription of a third of the data, researchers began preliminary analyses. Initially, transcription included detailed descriptions of physical movements and gestures. However, it quickly became clear that these descriptions were both overly detailed and potentially biasing; further preliminary investigation was necessary to establish which gestures and movements might be important before completing final analyses. A transcript is always a form of reduction - and distortion - of data (cf. Jordan & Henderson, 1995; Ochs, 1979). To remedy this issue, it was necessary to sync video data with the transcripts and conduct analysis simultaneously. The original transcripts were time stamped (the program F4 was used for transcription and the qualitative data analysis software MAXQDA 11 was used to store, organize and annotate the analytic results). This process linked video data and transcripts in the qualitative data analysis software. Preliminary analytic process of the video data involved repeated viewing of vignettes among the research team. Transcriptions served as a de-accelerated documentation of the spoken components of the data, while the videos themselves served as the primary source for interpretations of the interactions in the classroom.

Review of the video data quickly revealed that the video recording setup was not ideal to facilitate the fine-grained analyses of interactions planned in the analysis phase: the camera's angle was not wide enough to capture the length of the room, and transcription of the audio data necessitated significant effort to understand students farther away from the microphone. Further analysis will involve the reconstruction of interactional patterns within the fully transcribed data. The research team will then scan the rest of the video data for vignettes in which those patterns can be identified. Analyzing those will provide the research team with the chance to test, revise, and flesh out patterns while avoiding the complete transcription of exploratory data. The result of this preliminary study will consist of a set of initial observations, which will greatly support us in terms of pre-training for educators, researcher guidance in the field and data generation (e.g. interview questions, self-reflection exercises for educators). First outcomes are discussed in the last section of this proposal.

Outline of Analytic Strategy

Research goals for current and continuing analysis involve exploring how educators talk to students when they play *Citizen Science*: how teachers direct students and how they answer questions. By examining those interactions, we hope to learn how these practices frame the activity of 'playing *Citizen Science*', and how meaning is constructed in these situated practices. In short, current research, as well as the continuation of this research, will be an exploratory study that focuses on interactions.

According to Garfinkel, "[t]o recognize *what* is said *means* to recognize how a person is speaking" (1967, p. 30, emphasis i.o.). Following this prerogative, the research team began (and will continue) analyses by looking at linguistic phenomena in the data. While a variety of analytic tools borrowed from Conversation Analysis as analytic heuristics will be used (cf. Gee, 2010), the goal is to uncover underlying narratives and world-views constructed by participants in and through interaction. However, the research team approached data in a mindset closely related to Conversation Analysis: after all, we want to "elucidate and describe the structure of a coherent, naturally bounded phenomenon or domain of phenomena in interaction, how it is organized, and the practices by which it is produced" (Schegloff, 1987, p.101). Conversation Analysis is guided by an open mindset of *noticing* (Clayman & Gill, 2012) and a focus on describing the mechanisms that structure actions. Given the study's focus on how classroom interaction works, this approach seemed appropriate for this exploratory study.

During analysis, groups of two to three team members sat together and described the data in detail, word by word. Part of this initial process also involved the segmentation of transcriptions into stanzas (Gee, 2010), which supports the identification of possible patterns, specifically in the one-on-one interactions between teachers and students. The strategic goal is, in accordance to Gee's approach to Discourse Analysis, to discover "the situation-specific or situated meanings of forms used in specific contexts of use" (2010, p. 64).

During analysis sessions, the team took notes, which were later fleshed out and attached as memos to the respective data in the qualitative data analysis software. Throughout this process, we made sure to constantly ground emerging patterns in our data, and in concrete linguistic phenomena. By systematically comparing and contrasting these analytic memos, we identified and refined conceptual patterns emerging from the data (cf. Charmaz, 2006). These patterns later served as codes that we applied both to our data and the memos, thus creating a searchable index of emerging themes. This enabled us to further refine, crosscheck, and revise our analyses.

In short, the epistemological foundation of our analysis is ethnomethodological (Garfinkel, 1967; Cicourel, 1974), in such that we focus on distinctively language-based features in order to unveil how individuals do things with language, and how they indicate and negotiate meaning. The research team paid close attention to the ethno-methods displayed in the data; the goal is to scrutinize these indexical practices in order to reconstruct homologous patterns (Mannheim, 1993; Mannheim, 1952) of meaning making - which in turn provide insights in the concepts of the performed actions and enacted identities. Within this process, we utilized heuristics based upon findings from Conversation Analysis (Schegloff, 1987; C. Goodwin, 1979), specifically findings concerning direction-giving (Goodwin, 2006) and classroom interaction (e.g. Seedhouse, 2004; Seedhouse, 2005). Thus, techniques of analysis, documentation and self-reflection resemble memoing and coding techniques as utilized in the paradigm of Constructivist Grounded Theory (Charmaz, 2006), and the analytic stance taken in approaches falling under the paradigm of Discourse Analysis (Rymes 2009; Bloome et al 2008).

Tentative Findings

Tentative findings suggest that the way in which teachers talk about the playful activity might impact the success of implementation. The way the teacher conceptualizes the game and the activities afforded by the playful learning environment may impact the efficacy of the game as an educational intervention. Lexical choice is an important element of distinguishing between conceptual worlds (cf. Gee, 2010). For instance, analysis revealed that the teacher regularly uses vocabulary that the team identified as 'instructionist' (see Vignette 1).

- 1 Student 2: what do i do?
- 2 Teacher: well honey you've gotta READ a little bit
- 3 S2: ok well (unintelligible)
- 4 T: ok so collect the secchi disk readings so here's the secchi disk right
- 5 here. oh now those things pop up and you DO the readings. [click right,
- 6 ok great] you've done em already?
- 7 S2: yeah
- 8 S2: yeah

Vignette 1: Doing the readings

At first, the teacher suggests *reading* as an activity that solves the student's proposed problem: the student does not know what s/he should do, therefore s/he should read. This is followed up by a concrete description of what the student needs to do in the game (4). Then, the teacher stresses to "DO the readings" (5); a game element that provides players with building blocks for arguments is named "readings" by the educator. Text such as this in the game could be referred to as "hints", "arguments", "what people have to say"; i.e. it could be connected to the domain of the playful activity. "Readings", in our opinion, refers to the realm of instruction; to a realm for which games for learning are trying to function as an alternative.⁽¹⁾ We suggest that lexical choices such as in vignette 1 might re-ground a playful activity in a traditional setting of learning and assessment. Put bluntly, *Citizen Science* is designed to imbue the traditional classroom setting with playfulness (Gaydos, 2013); however, analysis of lexical choices suggests that, to some extent, an instructionist classroom setting may instead permeate the playful

elements of the game. At this point in analysis, the research team only examined the video data, but we will explore this element further when we integrate findings from our ethnographic field notes.

Another finding of our analyses concerns the way the term “learning” is used by the educator when students have questions about the game. The research team noticed that the word is used by the educator to describe, justify and explain the activity at hand. We started to de-indexicalize this expression by compiling and comparing vignettes in which the term is used. The team also noticed that ‘learning’ is often introduced as a remedy when students are stuck with the game; “learning” is conceptualized in the interactions as something that happens within concrete moments or within temporal boundaries (and oftentimes as a future event) (See Vignette 2).

- 1 Student 4: what IS this thing?
- 2 Teacher: OH that’s a GREAT question y-know what, do you have your document
- 3 up?
- 4 S4: yeah
- 5 T: put your-pu-get your DOCUMENT up and go down to where it says vocabulary
- 6 and write that word euTROphic in there, ok, good job. and then when we get to
- 7 START LEARNing, you might be able to go in [for] inforMATion ok, excellent,
- 8 perfect
- 9 (2.5 sec)
- 10 T: and i’m gonna let YOU figure it out, because they’re gonna TELL you through
- 11 gathering the EVidence and LEARNing, ok
- 12 S4: ok

Vignette 2: Learning

Here the teacher provides the term “learning” as a solution to the student’s proposed problem: The educator essentially says that learning will happen (6; 11) - and when it happens, the student will know the answer to the question. The student does not know the meaning of a word; the educator suggests that at a later point, *within* a process of learning (6) and *through reception* of learning (10f), the student will be able to discover the meaning of the unknown word.

The use of ‘learning’ in this vignette also illustrates how the teacher conceptualizes the tool *Citizen Science*. The educator says that “they” (i.e. the characters in the game) will provide a definition for the unknown word: on one hand by providing evidence and on the other hand by providing ‘learning’. In terms of agency (Emirbayer, & Mische, 1998), this frames the student as a recipient of learning, as opposed to being an agent in learning (such as in line 8). It is not our intent to point out that the educator is using ‘faulty’ language in any way. However, we believe that careful analyses of how certain central terms are perpetually used in classroom interaction can help us to provide researchers and educators with hints for implementing video games and other playful activities more successfully in the classroom.

Initial Consequences and Suggestions

Citizen Science was designed to promote engagement and learning when “embedded and supported by classroom curriculum” (Gaydos, 2013, p. 36). We suggest that putting the playful, experience-driven activity into a semantic (and thus conceptual) framework of instructionism may inhibit students’ playful engagement with the activity. This will have to be taken to the test in our subsequent study of *Citizen Science*. In our next round of data generation, we also will have telemetric play data available via the ADAGE framework (Halverson & Owen, 2013). With this data, we hope to be able to track whether certain conceptualizations - such as the ones shown above - impact the ways in which students use the game.

Analyses also suggest that it may be fruitful to interview both educators and learners concerning their conceptualization of central terms, such as “learning”. This will provide further insight into the life worlds of the

people who actually use the tool – since, after all, the tool will be situated within their conceptual framework. Based on our ongoing exploration of the data, we will be able to share question guides for semi-structured qualitative interviews and group discussions at the GLS conference.

Our work so far has raised the question of how we can prepare future educators and researchers to optimally communicate about the game and game-related activities. Specifically, it may be beneficial to have conversations with educators concerning the terms and metaphors used when talking about a genuinely playful activity. Based upon these ongoing analyses, we plan to design a series of intervention techniques and self-reflection tools that educators can use prior to the implementation of games such as *Citizen Science*, and information regarding the development of these intervention techniques will also be discussed.

Endnotes

(1) When we returned to this specific piece of data after the peer review process, we realized that our reading of “doing readings” is not as one-dimensional as we suggest in this version of the paper. In fact, the term “reading” is also a professional term used in the game: a reading from a scientific measurement device, the secci disk. While our data still supports the idea that “to read” is introduced with an instructional connotation, it is crucial to note that the teacher later connects the game experience (i.e., collecting and analyzing scientific data) with a professional term – a term that learners may know from the realm of their life world in school. Through referring to the experience of professional vision afforded by the game, the teacher supports the expansion of this term’s meaning into a new, scientific-professional realm. This forcefully reminded us to not overlook the realm of the game while doing analyses of audible interaction in the classroom.

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Learning, Play, and Identity in Gendered Lego Franchises

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Introduction

Lego is among the largest toy companies in the world. Its products are profoundly influential in the lives of millions of children. In press releases and marketing materials, Lego has positioned itself as a guardian of children's creative cultures and a sponsor of children's abilities to develop cognitively and socially (Nipper, 2012). In lockstep with its consumer base, Lego has shifted from marketing language focused on "skill and assembly" to language focused on "creativity and originality" in the last two decades (Lauwaert, 2008; Carrington, 2013). The creative, open-ended, and child-driven aspect of Lego toys and media is crucial for understanding the full scope of play and learning afforded by the brand, and it is one that the authors respect, value, and often study. However, because Lego permeates the home and school lives of many young children who are actively developing cultural models associated with constructs such as gender, race, and social class, it is also crucial to attend to the brand-driven cultural practices and forms of play that are embedded in Lego products through the company's processes of designing, manufacturing, and marketing.

In this paper, we use a mixed methods approach to compare the multimodal "building blocks" of play provided by the Lego Friends franchise, which is primarily aimed at female audiences, and several other Lego series that are marketed to similar-age male audiences. Using both quantitative and qualitative analyses, we examine if and how certain configurations of play and gendered-discourses may be privileged through what Johnson (2013) calls "preferred constructions... for which the company literally provide[s] instruction manuals and feature[s] in packaging and promotional imagery" (p. 2-3). We also focus on the constellation of digital artifacts (i.e., video games, videos) that give narrative structure to these preferred configurations of play.

Lego has attempted to cultivate a girls-only market for the last three decades. The Friends product range replaces Lego's previous female-consumer-oriented theme Lego Belville, which was in production from 1994-2009, and featured minifigs (that is, miniature figurines) that were morphologically more similar to humans than the traditional boxy figure included with other sets. Other female-oriented Lego product lines have included Homemaker (1971-1982), Paradisa (1991-1997) and Scala (1997-2001). Interestingly, in the 1980s, The Lego Group was lauded for using both girls and boys in marketing materials, with ads that seemingly positioned their products as gender neutral. However, more recently the company's marketing strategy has shifted to focus on portions of the children's market instead of children as a whole. As a case in point, the Friends line, released in 2012, represented the culmination of four years of market research on "the way girls naturally build and play" (Lego.com, 2014). The line is focused on a group of primarily female friends in a suburban environment called Heartlake City. Marketing materials for the line feature females, and the overarching product narrative centers on five core female mini-doll characters that, with their human-like figures, differ significantly from the traditional, blocky minifig.

Lego City, like Lego Friends, is focused on human characters performing tasks in an urban life setting and is therefore more closely aligned with the Lego Friends theme than Lego's specialty (i.e., Ninjago, Legends of Chima) and branded (i.e., Star Wars) lines. An offshoot of Lego Town, Lego City features male-dominated marketing materials, bricksets, games, and videos. Only six of the 38 Lego City minifigs released in 2013 are female. As such, in a qualitative comparison of gendered Lego franchises, Lego City offers an apt foil for Lego Friends. However, a direct quantitative comparison between Lego Friends and Lego City is made difficult by the fact that they are marketed to slightly different age groups, with Friends sets being marketed to children approximately a year older than the target audience of Lego City. Nevertheless, since many other Lego series are marketed to males as well, including several for the same age range as Lego Friends (e.g., Teenage Mutant Ninja Turtles, Super Heroes, and Castle), a direct comparison between Lego Friends and those other sets was suitable for our numerical analyses.

Theoretical Framework and Related Literature

In a detailed exploration of the "geographies of play" associated with the toys and digital cultures surrounding brands such as Lego and SimCity, Lauwaert (2009) describes "facilitated play practices." In this construct, "facilitated" refers to the idea that certain configurations of play are made easier and promoted by the design of a toy and its associated discourses. Lauwaert suggests that "[t]he structure of a toy, its technological specificities, its materiality, the rules and manuals, examples and guidelines, its 'reputation' and connotations create a network of facilitated

play practices. Both the material and immaterial aspects of a toy or computer game create a window of opportunities within whose boundaries the players can act” (2009, p. 12-13). Although Lauwaert rightly acknowledges that “there is no one essential use that can be deduced from the artifact itself” (Oudshoorn & Pinch qtd. in Lauwaert, p. 13), the author’s analysis supports the notion that product design and marketing can create a dominant discourse and core set of play practices for a particular toy.

Practices connected to play allow young people to build literate identities and early repertoires of social roles and interaction in relation to valued artifacts (virtual and material) and within the culture of their everyday lives. In their object ethnography of Legos, Carrington and Dowdall (2013) remind us that children’s play and social worlds – and concomitantly, spaces for making and marking identities – are increasingly linked to global brands and globalized franchises, such as Lego, Mattel, Nintendo, and Apple. In turn, these brands may “shape the contexts in which young people build repertoires of practice and a sense of themselves” as literate and cultural beings (Carrington and Dowdall, 2013, p. 97).

Sociocultural studies of literacy, identity, and play in early childhood (Marsh, 2000; Wohlwend, 2009; 2012) have analyzed artifacts and practices of children’s play worlds, increasingly mediated through global franchises and converging new technologies. For instance, Carrington (2003), Wohlwend (2012), and Black et al. (2013) analyze toys and their digital counterparts as identity texts that open, close, and invite certain ways for children to see themselves, e.g. as “doing boy” or “doing girl”. Specifically focusing on gendered expectations, both Wohlwend (2012) and Black et al. (2013) posit design of commercial products geared for children’s consumption and play as having built in “anticipated identities” that are embedded in the design of toys such as Disney Princesses and Barbie. These anticipated identities, akin to Lauwaert’s notion of facilitated play practices, are further indexed through the narratives of associated multimodal texts, such as books, songs, movies, games, and virtual worlds.

Research has demonstrated that the anticipated identities and facilitated play practices of similar products and games (Cassell & Jenkins, 2000) for girls and boys can differ significantly. For example, drawing on these notions, Black, et al. (2013) analyzed two Mattel-produced virtual worlds, one marketed for girls and one for boys. Although the two worlds were structurally and functionally similar to each other, they offered markedly divergent literacy and identity resources to their participants. The texts, games, tools, narratives, and character roles within the worlds positioned boys as knowers, scientists, and agents while “anticipating” girl players to be more passive consumers of media within the site itself and in the real world. Moreover, a quantitative readability analysis of the site texts revealed a reading level of approximately second grade for the girls and over ninth grade for the boys, despite these sites having the same target age group of 6 and up.

To understand if this sort of pattern persists in the Lego universe, we draw from a sociocultural framework to explore how socialization through the dominant narratives, anticipated identities, and facilitated play practices of the Lego Friends and Lego City franchises might influence young children’s conceptions of the social roles and cultural practices available to and expected of them. We do this by asking the following research questions: 1) What are the facilitated play practices of the Lego Friends and the Lego City franchises? 2) How do these practices compare in terms of difficulty? and 3) What are the anticipated identities associated with these preferred play practices?

Methods and Data

The bricksets themselves are the cornerstone around which the Lego franchises are built. Therefore, we began with a series of quantitative analyses to explore whether the Lego Friends bricksets are comparable (in terms of difficulty) to other products marketed to males of the same age group. We conducted two main analyses, one to establish a viable metric for age appropriateness, and one to examine gender differences across sets. In the first analysis, we evaluated the usefulness of set complexity as a metric for age appropriateness. Changizi et al. (2002) assert that the relationship between unique pieces and total pieces in a set may be used as an indicator of the complexity of that set. Therefore, when we commenced this analysis, we selected U/T (unique pieces over total pieces) as our indicator of complexity. In the first analysis, dealing with the relationship between complexity and age appropriateness, we compared 42 sets released in 2013 with between 300-500 pieces and for which brickset.com had data on the number of unique pieces in that set. In the second analysis, dealing with gender differences, we used all Lego Friends sets released in 2013 that were listed as “Ages 6-12”, and for which brickset.com had data on the number of unique pieces, and all other non-Friends sets that met those same conditions (2013, “Ages 6-12”, and availability of data on unique piece count) within the same piece range (160-500). There were five Friends sets and fourteen non-Friends sets in those groups (from the Teenage Mutant Ninja Turtles, Super Heroes, and Castle series).

To confirm that the sets used in this second analysis were targeted at a particular gender, we examined the marketing materials and content of the sets with an eye to gender representation. Lego Friends commercials show only female children, while the male-focused lines feature young boys and men. The Friends minifigs have a ratio of 24:3 female to male. Conversely, of nineteen Teenage Mutant Ninja Turtles minifigs released in 2013 with specified genders, eighteen are male. The one female character is an office assistant. In 2014 this series is introducing a second female character: a villain named Karai. Of 38 minifigs in the 2013 Super Heroes product line, all but four are male. Of the four females, none is a super hero; two are supporting characters, and two are villains. And of the eighteen minifigs in the Castle series, only one is female (a princess).

For the qualitative component of our analysis, we used content and discourse analytic methods to analyze comparable Lego Friends and Lego City sets and associated marketing materials to understand the configurations of play and anticipated identities (Wohlwend, 2009) that these products invite children to engage with. For example, the Lego Friends Water Scooter Fun and Lego City Surfer Rescue sets are comparable because both have a target age range of 5-12, include roughly the same number of pieces (32/28 pieces respectively), and are similar in terms of the focal components of activity. However, analysis of the accessories, aesthetics, and marketing materials for these particular two sets reveals marked differences between the facilitated play practices and discourses embedded in these artifacts. An inductive coding process was used to identify the specific discourses that were explicitly or implicitly referenced in relation to the sets. To illustrate, the code for a discourse of danger was developed to identify any reference to the presence of dangerous objects, threat of injury (from setting, situation), and/or any references to urgency to avoid harm or injury. The code of friendship was developed to identify any reference to talking, interacting, or spending time with others for enjoyment or leisure (as opposed to for work or other functional purposes).

Qualitative analysis also focused on fieldnotes and an observation protocol for the seven existing Lego Friends video games and seven Lego City video games. The thematic foci of the games were so distinct that we were unable to select comparable games but instead focused on all available Friends games and the first seven City games listed on Lego.com (which included the most recently-released games). The game observation protocols were focused on identifying the goal, difficulty level, reward structure, how players are positioned in the game, and the discourses indexed by the game.

Analysis

Construction Play

In creating a new Lego franchise specifically oriented toward female children, Mads Nipper, the VP of Marketing for Lego Group, explains that the group was motivated to have more children access and reap the “positive benefits of the construction play pattern” (Nipper, 2012, para 1). Therefore, our initial analyses focused on the construction play opportunities offered by the bricksets.

Our first analysis explored the usefulness of the ratio between unique pieces and total pieces in a set (U/T ratio) as an indicator for age appropriateness. Our initial hypothesis was that sets with higher U/T ratios are more complex (Changizi, 2002), and therefore more appropriate for older children. However, our results revealed that the average U/T ratio fell substantially over the age range, from 0.43 and 0.39 for 5 and 6 year olds to 0.19 and 0.11 for 10 and 12 year olds. Put another way, across all 300-500 pieces sets, there was an average of over 150 unique types of piece in each of the sixteen sets for 5 and 6 year olds, down to an average of 83 in each of the four sets for 10 year olds, and just 39 unique types of piece in the one set for 12 year olds. Sets for 7, 8, and 9 year olds fell between these extremes. These results suggest that our initial hypothesis was precisely wrong, at least if the Lego age ranges are correct (and the authors’ anecdotal experience supports the appropriateness of the Lego age ranges). Instead, our study found that sets with a low U/T ratio (that is, sets with fewer unique pieces) tended to be more appropriate for more developmentally advanced children.

Based on this finding, we then moved on to a second analysis, examining the U/T ratio across a range of Friends and non-Friends sets. Our results revealed that Friends sets tended to have lower U/T ratios than non-Friends sets (see Figure 1). That is, holding total number of pieces constant, Friends sets have fewer unique types of pieces than non-Friends sets.

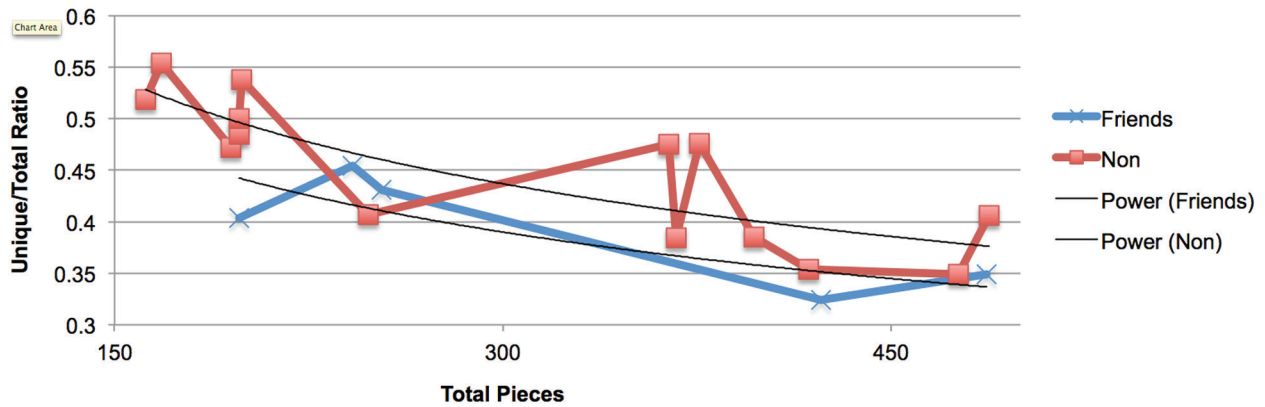


Figure 1: Across 160-500 piece sets, Lego Friends tends to have fewer unique pieces per set than other Lego product lines.

Connecting these results with the previous analysis, which suggests that lower U/T ratios correlate with older age groups, these results suggest that Friends sets are at a more developmentally advanced level than non-Friends sets. These results offer some evidence that, in terms of the complexity of their products, Lego is not systematically disenfranchising girls, and possibly even treating them as more advanced than boys.

Comparing these results with the findings of Black et al. (2013), which found that Mattel’s Barbie Girls online world was at a much lower reading level than another contemporary online product for boys (Xtractaurs), we offer that, while the gender roles embodied in their products may be problematic, Lego does not treat girls as less advanced than boys in terms of the core assembly activity of the sets, and in fact may treat them as more advanced. Taken together, the qualitative and quantitative results of this study point to the multiple levels at which a product may affect its users, not all of which may be consistent.

Play Construction

Qualitative analyses focused on five comparable Lego Friends and Lego city bricksets and their associated print marketing materials revealed strong similarities and differences between the product lines. The most prominent discourses indexed in the sets are illustrated in the following table.

	Adventure	Physical Activity	Friendship	Leisure	Work	Exploration	Danger	Rescue
Friends	3	3	5	4	1	2	0	0
City	5	4	0	1	4	1	3	3

Table 1: Prevalent Discourses in Lego Friends and City Sets.

The parity across the sets in terms of discourses of adventure and physical activity was an unexpected finding for the researchers, as discourses of exploration and adventure are often the purview of boys-only narratives (Jenkins, 2000, Black et al., 2013). Perhaps the most striking distinction between the sample sets is the overrepresentation of leisure pursuits in the Friends sample. All physical activity in the line is focused on activities such as biking, swimming, and surfing, while much of the physical activity in the City product line is related to work, and more specifically, work that involves rescuing people in danger. The single work-related Friends set, Emma’s Lifeguard Post, positions Emma (or the user) as someone who makes decisions about what flag to put up to indicate water safety but does not offer the female lifeguard or user the opportunity to take on the social role of a rescuer. Another noteworthy distinction was the prevalence of discourses of friendship and companionship in the Friends line and the lack thereof in the City sets. For example, for the Friends mini-dolls, car rides in the country and scooter rides in the ocean include the companionship of a cuddly cat or friendly dolphin, whereas the City mini-figs ride solo in their race cars or are pitted against a shark to rescue a surfer in trouble.

Analysis of the Lego Friends video games yielded similar findings to analysis of the sets, but with some noteworthy distinctions. Once again, discourses of leisure and friendship dominated the Friends games, while work and coming-to-the-rescue were prevalent themes in Lego City. Players of the Friends games were able to take on the roles of pet and beauty salon employee, hostess in a cafe, party planner, horse groomer, and person trying to emulate a friend's clothing choices. Lego City players were able to take on the roles of fire fighters, police officers, coast guard officers, race car drivers, and miners. Interestingly, many of the Friends games did not provide an explicit means of leveling-up but instead allowed players to continue playing at the same level with a slightly different configuration (e.g., groom a different pet, dress like a different friend). The reward for reaching the end goal of the Friends games was explicit affirmation and celebration (e.g., friends cheering, laudatory messages, balloons and confetti). Almost all of the City games listed explicit goals that players needed to accomplish to reach the next level and unlock a different vehicle or ability. The reward for accomplishments was generally a trophy or star.

Discussion and Conclusion

When the Friends line was released, the brand quickly garnered strong proponents and detractors in the online community, with some praising Lego's promotion of "good role models for girls" (Common Sense Media, 2014), and others damning the sets as "a pink and purple, gender segregated, suburban wasteland populated by Barbie/Bratz style dolls" (Feminist Frequency, 2012). These responses to the brand are illustrative of a long-standing conversation about the ways gender stereotyping permeates the material and media artifacts of children's play (i.e., Black et al., 2012; Cassell & Jenkins, 2000; Carrington, 2003; Wohlwend, 2009). Interestingly, our analysis for this paper serves to both temper and confirm the conflicting responses to the Friends franchise. On the one hand, the games and sets we analyzed emphasize friendship, exploration and adventure, and physical activity, with the latter two representing what are stereotypically thought of as part of "boys" play. On the other hand, the games and sets reify other feminine stereotypes, such as the ornamental, social, and dependent female.

The problems with these limited representations of females is perhaps best captured in a letter to Lego by a seven year-old girl named Charlotte Benjamin that went viral in February 2014. In her letter, Charlotte complains that women in the Lego sets only "sit at home, go to bed, and shop, and they have no jobs" (Examiner.com, 2014). She goes on to point out that "the boys went on adventures, worked, saved people, and had jobs, even swam with sharks" (Examiner.com, 2014). Clearly, in spite of Lego's avowals of exhaustive market research on "the way girls naturally build and play" (Lego.com, 2014), they have missed some of their target audience. The Friends line will allow Charlotte to engage in the same complex building practices as boys that are using Lego City and other male-focused lines, but as it stands, the line will not completely satisfy her desire to move beyond gendered social roles.

At the close of her letter, Charlotte makes a simple request. She asks Lego to "make more girl people and let them go on adventures and have fun...okay!?" We would extend this request to include a broadening of the social roles and discourses that are indexed by the preferred configurations of play in Lego sets for both girls and boys. If a house catches fire in Heartlake City, the residents are completely reliant on the Lego City characters to come extinguish it. Moreover, due to the changes in the Friends mini-doll physique, a Heartlake resident could not even sit securely in a borrowed Lego City fire truck to put out a fire (traditional Lego mini-figs have two holes on their backside that allows them to lock into the bricks that serve as seats for vehicles, but the mini-dolls do not). Heartlake City needs its own suite of municipal service sets to offer young female players the opportunity to explore a broader range of social roles. They could also throw a few sharks (or alligators) into the calm waters of Heart Lake. Similarly, why not include the sort of cooking, gardening, and homemaking options that characterize the Friends sets in Lego City?

Imaginative play offers children their first opportunities to envision and learn about the sort of professionals, parents, and people that they might end up being. Lego has a long history of supporting innovative opportunities for learning; thus, we encourage them to consider the findings in this paper and use their unique position in society to create these opportunities for both boys and girls as equitably as possible. In addition, next steps for this project should include an ethnographic account of how young children actually engage with material and virtual Lego products and how they may take up and/or transform the facilitated play practices of the different sets.

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It's Better to Talk With Honey Than Vinegar: Insights Into Collaborative Learning Within Mobile AR Games

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Introduction

According to the National Research Council [(NRC), 2012a], the ability to collaboratively solve problems is of the utmost importance in scientific careers. According to K-12 science framework authored by the NRC (2012a), “science is fundamentally a social enterprise, and scientific knowledge advances through collaboration and in the context of a social system with well-developed norms” (p. 27). The job prospects in science and technology are growing (Lockard & Wolf, 2012). However, our students are underprepared for the job requirements because these collaborative scientific practices are not cultivated in the majority of U.S. schools; when we do not prepare our students adequately for the workplace, then our national prosperity suffers (NRC, 2012b). To make the US globally competitive in science and technology, students need to be engaged with science education, build a suite of scientific practices, and learn to collaborate successfully.

Research on collaborative educational games has shown that gameplay positively impacts the development of collaboration skills (Sánchez & Olivares, 2011) and player’s perceptions of their social interactions (Mansour & El-Said, 2009). Specifically, students enjoy playing collaboratively because it encourages discussion amongst players (Sharritt, 2008). The sociocultural learning that takes place within the game works best when there is shared power and authority through scripted collaboration (Demetriadis, Tsiatsos, & Karakostas, 2012).

Within mobile learning science games, researchers have found that interdependent roles are an effective way to scaffold collaborative problem solving (Dunleavy, Dede, & Mitchell, 2009; Squire & Jan, 2007). By incorporating such interdependency, collaborative mobile augmented reality (AR) games rely on the social interactions amongst players as a key to the overall success of the games. As summarized by Klopfer (2008), students playing collaborative mobile learning games “help each other, observe each other, and act together to create communities as they learn to solve problems” (p. 223). Overall, research indicates that collaborative mobile games hold promise for promoting effective collaborative scientific practice by scaffolding and supporting discourse during gameplay.

This study investigated not only the scientific practices and collaborative responses of those playing a mobile AR game but also of those participating in a similar non-game-based activity. Specifically, this study assessed the collaborative practice and discourse of student teams during both the experimental game activity and the control lab activity. These questions guided the investigation:

1. How do communication responses within game teams compare to those within control teams?
2. How do scientific practices of game teams compare to those of control teams?
3. How else are treatment groups different when conversations are analyzed at the team level?

Methodology

Since the research questions stem from understanding the differences in the social process of learning within teams from different treatment groups, case study research was chosen as the analysis method (Yin, 2014). Specifically, a descriptive multiple case study approach was chosen with student teams as the unit of analysis (Miles & Huberman, 1994). Audio transcripts, photographic evidence, student reports, and field notes were compiled for within-case and cross-case analysis.

Participants were eighth grade science students from a middle school in Pennsylvania, USA. The school was located in a diverse, urban area with many low-income households. The district approved both the game and control activity as accepted curricula. Two teachers participated and taught several class periods including some control classes and other experimental classes. Since both conditions required collaborative groups, students were randomly assigned to teams consisting of three to four students. The process of selecting teams as case studies was purposeful random sampling (Patton, 2002). Since the school district used standardized math scores to track students into classes of above average, average, and below average math achievement, those categories were chosen to represent the continuum of achievement. In order to identify important common and contrasting patterns, teams were purposefully selected in order to achieve this continuum of achievement levels along with representation from both treatment groups (experiment and control). One team was randomly selected to satisfy

each category for a total of six case studies.

The intervention started on September 23, 2013 and concluded on September 27, 2013. During the entire intervention, selected teams were audio recorded as well as documented with photographs and field notes. Onsite researchers took photographs to document student interactions on all implementation days. Field notes included observations of each period along with informal interviews with the teachers. In the control cases, two audio recording devices were placed in the center of the table and recorded audio data for each class period. In the experimental cases, recordings were conducted at the individual level; every participant on the team wore a lapel microphone attached to a small digital audio recording device placed inside a pocket. To ensure high-fidelity of the qualitative data, all collaborative discourse was transcribed to clearly delineate conversational turn-taking. Transcripts then went through two separate levels of coding. The first level was a priori based on the literature review, while the second was emergent coding based on close reading of the transcripts.

Overview of Treatment Conditions

The experiment was a mobile augmented reality game played on iPads using quick-response codes (QR codes) located throughout the school (see Figure 1). The control was a 'tried and true' hands-on lab experiment where students had to determine the components of a mystery powder by testing three known powders (cornstarch, baking soda, and sugar) with iodine, pH paper, vinegar, and heat. During both activities, students developed hypotheses, learned about acids and bases, and conducted basic physical and chemical tests to analyze data and determine the mystery powder.



Figure 1: Game team arriving to scan a QR code.

Control: Group Lab Activity

The control activity for this study was the mystery powder lab activity, a pre-existing curriculum unit in the district. Conducted early in the 8th grade school year over the course of three to five days, the activity exposes students to basic scientific practices and some content about acids and bases. With the teachers and the principal, the researcher selected this activity as the control for several reasons:

- Students engage in scientific practices described by the National Research Council (2012a).
- It is implemented as a collaborative scientific investigation with small groups of students.
- It has the element of mystery.
- It has already been taught for at least one school year.
- The content lends itself to game-based learning.

Experiment: Collaborative Mobile AR Game

Using the mystery powder lab as the starting point for the design, the content from the lab was transformed into a mobile AR game. As students moved throughout their school building, they encountered QR codes that they scanned to access game information. This included conversing with virtual characters and gaining evidence to keep in inventory. Players were also required to talk to real people in the building to get additional game information. Players also deciphered a code and typed in the answer manually to the decoder. The game was played in teams of three or four where each student had a unique role: social networker, techie, photographer, or pyro-technician. Based on their role, they were provided with different pieces of information as they progressed through the game. The roles were designed interdependently; thus, to solve the mystery, players had to share information and work together.

In the game narrative, someone stole money from the cafeteria cash register and left behind a mysterious white powder. The game took place as five chapters, roughly aligning to one chapter per class period. Chapter #1: Students were introduced to the incident and the main characters. They visited the cafeteria to explore the crime scene and then several more locations to discuss the incident with the three main suspects: the janitor, the secretary, and a fictional fellow student. Chapter #2: Students visited areas of the school where the suspects left evidence. At each location, they found evidence of the known powders and conducted some simple, virtual tests including vinegar, iodine, heat, and pH tests. Content knowledge and test results were all conveyed using pictures and videos during gameplay. Chapter #3: A sample of a real mystery powder was provided for testing. Facilitated by some teacher instruction and assistance, game teams conducted tests on an actual powder (see Figure 2). Instructional prompts were provided by a main character from the game.

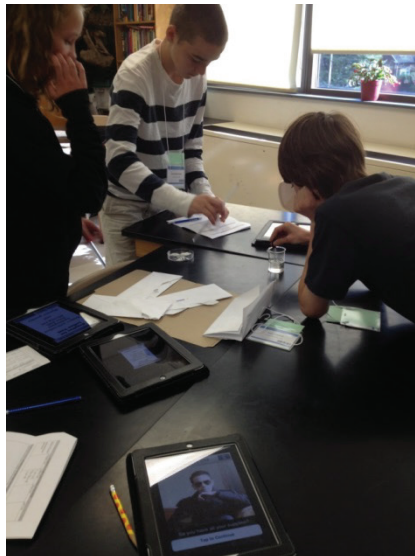


Figure 2: Mobile AR game team conducting hands-on experiment.

In Chapter #4 and Chapter #5: Teams revisited the crime scene to see if they missed anything and discovered an additional piece of data necessary to confirm the identity of the thief. Then, they revisited the locations where suspects stored their belongings and collected additional evidence. Once students determined the thief's identity, they gave their final accusation to the in-game principal.

Results

First, the within-case analysis for each team includes a brief case overview. Second, the cross-case analysis represents all cases in a meta-data matrix. The matrix is conceptually ordered: teams at the top worked together most effectively while teams near the bottom were not as effective. Finally, to answer the research questions, findings from the cross-case synthesis are discussed.

Control Team #1: Selected from a class with above average math achievement; this team consisted of two boys and two girls. In general, one boy did not want to do the lab, while the other one kept walking away from the group. One girl was very talkative with others, while the other was generally on-task. Over the course of the activity, no leader emerged. While their process of interaction was democratic, it was also fairly ineffective. The biggest problem for this group was their confusion.

Control Team #2: Selected from a class with average math achievement; this team consisted of two boys and two girls. First, the girls were somewhat hesitant to talk. One boy wanted to take leadership and did not want anyone else to do anything; the other boy seemed willing to defer to the leader boy. During the activity, the strong-willed boy controlled the leadership; he was a very controlling, demanding leader and an ineffective communicator. Group members disagreed often and did not support each other's ideas. Group issues seemed to stem from fighting over roles and responsibilities.

Control Team #3: Selected from a class with below average math achievement; this team consisted of two boys and one girl. In the beginning, the boys were kind of quiet. The girl seemed knowledgeable and interested in science and took a leadership role. She would delegate to the boys, yet sometimes she got aggravated with them. There was a mixed level of support for each other's ideas. The biggest problems for this group were there high level of off-topic conversations and moderate confusion.

Game Team #1: Selected from a class with above average math achievement; this team consisted of four girls. They were generally on-task and seemed to stay together and work well as a group. Over the course of the activity, no leader emerged. Instead, they discussed ideas as a group and supported each other's ideas. This team had no noticeable issues; they suffered little confusion and stayed on task towards their goal. They had the highest written report scores of any case study team.

Game Team #2: Selected from a class with average math achievement; this team consisted of three boys and one girl. In general, one boy did not seem to get along entirely well with the group. Over the course of the activity, no leader emerged. Group members disagreed about half of the time and supported each other's ideas the other half of the time. Their process of interaction was democratic and generally effective. Overall, this team struggled somewhat with group dynamics in situations that were outside of the game framework, such as conducting the lab experiment. However, when it came to synthesizing the information and drawing conclusions collectively as a group, they excelled.

Game Team #3: Selected from a class with below average math achievement; this team consisted of three boys and one girl. In general, all the individuals in this group seemed quiet and reserved; however, one boy took a leadership role and taught the rest of his group about the content and technology. The group's biggest problem may have been the reserved nature of members. The team had low conflict and low confusion; however, dynamics did not yield fully productive conversations. Overall, their process of interaction was a blend of directed leadership and communal effort.

RQ1: Communication Responses

Responses that occurred in team conversations were categorized as accept, discuss, and reject. The code structure built on the work of Barron (2003). When a student agreed with the speaker, supported the idea, or proposed a next step, the interaction was coded as *accept*. When interactions facilitated further discussion, such as questioning an idea, asking for clarification, or challenging an idea with new information, the interaction was coded as *discuss*. When a student rejected an idea or interacted in a way that would not facilitate further discussion, the interaction was coded as *reject*. Based on code reports, occurrences were categorized into levels of low (under 7), moderate-low (7-14), moderate (15-22), moderate-high (23-30), high (31-38), very high (over 38) for each response type.

When comparing communication response types between treatments, game teams and control teams showcased different patterns of communication responses (see Table 1 for occurrences). First, game teams had moderate to low levels of *reject* responses, while control teams had moderate to high levels of *reject* responses. Second, game teams had moderate to high levels of *accept* responses; while control teams had only moderate to low levels of *accept* responses. Lastly, game teams had high or very high levels of *discuss* responses; while control teams had mostly moderate levels of *discuss* responses. Barron (2003) categorized accept and discuss responses as *engaged* responses, while reject responses are considered *non-engaged* responses. Game teams produced a fairly high level of engaged responses in comparison to their non-engaged responses. In contrast, control teams produced a fairly high level of non-engaged responses in comparison to their engaged responses.

	Communication Responses	Scientific Practices	Language Style
Game Team #1 (above average math)	Discuss: High (33) Accept: High (31) Reject: Low (6)	Interpreting data: Very high (21) Constructing explanations: High (9) Arguing with evidence: Moderate (6) Defining the problem: Moderate (5) Planning investigation: Low (4)	Commands: Low (6) Communal: High (39)
Game Team #2 (average math)	Discuss: Very High (59) Accept: Mod-High (23) Reject: Moderate (18)	Interpreting data: Very high (38) Constructing explanations: High (14) Arguing with evidence: Moderate (5) Defining the problem: Moderate (6) Planning investigation: Low (4)	Commands: Moderate (23) Communal: High (63)
Game Team #3 (below average math)	Discuss: Very High (47) Accept: Mod-Low (14) Reject: Low (2)	Interpreting data: Very high (30) Defining the problem: High (11) Arguing with evidence: Moderate (5) Constructing explanations: Low (4) Planning investigation: Low (2)	Commands: Moderate (32) Communal: High (43)
Control Team #1 (above average math)	Discuss: Moderate (21) Accept: Moderate (15) Reject: Moderate (16)	Interpreting data: Very high (59) Planning investigation: High (13) Arguing with evidence: Moderate (7) Constructing explanations: Moderate (6) Defining the problem: Moderate (6)	Commands: Moderate (28) Communal: Moderate (22)
Control Team #3 (below average math)	Discuss: Mod-High (26) Accept: Moderate (21) Reject: Mod-High (26)	Interpreting data: Very high (65) Planning investigation: High (13) Constructing explanations: Low (3) Defining the problem: Low (1) Arguing with evidence: Low (2)	Commands: High (49) Communal: Low (7)
Control Team #2 (average math)	Discuss: Moderate (19) Accept: Mod-Low (13) Reject: High (37)	Interpreting data: Very high (106) Planning investigation: High (13) Constructing explanations: Moderate (7) Defining the problem: Low (3) Arguing with evidence: Low (3)	Commands: High (50) Communal: Low (17)

Table 1: Conceptually-Ordered Discourse Summary for All Cases.

RQ2: Scientific Practices

The scientific practices that occurred in team conversations were coded to align directly to the scientific practices from the National Research Council (2012a). When students discussed what was known about the investigation or tried to determine what needed to be answered, then the dialogue was coded as *Defining the Problem*. When students discussed their investigation plan or what information they needed to record, then the dialogue was coded as *Planning out the Investigation*. When students discussed characteristics of the experiments they were observing, then the dialogue was coded as *Interpreting Data*. When students tried to explain the relationships between data, then the dialogue was coded as *Constructing Explanations*. When students supported or refuted an argument by citing relevant evidence, then the dialogue was coded as *Arguing with Evidence*. Based on code reports, occurrences were categorized into levels of low (1-4), moderate (5-8), high (9-14), and very high (over 14) for each scientific practice.

When comparing scientific practices between treatments, game teams and control teams showcased different usage patterns of scientific practices during their conversations (see Table 1 for occurrences). Since reviewing the number of occurrences of each practice did not reveal the whole story, a more detailed analysis of the conversational occurrences was necessary. First, for occurrences coded as *Defining the Problem*, game teams revealed a stronger understanding of describing the problem as well as some understanding of how to create a hypothesis. While control teams did showcase this practice, they only revealed a basic understanding of describing the problem and a very basic understanding of how to create a hypothesis. Second, for occurrences coded as *Planning out the Investigation*, control teams had a better understanding of the plan they needed to execute in order to determine the identity of the mystery powder than game teams. Third, for *Interpreting Data*, although both treatments had a high level of occurrences, game teams offered observations that were more specific and substantive than control teams. Fourth, for occurrences coded as *Constructing Explanations*, the below average teams from both treatments struggled somewhat with this practice exhibiting only a basic understanding. However, in comparing the higher achieving students, game teams constructed explanations about both the game narrative and the scientific content leading to more opportunities to showcase this practice whereas control teams only explained the science content. Finally, when *Arguing with Evidence*, game teams revealed their ability to argue with evidence more than once during the activity; multiple team members were also involved in making evidence-based arguments. Not all control teams showcased this practice on their own; for those that did, they only revealed it once at the activity's end and only one control team had multiple members exhibiting the practice. Other than when *Planning out the Investigation*, conversations amongst game teams revealed a greater ability to engage in scientific practices than control teams.

RQ3: Other Differences

As mentioned earlier, some codes emerged during a second round of emergent coding. When reviewing transcripts, the researcher noticed differences in the general language style of the treatment groups. Students in the control were frequently telling each other what to do. They were using language such as, “don't reach across the table like that—here—give it” (Control Team #1, 510), “put the whole entire thing in” (Control Team #2, 122), and “go get the other one” (Control Team #3, 285). To capture this type of directive language, a new code was created called *commands*. Additionally, the researcher noticed that students in the experiment were addressing the group collectively, rather than one specific team member. They were also referring to the group as an entity with words such as “we,” “we're,” and “let's.” To capture this type of communal language, a new code was created called *communal*. Based on code reports, occurrences were categorized into levels of low (19 and under), moderate (20-38), and high (over 38) for each language style.

In terms of language style, game teams and control teams demonstrated an emphasis on different styles during their conversations (see Table 1 for occurrences). Game teams had high levels of communal language and moderate to low levels of command language. In contrast, control teams had moderate to low levels of communal language and moderate to high levels of command language. For the entire activity, conversations amongst game teams had not only higher levels of engaged responses but also higher levels of communal language and a greater ability to engage in scientific practices. These patterns of group communication seemed to connect with better group dynamics and more effective team communication. In contrast, over the whole activity, conversations amongst control teams had not only higher levels of rejecting responses but also higher levels of commands and a reduced ability to engage in scientific practices. These patterns of group communication seemed to connect with less effective group dynamics and poor team communication skills.

Discussion and Conclusion

Prior research indicated that collaborative games held promise for promoting effective collaborative practice by scaffolding and supporting discourse during gameplay. Specifically, when it comes to scientific practice, research has showed that students guided to socially construct their knowledge in *River City* had a stronger understanding of scientific inquiry than other students (Ketelhut, Nelson, Clarke, & Dede, 2010). Similarly in this study, game teams communicated well and showcased greater levels of scientific practice. The game in this study utilized interdependent roles and jigsaw pedagogy to scaffold player's social interactions. Based on the player's role, unique information was revealed to the player that he or she had to share with others. Aronson and Patnoe (2011), experts on using jigsaw pedagogy in the classroom, argued that this style of social interdependence is a way to promote effective group learning because as members start to learn from each other, the feeling that they need to outperform their classmates diminishes. Unfortunately, control teams struggled to understand their individual roles within the group and their group dynamics suffered. They showcased ineffective communication responses and language styles, possibly due in part to the desire to outperform teammates, which resulted in lower levels of scientific practice.

According to Reiser, Berland, and Kenyon (2012), students need to "actively listen and respond to one another" in order to be engaged in meaningful scientific practice (p.36). Game teams had more engaged communications responses along with higher levels of communal language; in other words, they spoke to each other with 'honey'. In brief, game teams met the precursor for meaningful learning by communicating with honey. Unfortunately, control teams had higher rejecting responses and higher commands, thus they spoke to each other with 'vinegar'. Control teams did not meet the precursor for meaningful learning since they communicated with vinegar.

As mentioned in the beginning of this paper, the ability to collaboratively solve problems is of the utmost importance in scientific careers, yet students in most U.S. schools are not exposed to activities that promote scientific practice in an effective and engaging collaborative setting. Collaborative mobile AR games designed with interdependent roles hold promise for offering exactly this type of learning experience. The game in this study was implemented within the practical parameters of a real school setting. For schools that have iPads, this type of game could be scaled up and implemented as support for the Next Generation Science Standards (NGSS). With the recent release and adoption of the NGSS, schools will need curriculum activities that support student learning aligned to these standards. The coded dialogue for scientific practice was perfectly aligned to the NGSS and the study shows that the game teams had greater levels of scientific practices in their conversations than control teams. Game teams also showcased that scientific knowledge can be advanced through student collaboration by talking with 'honey' and not 'vinegar'. All in all, collaborative mobile AR games that are designed to promote not only NGSS but also communication skills should be strongly considered by school policy makers.

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Children of the Sun: The Design and Evaluation of an Educational Game about Middle Mississippian Culture

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Introduction

“What kind of game is this? Is it asking you questions about Native Americans?” These were the first questions we received as we explained to a group of third-graders that they would be playing an educational game. When we told the student that it was not a quiz-style game, he responded, “It’s just like a regular game?” Children as young as eight are familiar with drill-and-practice edutainment software, and this student at least is clearly dubious of them. As educators and scholars, we know that positive learning outcomes can come from “regular games” when their design integrates good practices of game design and the science of learning (e.g. Clark and Mayer, 2011; Klopfer et al., 2009). In this paper, we describe the development and evaluation of a game that aligns gameplay and learning objectives—a game designed to promote learning through enjoyable competitive gameplay.

Children of the Sun is an original, educational, tablet-based video game designed to teach about the Middle Mississippians—pre-Columbian Native Americans whose culture thrived through the central Mississippi River Valley and surrounding areas around 1000–1500 CE (Pauketat, 2004). Middle Mississippian culture influenced a large geographic area, and *Children of the Sun* is primarily inspired by archaeological findings near Cahokia in modern St. Louis (Pauketat, 2004) and the Angel site in southwestern Indiana (Kellar,

1983). The Mississippians were mound-builders and lived in permanent settlements that ranged in size and complexity. Mounds held religious and political significance, and open plazas and community areas were usually situated near the central mounds. Chiefdoms were sometimes surrounded by wooden palisades and were usually located near floodplains and rivers. The size and scale of some chiefdoms have led some scholars to believe that there was substantial oversight and organization as well as social hierarchy in these settlements (Cobb, 2003). The Mississippians grew various crops including maize, beans, and squash—“the three sisters”—and also hunted for food. Many finely crafted artifacts made from shell, bone, stone and ceramic have been found in various sites, sometimes adorned with religious symbols. These artifacts were found far from where they were created, giving evidence to the importance of both trade and gift-giving among Mississippians. However, chiefdoms within Middle Mississippian society also fought each other over land and scarce resources, as well as for ritual or religious purposes (Kellar, 1983).

Children of the Sun was designed and developed by a multidisciplinary, primarily-undergraduate team at Ball State University, working in cooperation with The Indiana State Museum. The game was designed for integration with the museum’s educational outreach programs on archaeology and Native American culture. The design therefore needed to accommodate an uncommon set of constraints: the game needed to fit into a curriculum for collocated children, engaged in a series of activities on a theme, with only enough time to play the game once. This required the designers to forego common idioms of serious game design based around learning through replayability and, instead, to draw upon museum exhibit design idioms (Lord and Lord, 2001). That is, although the game would only be played once, it would be framed temporally and spatially by related artifacts and experiences.



Figure 1: Title screen (left) and Naming your chief (right)

Design and Development

The design of the game began in Fall 2012, when a multidisciplinary undergraduate team worked with the Indiana State Museum to develop board and card game prototypes. A committee of scholars and museum staff selected one from among these that could be converted into a digital game: *Mississippia*, a cooperative, variable-powers resource trading game about life in a Middle Mississippian village (Romelfanger,

2012). A multidisciplinary team of twelve undergraduate students and one graduate student was recruited to produce the game in Spring 2013 as part of a six credit-hour studio course. The team consulted with faculty mentors and museum staff to identify potential learning outcomes for the game based on the results of the paper prototyping and the museum's outreach program curriculum. The following learning outcomes were identified as most desirable: the Middle Mississippians built mounds corresponding to their village's power and status (O1); there were multiple chiefdoms that each lived in their own village (O2); chiefdoms farmed and hunted for food (O3); and chiefdoms competed for resources, sometimes raiding over scarce resources (O4).

Fundamental changes to the original prototype were required in order to meet these objectives and to leverage the affordances of the platform and context of play. The digital game—*Children of the Sun*—is a competitive three- to four-player game of resource management, and it was completed at the end of the Spring 2013 semester. The player takes the role of a chief who delegates his 300 villagers to tasks of hunting, farming, mound-building, and raiding. Hunting and farming generate food, which is steadily consumed by the villagers; without food, villagers will starve and the player's game will end prematurely. Hunting can produce more food faster than farming, but hunting grounds are limited; as hunters must travel farther for food, it takes longer for them to return. Raiding can be used to steal food and eliminate opponent's villagers, but it takes time and risks the death of the raiders. The victor is the player whose villagers survive and build the largest ceremonial mound, corresponding to the cultural importance of these mounds to the Middle Mississippians. The primary conflict of the game, then, comes from balancing food production and consumption rates, competing for limited hunting grounds, and investing villagers into the purely ceremonial activity of mound-building.

The game begins with the title screen shown in Figure 1. After each player names his or her chieftain, a still screen explains that the goal of the game is to build the largest ceremonial mound. Then, the player is shown

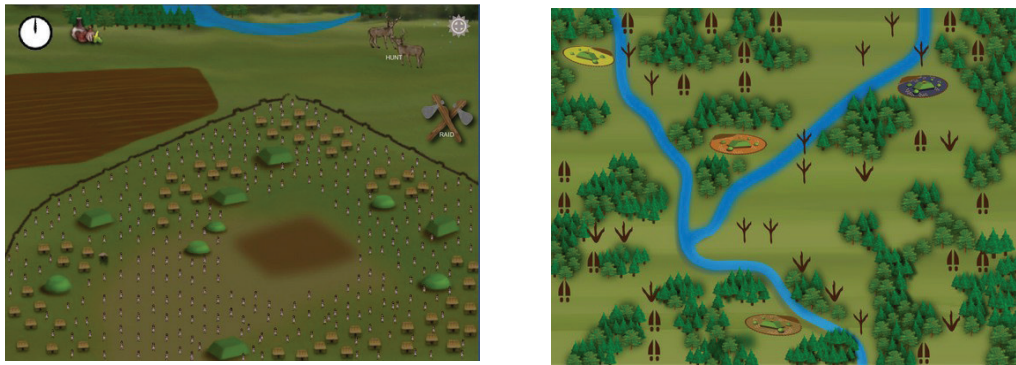


Figure 2: Village screen (left) and World screen (right)

a birds-eye view of the village (Figure 2), the design of which is based on archaeological maps of the Angel site from Black (1967) as cited in Green and Munson (1978). Villagers assigned to farming or mound-building engage in these activities on the village screen. Tapping the corner of the map brings up the the world map (Figure 2), which shows the distribution of villages. Villages and villagers are color-coded in historically authentic colors of yellow, orange, brown, and blue. Hunting grounds are indicated with deer, wild turkey, and waterfowl tracks. The river provides a natural impediment to villager movement. When villagers are assigned to hunt or raid, they are animated from the village screen to the world map, where they can be seen engaging in these activities. New hunters will seek the closest hunting grounds, moving outward from there if the grounds are occupied, while regular hunters will start by returning to the last hunting grounds at which they were successful.

As raiders leave one village and approach their target, both the attacker's and defender's tablets play an ominous audio track. This sets the mood for the raid and also signals the defender to bring hunters, farmers, and even raiding parties back to the village to protect it. The raid itself is seen on the defender's village screen, which flashes red and plays appropriate sound effects. It is worth noting that raiding does not directly contribute to the game's victory condition—building the biggest ceremonial mound—but it does diminish the target player's ability to hunt, farm, build mounds, or retaliate.

The game features original music and sound effects. Player commands are vocalized with an interpretation of the Middle Mississippian language based on the scholarship of Haas (1956), who conducted fieldwork with the last two living speakers of the Natchez language in the 1930s. This provided the best approximation of what would have been spoken by the Northern Middle Mississippians. The music in the game is based on modern interpretations and re-enactments, which employ quarter-note drum patterns and chanting.

Children of the Sun was developed using an incremental and iterative approach based on the principles of Crystal Clear (Cockburn, 2004) as enacted through Scrum (Keith, 2010; Schwaber and Sutherland,

2013). Physical and digital prototypes were playtested internally as part of each iteration, and later digital prototypes were publicly playtested. *Children of the Sun* was deployed at the museum in Summer 2013, and staff reported it to be an effective intervention as part of the Summer workshops.

Qualitative Evaluation

The successful deployment suggests that the game meets its learning objectives to some extent, but two critical questions remain: what elements contributed to or distracted from these objectives, and perhaps more importantly, what did students learn that was not articulated by the learning objectives? These questions require careful consideration of the lived experience of specific students, respecting the contextual and constructive natures of learning.

To investigate these questions, we developed a qualitative study following Stake (2010), using focus groups and ethnographic methods to gather data. Data collection was conducted in a third-grade classroom at a private school in the midwest. The families at this particular school represent low- to mid-level socioeconomic status. Eight participants were randomly assigned to two groups of four: both engaged in focus group discussions following a semi-structured interview protocol, but only one of the groups played *Children of the Sun*. An additional set of post-gameplay questions was used with the latter group. Although the game is designed to take

ten minutes to play, earlier informal evaluations demonstrated that all of the core gameplay could be experienced in less time; the gameplay duration was therefore reduced to five minutes in order to provide more time for discussion. The research data under analysis comprised: field notes from the researchers; approximately forty minutes of video from the two groups; and a memo from the students' teacher, who had been present in the room with the intervention group, though not participating in the study. In addition to the field data, the researchers had access to extensive documentation from the design and development of *Children of the Sun*, including design specifications, prototypes, and meeting notes, all of which were used for triangulation. We note that the goal was not to produce findings that generalize to all possible players, but rather to attempt to deeply understand what impact game elements have on these players.

The data coding process proceeded according to the methods described by Spinuzzi (2003, 2012). His socio-cultural research methods are based on activity theory, which describes human activity as being artifact-mediated and oriented toward objectives (Vygotsky (1978)). Activity theory is used in human-computer interaction design research (e.g. Kaptelenin and Nardi, 2009) and education research (e.g. Sannino et al.,

2009). Prior to analysis, the researchers identified five initial codes, representing five expected topics: hunting, raiding, farming, mound-building, and the game's user-interface. Two of the researchers independently proceeded with open coding followed by iterative axial coding—the identification of codes that emerge from the open codes following Saldaña (2012). The researchers met after coding to compare and consolidate their analyses, which were highly congruent.

Findings and Discussion

Through the iterative coding process, we identified three principle themes within these data, drawing upon design documentation and archaeological notes for triangulation. These themes are described and contextualized in the following subsections. During the discussion, we reference the four players by the pseudonyms Amanda, Andy, Julie, and Mark; the four non-intervention discussants are Alex, Bruce, Chris, and Samantha.

Identification with villages

The players strongly identified with the village and villagers under their control, as one might predict: players identify with pieces over which they have agency in gameplay. The players comfortably referred to the villagers as “theirs” based on the color-coding and the fact that they could be directed to different village actions. When the raiding music began and Mark asked who was being attacked, Andy responded, “Mine! There's bad people outside mine!” Andy did not know who had attacked him, but he interprets them as “bad” because they oppose Andy's own villagers. Perhaps ironically, it was Mark himself who attacked Andy's village, not knowing whose village it was. The designers' intention was for players to recognize each other by color, but the data show that these players were unaware of the mapping.

Although the players immediately showed a sense of ownership and pride in their villages, they also showed little empathy. For example, Mark did not commit enough of his villagers to food-producing actions early in the game, leading his village to starve; yet, his comments show little remorse, except that he could no longer play. That is, he perceived the villagers as an abstract resource. This stands in contrast to the comments from the non-intervention group, who described a chieftain as a merciful role-model who cares about his people.

Clarifying Misconceptions about Native American culture

The non-intervention group exhibited considerable misconceptions about Native Americans, conflating the wide variety of cultures into a composite archetype. Of particular interest to the study was the assumption that all Native Americans lived together in peace. Samantha recalled “a fake bow and arrow” that she and her classmates had seen at a museum during a field trip, leading the group to eagerly discuss how Native Americans cut down trees to make “houses” and “rowboats,” as well as “axes” and “saws.” When asked what they would fight with these weapons, the group responded with a range of animals, including wolves, wolverines, mountain lions, and eagles. Alex mentioned that they fought “other Indians” at the same time that Bruce suggested “the Pilgrims.” Upon further discussion, Alex and Bruce agreed that the Native Americans did not fight each other, though perhaps they “spied” on each other, and also on the Pilgrims. Chris explained, “In a story I heard about Native Americans, some of the pilgrims had guns and they were spying on the Native Americans and going to shoot them, but they ran away before they shot them.” The rest of the group appeared to agree with this summation. Unfortunately, we were unable to identify what story, experience, or lesson prompted these classmates to confirm this shared narrative.

The intervention group's post-gameplay responses to the same prompts stand in stark contrast. When asked, "What do you think the Middle Mississippians did?" Amanda suggested that "the Middle Mississippi-ans went over to other people's villages and fought." It is unclear whether her use of the term "Middle Mississippian" reflects real understanding or whether she was simply repeating back the words of the prompt. Mark added that the Middle Mississippians farmed to get "a lot of food," which is a notable comment from a player whose villagers had starved. Amanda added that they hunted and built mounds, demonstrating how the students recognize that actual Middle Mississippians performed the same four activities allowed in the game. However, these were also the only four activities that the students offered in answer to the prompt. The study was conducted in a school, and in this setting, the students may have seen these as the expected and therefore correct answers.

The intervention group did not mention Europeans during gameplay or in the discussion, and so we do not know how or whether this experience integrated with their prior understanding. However, it is safe to assume they approached the game with the same misconceptions as the non-intervention group, as they were randomly selected from the same class.

Children of the Sun lacks non-violent, non-competitive interactions between players, and it appears this contributes to players' inaccurate understanding that all inter-village interactions were violent or competitive. The design team had planned to include peaceful village interaction options into the game, particularly relating to trade, reciprocal gift-giving, and *chunkee*—an important Native American sport. However, production constraints led to these features' being cut. Playtesters enjoyed raiding, which encouraged the development team to invest even more effort into this feature: raiding had more custom animation, villager behavior, and custom audio than any other game feature. This positive feedback loop between developers and playtesters seems to have caused the players to mischaracterize the inter-village relationships of the Middle Mississippians.

Collocated play and interface barriers

The study demonstrated how peer learning and collocation allowed players to overcome interface design defects. This point can be illustrated with four short vignettes. To start the game, Julie created a game that the other four had to join. Mark had trouble figuring out how to connect to the game, and so she scooted over to help him. Later, some of the players had difficulty interpreting the interface tutorial, but when Andy exasperatedly admitted, "I'm not getting this," Amanda was able to show him what to do. When Mark looked over the village screen, he asked, "How do I attack?" Julie searched her screen for such an option, but not finding it, asked "What's 'Raid'?". Mark clarified that this word meant "attack," and both were able to use this feature. Finally, during the game, Andy narrated, "I'm bringing my people back." Amanda and Mark simultaneously asked in reply, "How do you bring your people back?" Andy explained, and after trying it, Amanda confidently responded, "Oh, I know how to do it."

There was almost no discussion of mound-building during play. Indeed, Amanda was surprised to find out that she won the game. She had been the only one who acknowledged seeing the game's brief explanation of the victory conditions—the others disregarded the text in their eagerness to get into the gameplay. The game designers intentionally omitted an in-game leaderboard so as to encourage players to keep tabs on each others' villages in their shared physical space. However, without understanding that there was something to monitor—namely, the size of the central ceremonial mound—the students showed no interest in watching each others' screens. During the post-game discussion, after being reminded that it was the size of the mound that determined victory, Andy asked, "But what about the raid and the hunt and all that?" After clarifying that this was for food, Andy realized, "If you don't get food, you don't live, and you can't build the mound." Amanda expressed pride in winning for having built the mound, but there is no evidence that this was an intentional strategy during gameplay. In her own words, her strategy was, "I moved people around. I moved some to go hunt and some to the raid, and then I moved some to plant and grow crops. And then I moved some to build the mound. And then I took some from the mound to the crops."

None of the players discovered that they could switch between the village and world map screens. The animations had been designed to encourage the player to follow outbound villagers to the world map screen, but nothing in the game design explicitly calls the players' attention to this. In the absence of a perceived affordance, the player could learn nothing about it (Gibson and Pick, 2003; Linderoth, 2010).

This discussion needs to be contextualized within the unconventional design constraints of the game. Outside of the study, players would only be able to play this game as part of a larger museum experience involving artifacts, lessons, and discussions, the gameplay itself mediated by museum educators. The formal evaluation was unable to use this context, but just as the school context influenced our subjects, the museum context surely influences those who play the game within its intended environment.

Conclusions

Children of the Sun teaches fundamentals of Middle Mississippian culture by placing the player in the role of a chief. We find that players—in both informal playtesting and formal evaluation scenarios—were able to clearly articulate facts about the Middle Mississippians based on their gameplay experiences. The game meets the learning objectives for which it was designed, validating a development approach that included two semesters of multidisciplinary, primarily-undergraduate teams. Although *Children of the Sun* meets the needs of the client and the learning objectives of the designers, the scholarly evaluation reveals more interesting relationships between player experience and learning. What players learned was directly related to their gameplay experiences, but pre-ordained measurable learning outcomes cannot account for the background knowledge that a user brings to the play experience. We find that, regardless of whether the play experience supported a learning objective, each play experience can be traced back to a design decision made by the development team. This reinforces the need for great care in designing gameplay around learning objectives Klopfer et al. (2009); furthermore, this exemplifies the need for evaluation of educational games to consider perspectives much broader than the articulated learning objectives. Recognizing the constructive nature of learning requires an evaluator to consider what students learned that is not within the learning objectives.

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On the Fields of Justice: The Emergence of Teamwork in *League of Legends*

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Introduction

Teamwork; love it or hate it, all people deal with it. In today's increasingly interlinked world, no one person can do everything alone. Whether it is closing on a major business deal, coordinating lesson plans for a school day, or running an experiment in a lab, most careers require coordination and teamwork among co-workers to achieve optimal efficiency and results. Developing these skills has been a subject of interest for many researchers over the years resulting in many team-based interventions being implemented in educational environments.

With the relatively recent development of online game environments, many researchers have also begun to investigate elements of leadership and teamwork that emerge during in-game group interactions and how to potentially utilize those aspects to teach highly sought collaborative skills. If researchers and educators are starting to consider utilizing online game environments to train skills and teach content, then it becomes increasingly necessary to investigate all aspects of interaction within these worlds, both positive and negative, to determine how best to implement and design educational game environments.

Research Questions

This exploratory study investigates the following questions:

- [1] How is teamwork encouraged and inhibited in *League of Legends*?
- [2] How can these observations inform instructional game design?

Literature Review

Teamwork

Much has been written on the importance of developing teamwork skills, especially in higher education, to prepare students for the working world (Feichtner & Davis 1984; Dunne & Rawlins, 2000; Pfaff & Huddleston, 2003; McCorkle et al., 1999). A number of teamwork skills and capabilities are expected of those seeking employment. As Feichtner & Davis (1984) put it, the "most important single factor is that as the business environment has become more complex, the ability of any one person to cope with it satisfactorily has been greatly reduced" (p. 58).

Essentially, in today's working world, no one person can accomplish everything by him or herself. A person needs to be able to trust in and coordinate with team members to carry out tasks. McCorkle et al. (1999), however, warn about one danger of distributed workloads in that "when students have their work divided for them or divide work themselves, the possibility exists that each student only learns only about his or her area of specialization" (p. 38). In addition to trusting in others, one must also understand what everyone else is doing as well in order to ensure cohesive team productivity.

Of particular importance in recent years is the ability to cooperate cross-culturally in this increasingly globalized world. Pfaff and Huddleston (2003) mention that "it is important for students to learn to work with and form relationships with others who are not like themselves" (p. 38). A case-study written by Lee-Kelley & Sankey (2008), however, mentions a number of issues encountered within cross-culturally teamwork. Some chief issues included: unclear roles and responsibilities, difficulties coordinating across time zones, cultural differences, dissonance due to time and pressure, trust on delivering, and training.

Lee-Kelley & Sankey (2008) specifically mention that "the general agreement is that the ability to work at a distance with colleagues from diverse cultural backgrounds came only with experience and is part of the 'on the job training'" (p. 59-60). When it comes to working cross-culturally, the main method of practice is by actually doing it on the job, when the stakes are higher. There are few if any risk free environments that promote cross-cultural teamwork and collaboration.

Of late, many researchers have also begun to investigate leadership and teamwork encountered in virtual environments (Williams, 2006; Yee, 2006; Jeng & Teng, 2008; Chen, 2009; Wolfenstein 2010). The literature mentions many of the skills employed by leaders in games. Williams (2006) mentions that GMs (guild masters) facilitate social support in terms of small-scale leadership and ethics, disputes, scheduling, and philosophies on the larger-scale (p. 350). Yee (2006) also discusses the roles of a leader in an MMORPG writing that “administrative tasks include: role assignment, task delegation, crisis management, logistical planning, and how rewards are to be shared among group members. Higher-level strategy tasks include: motivating group members, dealing with negative attitudes, dealing with group conflicts, as well as encouraging group loyalty and cohesion” (p. 32).

As mentioned by some authors, there is also the possibility to learn some of these leadership skills from others during game-play. As Williams (2006) notes “for some, guild leadership was an extension of their life at work that naturally transferred to the game world” (p. 355). Yee (2006) mentions that “there are very few activities, hobbies or games in real-life where you find people with ages ranging from 11 to 69 interacting and collaborating to achieve shared goals” (p. 35). Both Yee and Williams illuminate the existence of a great network to potentially learn leadership skills from while playing. A survey analyzed by Yee reported a 50-50 split among players asked if they felt an improvement in their leadership skills.

Though it may seem insignificant that only around 50% of those surveyed perceived any gains from game-play, Yee mentions that it is “remarkable for MMORPG environments that were not designed to teach leadership skills and have no structured pedagogical goals or curriculum” (p. 34) to have any perceivable gains at all. Most notably, the group that reported the most significant amount of experience gains was the 18-24 year-old bracket—those whom many higher education teamwork programs aim to train (Yee 2006, p. 34).

In addition to potential gains in leadership skills, some authors have investigated the importance of teamwork in game-play. Yee (2006) mentions that “all roles have strengths and weaknesses, and a successful group is one where all members take full advantage their own strengths while mitigating the vulnerabilities of their teammates” (p. 29). Chen (2009) comments that “success depended on the ability of our group members to coordinate our efforts and maximize group efficiency by having each member take on a specialized role” (p. 47). As these two authors note, an important factor of teamwork is understanding the strengths and weaknesses of all team members and using that information efficiently to coordinate optimally.

Communication has been cited as an invaluable component of virtual teamwork and a necessity to ensure successful operations (Iacano and Weisband, 1997). Williams (2006) discussed how many raid groups utilize voice over internet protocols (VoIP) to chat while Chen (2009) primarily recounts the use of multiple, specialized text channels and voice software to coordinate team actions (p. 58). Chen (2009) also comments on how communication and reflection on failures are vital to a team’s ultimate success (p. 69).

League of Legends

This study examines teamwork featured in a game minimally explored in the literature, *League of Legends (LoL)*, a multiplayer online battle arena (MOBA) video game developed by Riot Games. This article focuses on *LoL* because of the highly team-motivated aspects of gameplay and the incredible number of active users of the game. *LoL* was first released in 2009 and has since then become the most played game in the world by hours played per month according to Riot Games. As most recently reported in November 2012, *LoL* boasts 70 million registered users with 32 million listed as monthly active users (MAU) and 12 million daily active users (DAU). To place this in perspective, Xbox Live has 40 million monthly subscribers and *World of Warcraft* had 12 million monthly subscriptions at its peak (1). *Farmville 2*, the currently most played Facebook game, has 48 MAU and 8.7 DAU in comparison (2). *LoL* is played all over the world with servers in North America, Europe, Brazil, Turkey, and Asia.

Observations

The Metagame

As mentioned, *LoL* is a game that relies on teamwork in order for players to achieve victory. Players most commonly play casual 5v5 matches by teaming up with people they know or by being individually placed in a solo queue to be paired with random players. Like in the content found in many MMORPGs, an individual player cannot carry an entire team to victory alone. As will be discussed later, each player on a 5-person team is expected to fulfill a certain role as dictated by *LoL*’s metagame. *LoL* differs from MMORPGs though in that players do not develop their own individual characters over the course of hours of play. Instead, players select from 100+ individual champions with set skills, roles, and lore and customize these characters according to their expected roles with items purchased throughout the course of a game.

Each character fulfills certain roles as outlined by *LoL*'s metagame. These roles correspond with the battlefield in *LoL* which consists of three main lanes: top, middle (mid), and bottom (bot) and a jungle area that lies between the three lanes. In a typical team arrangement, one champion goes "solo top", one goes "solo mid", two "go bot", and one "jungles". Depending on the level of play, some teams may not have a "jungler" and may have two champions who "go top" together.

"Welcome to Summoner's Rift": Building a Team

Where this information matters the most is in the creation of teams in the pre-game lobby. Players are encouraged and often expected to pick champions that will best fit with the team dynamic. It is discouraged for players to instantly "lock in" a character without consulting with the team and can create for tense playing environments when one player is uncooperative in such a way (4). The following screenshots of pre-game lobbies illustrate the aspects of communication exhibited in a game of *LoL*.

The first screenshot features 2 players, presumably 2 friends playing with each other, stating that they want to play in the same lane. Since the character Ashe typically does not play alone in a lane, another player asks the one playing Ashe if that is an acceptable situation. The one playing Ashe says it is ok though the player responds somewhat hesitantly (see Figure 1 Left).

In the second screenshot, one player is playing as a character that can potentially be built as a tank. The player, however, states that he is not capable of playing a tank and does not want that expectation to be placed upon him thereby disappointing his teammates. One other player proposes that another character (Taric) could perhaps build as a tank. Another player declares that that Taric will be the tank for the team. The person playing Taric agrees but inquires about the best way to fulfill his role (see Figure 1 Mid).

Lastly in the third screenshot, one player asks another player if he knows how to jungle, since they already have 2 champions in the top lane and having a jungler is preferred for team composition. The asked player responds that he does, but prefers not to because he has only had negative team experiences playing as a jungler. The other player accepts the response and does not inquire further (see Figure 1 Right).

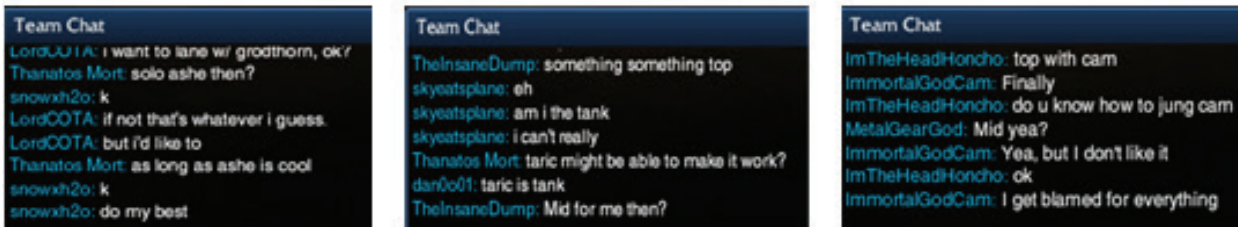


Figure 1: Pre-Game Lobby Screenshots

What is important to learn from these observations is the necessity for utility in a player's skill set and an understanding of all of the positions that can be played. If a player is unable to fit the team's composition, then the chances of a team's success become diminished. By being flexible with play-style and understanding how to play all positions and what each position does, a player is able to better coordinate with other teammates, creating a better cooperative team environment. Such universal understanding of all team members' roles is crucial for collaborative success (McCorkle et al., 1999).

"Tactical Decision, Summoner!": Communication

In *LoL*, as in any team-oriented environment, communication is key to achieve optimal results. As *LoL* is an online game with many teammates often playing from different location, communication is a skill that requires more coordination than one may typical require in a face-to-face situation. Included within the game are two options for communicating: in-game chat and the smart ping system. Players also use Voice over Internet Protocols such as Skype, Google Hangouts, and Curse Voice to verbally communicate. Lastly, Players engage in Face-to-Face



Figure 2: Types of Communication in *League of Legends*

“Justice!”: Community Development

From my observations, I have come to understand that *LoL* features a player base notorious for mean-spirited behavior. A large part of this hostility may stem from the duration of play-time and the anonymous and random mechanics behind team pairings. In comparison with MMORPGs which feature lengthy end-game content which can range from 2-8 hours in duration (Chen, 2009), an average match in *LoL* lasts about 30-40 minutes.

Since players who are playing by themselves are placed on teams with random people and considering that there are about 12 million DAU, the chances of encountering another player in a match a second time are astronomically low. In a raid, teams tend to be coordinated so that one tends to be familiar with other players participating in the raid with some strangers participating on the occasion as well. If these strangers are found to be poor team players, then those involved in the raid will ensure that they do not raid with that player again. In that regard, there is a degree of social accountability expected for players if they want to participate in large group play.

Since players only interact with each other for a short span of time and since there is no degree of social accountability for players to consider on account of the random team placements there is no need to be civil towards another player. To counter such a mentality from consuming the whole player base, Riot incorporates both a reporting and honor system, both of which are featured in the post-game lobby.

After a game ends, players may report players who they believe conducted themselves poorly during the match. Players are allowed to file reports for a number of reasons including dropping from the match, verbally abusing other players, or playing poorly. These reported players are then investigated by a jury of their peers in what is known as the Tribunal. Players who are level 20 or higher are able to examine the reports filed against a player and decide whether or not that player should be punished or pardoned accordingly.



Figure 3: The Honor and Reporting System in *League of Legends*

From Master Yi to Wu Kong: Expert-Novice Interaction

In addition to the pre-game lobbies, there are also post-game lobbies in which players complement or criticize players on their actions in a game. The adjacent screenshot details a telling moment of interaction between two players who were on the opposing team as seen in Figure 6. In this exchange, one player offers advice to the player who chose Diana as his champion. He tells him that he needs to use his ultimate ability more often and then advises him on how to do that effectively. The champion Diana is able to use an ability know as “Crest Strike” which, as another player comments, reduces the amount of time required to wait for her ultimate skill to be ready again (aka cooldown). This constructive feedback, especially after a losing match, was particularly interesting to observe as most post-game commentary tends to be deprecating rather than helpful (see Figure 2). Understanding how to encourage such constructive expert-novice interactions prove beneficial for developing instructional game environments (Yee, 2006; Williams, 2006).

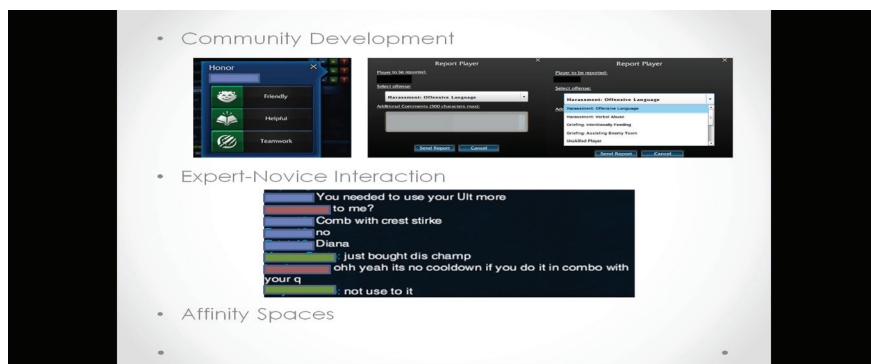


Figure 4: Expert player advising novice player

The Honor system is a form of positive reinforcement implemented by Riot Games in order to encourage players to work well together and promote a friendly and insightful learning environment. These honors include: “Friendly”, “Helpful”, “Teamwork”, and “Honorable Opponent”. Currently, there are no in-game bonuses for accruing honors. Players who do receive a number of honors do receive aesthetic ribbons for their player accounts though how one acquires such commendations is not information disclosed by Riot. Riot mentions that they are exploring more ways to reward those who receive numerous accolades.

Beyond the Battlefield: Affinity Spaces

In addition to the information that can be learned in game and from the official website, many guides have been created by players that detail the roles that each champion can fulfill and what items a player would purchase to build the champion in the appropriate way. Two websites that host these build guides are www.mobafire.com and www.solomid.com with some of the guides they feature receiving 1 million+ hits. In addition to character build guides, players have also posted guides intended to assist new players in getting acclimatized to the game. Of note from this guide were some of the opening words which state “do not expect a a game, where you can go all out solo and expect to get killing spree after killing spree. It is a teamgame and it should be played as a teamgame”. From the very beginning, more experienced players want newer players to learn that team-play is at the core of the game and there are expectations for all those who chose to participate.

Additionally, one guide encountered on mobafire was of particular interest for the purpose of this study. The guide entitled “General guide how to build morale, and how to lead”(6) written by a player named glizdka describes 17 different player attitudes one may encounter while playing a game of *LoL*. In this guide, glizdka suggests optimal ways to work with these types in order to lead and facilitate teamwork. Glizdka also suggests ways in which a player can develop into a “natural leader”, the ideal type of player who is able to lead a group of 4 random teammates to victory. These include targeting objectives, managing teamfights, giving advice on battles, showing them the way to build their characters, and complementing them when they are successful. In order to be such a leader, though, the player needs a good working knowledge the game, making this guide not as relevant to newer players. The creation of the guide, however, does emphasize the communities’ encouragement of team-play and cooperation.

Conclusion

As mentioned by Jenkins et al. (2006), collaborative problem solving is a skill crucial for students to practice and learn in order to participate in 21st century working environments. Collaborative problem solving entails “working together in teams, formal and informal, to complete tasks and develop new knowledge” (Jenkins et al., 2006, p. 3). As illustrated by this study’s observations, online games offer the groundwork for environments in which players can practice such collaborative skills. Additionally, as mentioned, online games also offer the potential for interaction between novices and experts who can work together to understand and create new knowledge. Online educational game environments can also produce environments that could provide much needed practice and training for cross-cultural teamwork.

There are, however, some potential complications that may arise in the development of online educational game environments. Random team compositions may prove detrimental in some cases if not monitored. To enhance team-play experience, user anonymity should be avoided as much as possible so players may act more accountable for their actions. Modes of communication should also be strongly considered in the development of a platform. As mentioned, communication is what tends to make or break a team. How the understanding and generation of content will actually be implemented in such game environments is also a looming question for educators, researchers, and game designers. Whether that should be the purpose of some educational environments is also another question to consider as well.

If some educational environments may potentially become digital, then interactions among users of those spaces must be observed in order to better inform design. Regardless of whether or not such spaces will be created for educational purposes though, investigating such game environments will still prove beneficial for the understanding of teamwork. With improved understanding perhaps teamwork may one day become something we all could learn to love.

Limitations

Some limitations of this study derive from the fact that it was only conducted by one individual making only pure observations. The observer did not conduct any interviews or distribute any surveys to ask for outside, player feedback. Additionally the observer is a relatively new player of the game and was unable to experience much of the inner workings of player vs. player content in *LoL* where increasingly more player interactions take place. Additionally, software prohibited data collection as the observer was unable to obtain chat logs of play where a great deal of communication takes place.

Endnotes

- (1) http://majorleagueoflegends.s3.amazonaws.com/lol_infographic.png
- (2) <http://www.gamesindustry.biz/articles/2012-10-16-riot-president-make-the-s-in-riot-games-mean-something>
- (3) <http://na.leagueoflegends.com/board/showthread.php?t=207449>
- (4) Having “Riot” in one’s username indicates that the player is an employee of Riot Games.
- (5) [League of Legends - A guide for beginners and other people](#)
- (6) <http://www.mobafire.com/league-of-legends/build/general-guide-how-to-build-morale-and-how-to-lead-209226>

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“Gradequest Strikes Back” – The Development of the Second Iteration of a Gameful Undergraduate Course

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Introduction

Gamification – or the use of game design techniques for purposes outside of gaming – has been a hot topic in the last couple of years. According to the 2013 Garner Hype Cycle Special Report (i.e., a subjective overview of the relative maturity of an innovation), gamification has reached its ‘peak of inflated expectations’ (Rivera & Van der Meulen, 2013). While gamification holds considerable promise (i.e., turning any tedious or mundane activity into an engaging, motivating or enjoyable one simply by adding game design techniques), both designers (e.g., McGonigal, 2011) as well as game scholars (e.g., Fishman & Deterding, 2013) have distanced themselves from the term. The reason for this can directly be attributed to the hype and unrealistic expectations that surround the concept. Gamification is often seen as an easy to implement panacea, and - as game scholar and designer Ian Bogost discusses in his often cited blog post (2011) - such notions of gamification are simply missing the point. Games are not engaging as a result of high scores, experience points, badges, achievements, or other largely extrinsic reward systems. While such systems might expand an already engaging gaming experience, the real “magic” of games is arguably to be found in other areas of the game experience, such as its game mechanics (e.g. turns, limited resources, time constraints, etc.) and design principles (meaningful choices, clear goals, enduring play, etc.). By successfully implementing these elements of the game experience, ‘gameful design’ hopes to provide some of the ‘magical magnetism’ that gamification seems to be missing.

While the debate on which elements of game design are transferable to other context is still ongoing, academic literature has studied the effectiveness of gamification. In their analysis, Hamari, Koivisto & Sarsa (2014) analyzed 24 studies, some of which are focused on classic gamification (i.e., points, leaderboards, achievements, rewards, progress, feedback, etc.), while others include the recommendations of gameful design (levels, story, clear goals, challenge, etc.). The study concludes that while the results of the gamified experiments are partially positive, the success of gamification often depends on mediating factors, such as the motivations of users or the nature of the gamified system. As a result, it has been challenging for research to make claims that transcend descriptive findings and provide recommendations that can be generalized or transferred to other contexts. Furthermore, the study indicates that gamification mainly leads to short-term effects, and that these effects could be caused by the novelty effect. While these findings are certainly interesting, they are also very much in line with what motivational research has indicated for years: extrinsic motivation can lead to weak but positive short-term effects, and potentially detrimental effects to the individual’s desire to perform the activity in the long run (e.g., Bénabou & Tirole, 2003; Deci, 1975). Gameful design’s emphasis on game elements that move beyond the quick and temporary solution of extrinsic motivation therefore seems to be a potentially more successful approach to meeting gamification’s promise. However, there are no guarantees that this approach will always lead to intrinsic instead of extrinsic motivation, or that it can be applied to just any kind of non-gaming context.

Gameful Instruction

Education has not lagged behind in experimenting with gamification and gameful design. Hamari et al.’s literature review (2014) identified 9 studies that are using gamification for learning and education, which also follow the partially positive trend of the non-educational applications mentioned in the article. The authors identified a possible effect of increased competition in the class room (Hakulinen, Auvinen, & Korhonen, 2013), difficulties in evaluating a task (Domínguez et al., 2013) and increased work load in doing so (Rozeboom, 2012), and design problems that are unique to very specific contexts (Dong et al., 2012).

The academic literature also provides educators with advice towards the design of gameful classrooms. Stott & Neustaedter’s analysis (2013) who present 4 underlying dynamics and concepts that “*are shown to be more consistently successful than others when applied to learning environments*”: 1) freedom to fail, 2) rapid feedback, 3) progression, and 4) storytelling. Nicholson’s (2012) work provides a user-centered theoretical framework, while also focusing on a variety of theories and concepts that emphasize the importance of freedom of choice and meaningfulness. Kim & Lee’s Dynamic Model for Gamification of Learning (DMGL) (2003) and to widely announce a pure and right function of game through our model. For the theoretical contribution of gamification, we propose a dynamical model of game based learning that aims to maximize educational effectiveness that correlates with the four main primary factors (curiosity, challenge, fantasy and control provides a design model that is similar to acclaimed game design models such as the MDA framework (Hunicke, LeBlanc, & Zubek, 2001). Basing itself

on both game design theory, instructional design and the influential work of Thomas Malone (e.g., Malone & Lepper, 1987; Malone, 1980), DMGL aims to maximize educational effectiveness through four primary aesthetics: challenge (e.g., clear fixed goals, uncertain outcomes, appropriate difficulty levels, etc.), curiosity (e.g., progressive unlocking of new content, time-based patterns, thrills, comedy, etc.), fantasy (storytelling, audio, visuals, etc.), and control (i.e., offering the player control over the 'game'). Finally, Sheldon (2011) provides an overview of the many iterations that his gameful classes underwent.

In summary, the literature currently seems to indicate that there is potential value in adding game design elements to educational courses, while at the same time emphasizing the many issues and complexities that need to be considered in order to design a course using game design techniques. This article describes a design research project that attempts to facilitate engagement and intrinsic motivation among undergraduate students through the use of gameful instruction (i.e., instruction that adopts the principles of gameful design).

The Gradequest Project

The Gradequest project (De Schutter & Vanden Abeele, 2014) started in the Fall of 2013 by applying game design principles to a 3-credit hour undergraduate course on game design for educational purposes (N = 17; 7 female students. 10 male students). The game design elements that were used in course were derived from the previous literature that was mentioned above, as well as from literature on player motivation (e.g., Jansz & Tanis, 2007; Sherry, Lucas, Greenberg, & Lachlan, 2006) 2006 media enjoyment (e.g., Vorderer & Hartmann, 2009) and general game design (e.g., Adams & Dormans, 2012; Salen & Zimmerman, 2003; Schell, 2008). The course design strived for as much 'gamefulness' as possible (i.e. striving for activities that are fun in their own right, without having to rely on external reward systems to motivate students). Finally, Lee Sheldon's book (2011) on his 'multiplayer class rooms' had a large influence on the class' design. Briefly summarized, the course used the following game design elements:

- heroes (fantasy alter ego's for the students),
- guilds (a different term for a group of students),
- quests (a different term for the course assignments),
- a backstory (occasionally told by instructor during class),
- experience points (XP; gained by successfully completing quests and transferred to a grade at the end of the semester),
- achievements (rewards for certain goals in class),
- character levels (based on the amount of XP a student gained),
- character skills (in-class super-powers chosen when reaching a certain level), and
- leaderboards (high-score tables).

The course offered different types of quests. Main quests were unavoidable quests that took place in class on set dates (e.g., midterm, presentations, etc.). Side quests were quests that students could pick themselves (e.g., game analysis, game design, literature review, etc.). Finally, there were optional quests that students could do every week (e.g., blog posts, attendance, etc.) and random quests that could occur during any given session (e.g. pop quiz, short in-class assignments, etc.). Every quest was made as playful as possible, by attempting to add some sort of intrinsic value to it. For example, the midterm quest was named "Survive the Gauntlet", and was similar to Hasbro's Taboo game (i.e., a game in which one player explains a term without actually naming it, while the other players attempt to guess the word).

The course was managed using Gradequest, a custom designed PHP-based jQuery Mobile application that offers a back-end (allowing to grade the students and view their grades and skills) and a front-end that allowed the students to access a personal profile page, a quest overview page, a guild/team overview page, and a leaderboard.

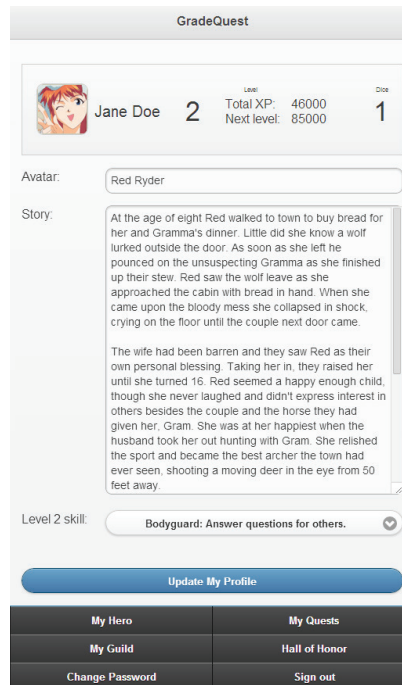


Figure 1: Gradequest's 'My Hero' screen on a smartphone

Evaluation of the first iteration

The research questions for the first iteration were:

1. How does self-reported intrinsic motivation and engagement of students differ from the non-gameful course?
2. Which game design elements improve/worsen students' self-reported engagement, enjoyment and motivation?
3. How can the course design (as well as Gradequest) be improved?

The study used mixed methods to answer these questions. During the semester, the students were asked to provide informal feedback whenever they saw fit. They could do this by talking directly to the instructor, but in addition, an online feedback form (using freesuggestionbox.com) was provided so they could provide feedback anonymously without having to fear any repercussions. At the end of the semester, two sessions of the educational game design course were devoted to evaluating the gameful design of the course. The evaluation was done using both quantitative and qualitative methods. The quantitative part was done using a Qualtrics survey. The questionnaire consisted out the Situational Motivation Scale (SiMS) (Guay, Vallerand, & Blanchard, 2000) and the core module of the Game Experience Questionnaire (GEQ) (IJsselsteijn et al., 2008). A focus group session was held after the students finished filling in the survey. During this session, the teacher acted as the moderator.

The gameful course was compared to a similar but non-gameful course on the principles of game design (N = 23; 4 female students, 19 male students). This comparison is published in detail in a previous conference paper that was published earlier this year (De Schutter & Vanden Abeele, 2014) publisher-place: "Fort Lauderdale, FL", event: "Foundations of Digital Games 2014", event-place: "Fort Lauderdale, FL", author: [{"family": "De Schutter", "given": "B."}, {"family": "Vanden Abeele", "given": "V."}], issued: {"date-parts": [{"2014}]}, schema: "https://github.com/citation-style-language/schema/raw/master/csl-citation.json". In summary, the comparison revealed how that the gameful instruction did not lead to expected higher levels of intrinsic motivation or engagement in comparison to the traditional course design. Instead, the non-gameful course scored significantly higher on intrinsic motivation ($t(16.163) = 2.802, p < .05$). However, when controlling for mediating factors (i.e., teacher effectiveness, classroom atmosphere, clarity of the course, competence development, prior interest, and playing time), the difference in intrinsic motivation between both courses disappeared ($F(0.335, 1) = 4.688, p = n.s.$). These results matched the findings of the various qualitative methods of data collection that were used during the project, as some of the students complained about needing more structure (~ clarity of the course) or about problems that occurred while trying to work on an assignment with other students (~ class atmosphere).

Design of the second iteration

For the second iteration, no significant changes have been made to the content or the learning outcomes of the game design for education course. The gameful aspects of the course did receive a significant update based on the evaluation of the first iteration.

Reduced course documents

While the majority of students in the course noted that they never had any problem figuring out the rule book, some students mentioned that it was “too long” or “complicated” for them to figure out. In order to avoid this complaint for the second iteration, and to simplify the tasks the instructor has to do, the rules of the course’s inner game were made clearer, less complex and more elegant wherever possible. As a result, the syllabus for the second iteration was 38% shorter (from 8,623 words to 5,328 words). The biggest reason for the shorter syllabus could be related to changes that were made to the quests and their evaluation (see below). The rest of the document largely remained the same. The syllabus also contained some new additions. For example, it now included a planning that clearly stated when each quest would start and when each quest was due, as some students seemed to have problem keeping track of everything during the first iteration.

Transparent quest titles

The first change that was made to the quests was the result of a student suggestion. During the focus group session at the end of the first iteration, a student asked to make the names of the quests more transparent. For example, the quest that required students to do a playtest session for their educational game design was originally named “Consult the Oracle”. For the second iteration, the quest was renamed to “Consult the Oracle of Playtests”. By doing so, the course keeps its fantasy theme, while potentially communicating the content of each quest better to the students.

More opportunities to fail (or succeed)

While the story quests (i.e., required and unavoidable in-class quests such as the midterm and final project quests) remained largely the same, the function and structure of the side quests were changed dramatically. The students could still pick their favorite type of side quest (game design, game analysis, or literature review) and their favorite medium (i.e., prototype, poster, or video) for a side quest, but they were now able to submit their side quest at five different times during the semester (as opposed to two times previously). This change allows for students to get a subpar evaluation or even a ‘wipe’ (i.e., the equivalent of an ‘F’) once and still be able to make up for it at a later time. To make room for the larger possible amount of side quest, the students were no longer required to write blog posts. Furthermore, some of the amount of experience points that was associated with the midterm and the final project was carried over to the side quests.

Unified rubrics

During the first iteration, students could pick one out of 6 possibilities for their side quest: write a literature review paper on the topic of games and learning, make a video about games and learning, analyze the educational potential of a game in a paper, analyze a game in a video, write a game design document for an educational game, or develop a prototype for an educational game. While the students were positive about being able to pick their preferred type of quest (with an overall score of 5.55 out of 7; see De Schutter & Vanden Abeele, 2014)^{publisher-place: "Fort Lauderdale, FL", "event": "Foundations of Digital Games 2014", "event-place": "Fort Lauderdale, FL", "author": [{"family": "De Schutter", "given": "B."}, {"family": "Vanden Abeele", "given": "V."}], "issued": {"date-parts": [{"2014}]}, "prefix": "with an overall score of 5.55 out of 7; see [", "schema": "https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} , every option required its own rubric and this led to a lot of confusion.}

For the second iteration, it was decided to expand the range of option to 9 possibilities (i.e., choose between a poster, video or prototype as the medium, and choose between game analysis, literature review or game design as the topic). Instead of providing a rubric for each possibility, a unified 4-item rubric was developed that could be applied to every type of side quest (and even some of the main quests). The new rubric evaluates the following elements:

- *Structure* is the extent to which a quest utilizes the structural form of the medium correctly; e.g., a text should be grammatically correct, a video should be edited properly, and a game should have clearly stated rules.

- *Presentation* is the extent to which a quest successfully uses audiovisual materials; e.g., a prototype should use graphics to support its theme, a text should use graphics to clarify its arguments, and a digital video should use in-game footage.
- *Source* is the extent to which a quest appropriately relates to high-quality sources; i.e., an educational game design should relate to empirical research in its design decisions, a paper should reference peer-reviewed research, and a video montage should reference its source materials.
- *Content* is the contribution of the quest to the field; e.g., a video or a poster should provide an insightful and relevant argumentation, and a game should contain interesting or innovative gameplay.
-

Less emphasis on guilds

The first iteration's emphasis on teamwork within guilds led to some problems. Some of the students were very enthusiastic about the course and willing to work hard, while others were not really interested in the topic and barely put in any effort. As a result, both groups became frustrated with each other which led to problems when students had to work together. To avoid this in the second iteration, the guilds' importance was minimized. Guilds are now only used for in-class quests such as ambushes (i.e., an in-class quiz game or assignment). In order to encourage students to work together and help each other, a new quest (named "A helpful hand") was introduced that rewarded a student who added a significant contribution to completing the quest of one or more other students.

Clearer communication of expectations

Aside from reducing the importance of the guilds, the second iteration also attempted to improve overall communication to the students. The first session of the course is therefore now fully devoted to communicating the rules of the course and to set the expectations. While the first iteration of the course already attempted to do this, the new version confronts students with some new messages. First, the students were told that this would be a challenging course that would require 6 hours of time investment outside of class on a weekly basis. Second, the students were confronted with fictional scenarios resulting in an F, a C and an A. In particular, the students were made aware that not doing any work prior to the midterm would result in a C or lower at the end of the semester. The students were also informed how they redeem themselves by doing optional quests to make up for another class leading to a less than optimal outcome. While these measures might seem harsh, they were deemed essential as some of the students voiced in their course evaluations that they expected a "casual and easy course about games" based on the title.

Improved backstory and presentation

While the first iteration of the course contained story and a narrative for the heroes, the majority of preparation time was invested in the course materials and developing Gradequest. One of the students mentioned during the focus groups that he loved the fantasy aspects of the course, but that the implementation was just too minimal. Since, the story elements also received a respectable score in the quantitative survey (with an overall score of 4.52 out of 7; see De Schutter & Vanden Abeele, 2014)^{publisher-place: "Fort Lauderdale, FL", "event: "Foundations of Digital Games 2014", "event-place: "Fort Lauderdale, FL", "author: [{"family: "De Schutter", "given: "B."}, {"family: "Vanden Abeele", "given: "V."}], "issued: {"date-parts": [{"2014"}]}, "prefix: "with an overall score of 4.52 out of 7; see "}, it was decided to invest more time into them for the second iteration. In particular, a map was used that was procedurally generated using the resources available through donjon.bin.sh/fantasy/world, and story elements were added to some of the lecture slides as well. For example, game scholar and designer Kurt Squire was transformed into a Gandalf-like figure warning students of upcoming ambushes, BF Skinner was depicted as an old vampire (i.e., Gary Oldman in Francis Ford Coppola's 1992 Bram Stoker's Dracula movie) who manipulates people through behaviorist techniques, and the first session opened with an edited version of the intro of the 1983 animated Dungeons & Dragons TV series in which "Venger, Force of Evil" was replaced with the instructor. To add to the fantasy aspect of the course, all e-mail communication between from instructor to the students was done in-character.

Hall of Legends

During the first iteration, students were given access to the "Hall of Honor" on Gradequest. This is a high score leaderboard showing the students' avatars and their level. (For privacy reasons, a student's name and actual

experience points were never disclosed with the other students. Furthermore, the levels stopped at an amount of experience points that was lower than the amount that was needed to get a D-.) The leaderboard was received well by students (4.78 overall score out of 7; see De Schutter & Vanden Abeele, 2014) and some students specifically pointed out during the focus groups that they felt that it was motivating. Therefore, the Hall of Honor was expanded upon in the second iteration, by adding the “Hall of Legends” to it. While the Hall of Honor contained a leaderboard with all current students, the Hall of Legends contains the top 3 students of a semester who are ranked by their total amount of experience earned during the semester. Students that manage to get into their top 3 will have their avatars and backstories immortalized for generations of students to come.

Discussion

The second iteration of the course is still in progress at the time of writing. (The research questions are the same for the second iteration.) After three weeks of classes, some differences with the previous iteration are noticeable. The class atmosphere seems to be improved drastically and the students have asked remarkably few questions about the rules of the course. The students also seem to be more engaged and less distracted. There has not been one occurrence yet of a student being preoccupied with Facebook or Reddit yet, and students are much more active in class. There is also a lot more playfulness.

While the first impressions are very positive, the changes that were described in this paper will be evaluated thoroughly at the end of the semester. In order to do this, the research questions and methods of the first iteration will be replicated, and expanded upon by also comparing the first and second iteration to each other. Furthermore, the evaluation will add Small Group Instructional Diagnosis (SGIDs) to its methods, and these will be held by a third party.

Our experiences with Gradequest so far lead us to believe that three guidelines are essential in designing a course that aims to engage and motivate students through game design elements. First, the role of the teacher, the class atmosphere, and the clarity of course documents cannot be overstated. If either one of these elements is preventing students from being engaged or motivated, then adding game design elements to a course will not help to achieve this. Second, the course designer should be very careful when implementing game design techniques, in particular if he or she is a gamer or game designer. It is easy to get carried away and end up designing a course that requires too much pre-existing knowledge about games. Finally, a course designer should communicate from day one that gameful instruction is all about challenges and engagement. Students seem to relate gameful instruction to fun and casual course with little work load, which is often not the best attitude to enter a course with.

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Learnable Computing with Kodu? Computational Thinking and the Semiotics of Game Creation Interfaces

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Introduction

More research suggests that easy-to-use game creation software, some of which feature visual programming environments, could help interest young people in computing while supporting their nascent development of computational thinking practices (Games, 2008; Kafai et al., 2010; Berland & Lee, 2011).

This paper looks at an afterschool program's use of a tool called Kodu Game Lab to introduce middle-school students to basic elements of programming. It investigates the unique design of Kodu's visual programming interface, and asks how learners think computationally with unique visual programming representations. To do so, it analyzes data from a programming challenge presented to middle-school program participants, and argues that the *economy of activity* embedded in Kodu's interface design shapes and structures participants' understandings of basic programming concepts in particular ways.

Theoretical Framework: Computational Thinking & Game Design

Understandings of computational thinking emphasize a person's ability to abstract problem spaces and use algorithms to systematically frame solutions – practices fundamental to high-level computer science practice (Wing, 2008). While the core emphasis in computational thinking is the use of algorithmic procedures to solve problems, some scholarship places more emphasis on building learners' competencies with programming languages (Guzdial, 2008). Aiming to support the development of computational thinking practices among young people, recent research initiatives have employed game- and animation-creation environments.

These game creation environments, like Scratch (Resnick et al. 2009, Kafai et al., 2010), AgentSheets (Reppenning & Sumner, 1995), and IPRO (Berland et al., 2013), use intuitive end-user, visual programming languages to support the development of computational thinking practices. These high-level languages are often integrated within visually-rich interfaces that attempt to support and scaffold learners' understanding of programming principles like conditions, iteration, events and modularization (see Berland et al., 2013).

Kodu Game Lab is one-such game-focused, high-level visual programming environment, which was developed by Microsoft Research. Kodu distinguishes itself with a unique visual interface (described below), which provides users with point-and-click tools that afford the fashioning of three-dimensional game levels. These tools allow the use to place characters and objects in a world, program those characters using conditional logic, and employ a set of game-focused commands to craft in-world events. Early research suggests Kodu aids in the development of foundational computational thinking practices (Anton et al., 2012).

Programming interfaces as semiotic-material 'pillars' of computational literacy

This study understands programming languages to be a material pillar, to use DiSessa's (2001) language, of computational literacy. In framing computational thinking practices as a form of literacy, DiSessa writes that every type of literacy has three pillars: material, cognitive and social. He further argues for the importance of representational form in shaping literacy practices and material intelligence. People, in DiSessa's reckoning, do not "have ideas and then express them in the medium"; rather, people "have ideas *with* the medium" (2001, pg. 116).

Scholarship in systemic-functional linguistics on multimodal representations has similarly been concerned with the interconnectedness between semiotic, cognitive and social elements of the world (Kress & van Leeuwen, 2006; Lemke, 2009). The way that people recognize, produce and think with images is in part a product of the "design grammar" visual of representations – the organization of depicted elements into semiotic-cognitive meanings. What, then, is the design grammar of Kodu Game Lab? And how does it shape the way that users *have ideas with the tool*? In what respects does the design of this tool render aspects of computational thinking more or less "learnable" (see DiSessa, 1977)?

The 'Design Grammar' of Kodu Game Lab

Kodu has two modes, an edit mode in which the player creates the game, and a play mode in which they play the game they have produced. The edit mode has two types of interfaces: one type concerned with world level design in which users can place objects and character, shape and design the landscape, and place automated character paths; and the second focused on object programming in which the character can set the behaviors of an object (or character). The former set of interfaces is immediately visible to the user in the 'default' edit mode, while the latter must be accessed by right-clicking on an object and selecting 'program.' Characters and objects are each individually programmed like agents – they each respond to the world in a different way (see Figure 1).



Figure 1: Programming a Kodu bot to find and eat apples

Designed originally to be interoperable on personal computers and gaming consoles, Kodu's programming interface uses a wheel menu that shows which conditions, actions or modifiers are available to be used. As of July 2013, the number of conditions and actions is large, with over 64 conditions and 111 actions available. At most twelve programming 'primitives' – conditions, actions or modifiers - are available to select on the screen at any one time, meaning that users have to navigate a multi-level hierarchy of wheel menu interfaces to find a primitive (see Figure 2).

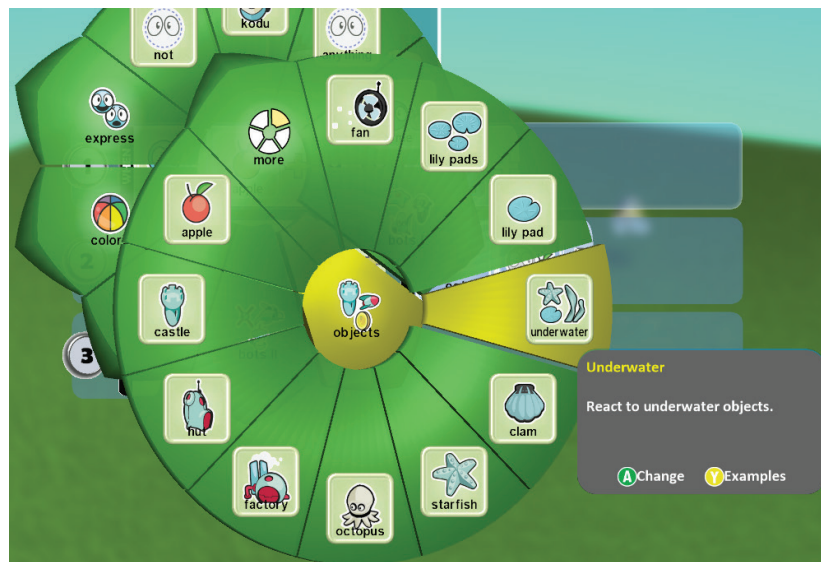


Figure 2: The programming interface shows a limited number of primitives at once

Data Sources and Research Context

Data analyzed is drawn from participants' Kodu files that researchers archived, audiovideo recordings of participants' activity, and researcher field notes from a nine-week after-school program at a middle school. Between 12-17 participants attending each session, and all participants were asked to commit to missing at most one session. Each session ran for one hour.

During the fourth week of the program, participants were challenged to solve a problem in the game world: Given two pieces of virtual land suspended in the air, how could they create a game where a character teleported from one piece of land to another? (see Figure 3) Participants were put into teams of two, and asked to collaboratively create a solution inside the Kodu programming interface. Six pairs of participants, eleven males and one female,

all between the ages of 10 and thirteen who had completed five introductory tutorials on object and character programming took part in the challenge.

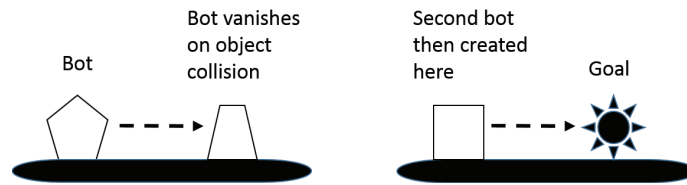


Figure 3: The solution to the challenge

In the starting condition, the following objects were already present in the virtual spaces: a) two game characters (called “Kodu bots”), one visible and one marked “creatable” – visible to creators but invisible in play; b) one object on each platform – a bumper and a rock; and c) a castle that marked the creator’s final goal. Participants were told that there was no single “action” that would solve the problem, that they would have to be creative, and that they would need to use a second character present in the file.

The second character, a “Creatable” character, was invisible in game play until instantiated though it was visible and programmable in Kodu’s edit mode. This challenge, which was a very difficult one for players in their fifth hour of game play, was a perhaps poorly conceived attempt to help participants understand that Kodu characters were instances of an object and not permanent figures in a game world as some participants seemed to think.

One correct solution to the problem is to create the illusion of teleportation: when the character hits an object on the first landform, it plays a vanish sound and becomes invisible. The sound event tells an identical second character-object to become visible on the second landform, giving the appearance of teleportation.

Methodology: Multimodal Discourse Analysis

This study employs multimodal discourse analysis (Lemke, 2012) to examine the design grammar of participants’ game artifacts relative to the authoring environment, and utilizes D/discourse analysis (Gee & Green, 1998) to examine how meanings are generated relative to particular contexts of activity (e.g. the visual grammar of the game, the social system of an afterschool club). This study was conducted as part of a nine-week design-based research investigation (Collins, 1992). Verbal data is represented using a version of *naturalized transcription* in order to provide a verbatim account of talk as social action (Jefferson, 1984).

This paper presents data from a single case study, chosen using “typical text” selection methods. Like other forms of qualitative inquiry in which external validity is established socially, through the accumulation and assessment of the collective body of research, this paper does not purport to demonstrate the external validity of its sample through its methods (Wodak, 2001). Rather, it adopts a purposive, convenience sample (Stake, 1995) as a means of iteratively developing constructs of inquiry relative to game creation, computational thinking and visual interface design.

Results

All groups failed to solve the difficult, in-game problem of ‘teleporting’ a Kodu bot from one floating island to another. But the nature of their attempted solutions is significant: Almost all participants’ attempted solutions employed actions that were visually prominent in the environment’s interfaces. The solution path of Chuck and Sean, presented below as a case analysis, was in many ways emblematic of participants’ problem-solving activities.

Chuck and Sean’s solutions: Bigger, faster, more explosions

First Solution: Level manipulation. Chuck and Sean initially sought to craft a solution to the programming challenge posed them that did not employ programming at all. Instead, they attempt to manipulate ‘physical’ properties of the virtual landscape and the objects within it. The first tried to flood the space with water, presumably so that their bot character could swim across the space between the floating islands. When their attempt to swim between the islands failed, they made their character bot bigger, believing that it might aid in the endeavor. These two actions – flooding with water and increasing character size – require little navigation of interfaces from the default edit screen. The water tool is immediately visible, requiring one click, and the size increase tool requires two. Neither requires use of the programming interface.

Second Solution: Exploding object. In their second set of solution attempts, Chuck and Sean focused on inserting an object – an exploding mine – into the world that would do the work of transporting their character bot for them. After placing the mine in the world, they switched to play mode, maneuvered the character-bot into it, and nothing happened. The two then increased the size of the mine, but then realized that they would have to program the mine to make it explode:

(0:05:35.2)C: Change size. Bi::ig °mine° (.) Per::fect.

(0:05:40.2)C: Ok so when- ((Opening Programming Screen))

(0:05:41.0)S: when (.) when bump. when [bump.

(0:05:44.5)C: bump]. it will- ((Searching primitive wheel menu))

(0:05:48.1)S: when bump into-

(0:05:48.9)C: it will- (2.0) °it will° (4.6) Oh! ((Searching wheel menu))

(0:06:04.2)C: it will- (3.9) it- (.) it will- ((Searching wheel menu))

(0:06:09.9)C: it will shoot? it will (.4) °shoot°.

(0:06:18.9)C: (hhh) (1.1) °cruise°.

(0:06:23.3)S: Alright? let see what happens?

In overlapping turns of sometimes self-directed talk, Chuck and Sean came to the joint realization that they will have to program the mine with the condition “WHEN BUMP KODU BOT, THEN [ACTION]” to try out their strategy. However, they were unsure what the [ACTION] should be.

The two spent almost forty seconds searching the wheeled primitive interface for an action to take. Much of this time was occupied by overlapping, self-directed talk, with long pauses as they sought to complete the conditional-like sentence “when bump into bot, it will explode” while trying to program that very sentence into the interface. However, they could only find the primitive action “shoot” instead of explode, so they chose to program the mine to shoot missiles upon colliding with a character bot. When they entered the “play mode”, the mine shot a missile into their bot upon collision, destroying it.

Third Solution: Launcher Creation. In their third solution attempt, Chuck and Sean tried to create a launcher that would catapult them between the two pieces of land, a more complicated iteration of their mine gambit. They conjectured that a large object, programmed to launch character bots on contact, would sling the character with sufficient velocity to make it to the other piece of land. To test out this theory, Chuck inserted a large castle-tower on the starting landform, prompting a moderator (M) to ask him what he was doing.

(0:07:05.1)M: Ok so you're creating a big castle over there?

(0:07:06.5)C: ° >Yeah so we haven't - I haven't - I have an idea for an action-°

(0:07:09.6)M: What's your theory?

(0:07:10.8)C: >My theory is (.) the castle's big enough that we're probably<

(0:07:14.0)C: We're going to put a launcher that will be strong enough to launch us

(0:07:16.9)C: Cause that launcher down there is too weak.

(0:07:19.7)M: Oh (.) well that's a theory

(0:07:21.0)S: >I HAVE- I have [an idea<

(0:07:22.0)C: >°Stop] stop stop°< we already- we already-

(0:07:24.1)S: The size! The size of the launcher.

Prompted by the moderator, Chuck outlined his theory that it is the size of objects that has to do with how far they can “launch” – a name of one of a catapult-like Kodu primitive – characters far enough to reach the other island. Sean, who seemed not to have been listening to Chuck, acted like he had reached the same conclusion independently.

After their launcher failed to propel their character across the gap, Chuck and Sean then tried launcher-based solutions that involved increasing the size and speed of their bot, solutions that also failed to accomplish their goal. Sean then pointed out that their launchers did not actually launching the bot. This observation frustrated both of them, and led them to abandon trying to formulate their own solutions. Instead they spied on others and mimicked their attempted solutions, and eventually ‘cheated’ by building a land bridge to between the pieces of land.

Discussion

Research has indicated that game creation tools, like Kodu with accessible and structured visual programming interfaces can support young people’s development of programming fundamentals and computational thinking practices. But questions remain about the manner in which these tools carry out this undertaking: How does the visual *design grammar* of a tool afford and constrain certain modes of problem-solving practice? What is the relationship between what is visible in an interface and what is learned?

The three solution paths of Chuck and Sean, which we understand to be typical of those in the club, gradually began to employ programming primitives that were further from the default edit screen. While their proposed solutions may seem naïve, they grew more willing to craft solutions that used programming primitives that were less perceptible to the new Kodu user that were deeper in the layered menu interface (see Table 1).

Solution Number	Action	Action Type	Interface Layer Depth
1	Character size increase	Object/environment manipulation	1
1	Flooding level with water	Object/environment manipulation	1
2	Programming mine to shoot missiles	Object condition programming	2
3	Programming castle to launch characters	Object condition programming	3
3	Increasing the size of the castle	Object/environment manipulation	1

Table 1: Interface Layer Depth of Solution Actions

However, at the same time, the hierarchical and layered nature of the interface may have been an influence on the willingness of Chuck and Sean to pursue overly-simple solutions. Kodu makes creating game actions easy because of its extensive primitives, but it may in turn encourage a reliance on using existing primitives instead of thinking creatively.

Conclusion

The larger question emerging from this study is: What is the nature, to paraphrase DiSessa, of having ideas and thinking with Kodu and other highly-visual programming environments? This qualitative study suggests that thinking about computational problems with Kodu Game Lab is bound up with the activity of exploring layered visual interfaces. Given the very-developed visual interfaces of programming tools like Scratch, AgentSheets and IPRO, it is also likely true that the understanding and interpreting of interfaces is intertwined with computational thinking with those tools as well.

While researchers focused on computational literacy have always been concerned with the relationship between thinking and representation, historically they employed simple textual programming languages, rather than visual programming interfaces that are complex visual semiotic systems. How then do design grammars of visual representation and interaction support new modes of computational thinking for learners, while perhaps

constraining others? What constellations of semiotic, cognitive and social relationships are engendered by new ways of representing programming?

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“About as Educational as *Minecraft* Can Get”: Youth Framings of Games and Learning in an Affinity Space

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Introduction

In this study, we address the ways that teachers, parents, and youth frame gaming activity in affinity spaces, focusing in particular on ways the popular game *Minecraft* are considered by both. As part of a larger study into how groups of teachers, parents, and youth interact around games in informal, online contexts, we aim to isolate the ways that language statements within these spaces reflect different goals, expertise, and intent toward games. If games and learning is to be consequential beyond the classroom, we need to better understand the ways that individuals with investments in instructional spaces consider and evaluate the potential of games.

This study focuses in particular on learning in terms of the relationships and interactions of *teachers* and *youth* within online learning contexts. As we are interested in investigating the sharing of knowledge and connections between these groups outside of instructional contexts, we focus on the *gaming affinity space* (Gee, 2005; Author, 2012b) as an informal situated learning environment, one which allows users to socially negotiate the meaning of phenomena (Barton & Tusting, 2005). By observing the interactions and communication of participants online, we examine how the sharing of knowledge and negotiation of terms related to *Minecraft* reflect different — and potentially consequential — framings of gaming activity.

Minecraft and Affinity Spaces

The open world game *Minecraft* (see Duncan, 2011) has become a surprisingly persistent hit with children and parents alike (Duncan, 2012a). With its relatively peaceful environment, large degree of freedom for the player to explore, create, and recreate the environment of the game, and multi-platform availability (originally personal computers, but also iOS devices, Android devices, and the Xbox), the game has been distinctly popular with young children in recent years. As such, projects such as *Minecraft.edu* (Levin, 2013) have attempted to leverage the game toward instructional aims, and the game has featured an intriguing interaction between those who have been interested in using the game to *teach* and those who have been drawn to the game to *play*. In the present paper, we argue that this interaction can provide us with an interesting window into the ways that instructional framings of games are more than just the purview of the teacher, and allow us to see how players (youth players, in particular) can become invested in the design of instructional uses of the game.

Affinity spaces give us a locus for these kinds of analyses, given the wide variety of participants who are drawn to them, and the range of potentially instructionally oriented discussions that have arisen within them. According to Gee, affinity spaces are important and understudied sites of situated learning. In these environments, “newbies and masters and everyone else” can interact with each other via correspondence over a “common endeavor” (Gee, 2004, p. 85). Also, he claims that the common endeavor of an affinity space provides a sense of unity through *anonymity* within affinity spaces, as participants do not have to share social factors such as age, geography, or occupation. We were curious as to how interactions changed when participants did share information regarding the instructional uses of games, and consequently focused on spaces in which participants self-identified as teachers, parents, or youth.

For this analysis, we have conducted analyses on textual interactions drawn from “/r/minecraft,” a “subreddit” found on Reddit.com. Reddit (located at <http://reddit.com>) operates as an umbrella site for multiple discussion topics ranging from politics to gaming to pornography. Drawing millions of users from over the world, Reddit hosts what we argue are actually *multiple* affinity spaces, each denoted by a different /r/ prefix and addressing topics of wildly different scale (e.g., from /r/askscience and /r/politics, to /r/breakingbad or /r/frugalmalefashion). serving to curate and host a number of interesting and contentious interlocking discussion spaces (see Bergstrom, 2011; Massanari, 2013 for recent critiques of Reddit). Given its potential to host discussions of any sort regarding *Minecraft*, as well as allowing participants of many ages to participate, subreddits have been the focus of recent investigations in digital media and learning (Duncan, Huang, & Georgen, 2014), and as such /r/minecraft was selected in this study for further analysis.

As part of our ongoing study investigating the interactions of teachers, parents, and youth in gaming-related affinity spaces, we focus here on just the *teacher-youth interaction* around games, elaborating a case study of one observed thread from /r/minecraft.

Instruction and /r/minecraft

We sampled a thread from /r/minecraft from August, 2013, entitled “Help. I’m a middle school teacher that wants to start a *Minecraft* Club with her students.” At the time of our sampling (in December, 2013), the thread contained a total of 153 comments, which had been upvoted by Reddit participants 85% times and downvoted 15% of the time, indicating a moderate degree of interest in the topic within the /r/minecraft community. Of particular interest was a discussion between the original poster (a self-professed, female teacher) and a respondent (a self-professed 9thth grade student of indeterminate gender). We have pseudonomized both poster names, referring to the teacher throughout this paper as “literatemuse” and the youth respondent as “doinstuff.”

literatemuse began the thread with the following (edited for length):

*I’m a seventh grade social studies teacher who is currently working throughout the summer (woohoo summer school!) A few of my students have asked me if I’d be willing to help them establish a *Minecraft* Club for the upcoming school year. I’m a little familiar with the program but I’m not sure how I can incorporate it with education. I’ve asked the tech coordinator at school but he hasn’t been much help. I thought I’d ask Reddit for help in setting this up.*

A few questions:

*-Where can I learn more about *Minecraft*?*

-Can it be used in an educational setting?

-What’s the cost to run a program like this for 15 students?

-Is there any way the “world” they create can stay private?

Not sure if this makes sense, but any reasonable suggestions help!

Thanks :)

The thread received many responses, including a rather detailed response by “doinstuff,” presented in an excerpted form below:

Hello! I am an incoming 9th grader, so I’ll see if I can be of help.

**Minecraft* in education is normally limited to team-building through construction projects, and used at an elementary school level. Seeing as you are a social studies teacher, you may see my idea as fit. If you are teaching the same material as my 7th Grade SS teacher, you may at some point want to do a social experiment with your students, and *Minecraft* could pass as a tool for that. But before I explain the experiment, you will need to know how to set up a server... [doinstuff describes technical installation issues]*

*Now for the experiment: Start the server and get all the players online. Then use the /spreadplayers command to distribute them evenly across a map. Then let the games begin. The students will have to gather resources to survive, which is normal to *Minecraft*, but the interaction between the players becomes a social experiment to see how people would survive in an anarchical society: will they team up and start towns? Will they fight off each other till the last man alive is all that is left? Will they burrow away and avoid all “human” contact? The interactions are all up to the students. After whatever period of playing time, I suggest you have a discussion with your students about events and interactions ingame and the motivations behind them. This may not be as educational as you might hope, but it is very fun and interesting and about as educational as *Minecraft* can get.*

*This whole idea is very similar to a public server i play on called *Civcraft* (/r/civcraft) that has basically the same setup and idea but with many modifications and plugins into the game and at a more intensive level, with cities, alliances, economy, and lots of drama. It is very hard to organize anything with friends on this server because the beginning spawn is completely random, and your friends on the server are the first few people you meet. In addition, most people on this server are between the ages of 14 and 17, but with plenty of young adults up to ages in the low 30s, so the maturity level is much higher and people often are assholes to each other and language you don’t want 7th graders hearing is thrown around like nobody’s business...*

While detailed and rather lengthy, this response reflected a degree of involvement from the self-professed 9th grader that was atypical for the thread, and served as an unusually eager contribution to the teacher's original request. We make no claims regarding the typicality of this response, nor do we have concrete evidence that doinstuff is actually a 9th grader or that literatemuse is a teacher. The post was the only response we could identify from a self-professed youth Redditor on this particular thread, and we are taking both the teacher and youth self-identifications at face value for the purposes of this analysis. Regardless, we found many of the forms of speech and specific instructional contributions of doinstuff in this post to reflect interesting insights into the ways that the players' lived experiences with the game (and school) influence instructional recommendations given freely in affinity spaces.

Discourse Analysis

In order to better understand doinstuff's post, we find ourselves in need of an approach that will allow us to investigate the specific framings of instruction and gaming that are present in the post. Due to space limitations, an analysis of just doinstuff's response will take up the bulk of the remainder of this paper, which we provisionally analyze using Gee's (2010) "big-D Discourse analysis" approach. According to Gee, beliefs, social roles, and cultural commitments can be revealed based on the language moves found in spoken and written text. Utilized widely in games and learning research (e.g., Steinkuehler's, 2006, classic, deep Discourse analysis of an eight-word utterance drawn from the game *Lineage*), Discourse analyses provide a window into meaning-making within gaming communities. In particular, they help to illustrate the ways that meanings of games and learning are negotiated and contested through a "deep read" of gaming-related text. We thus apply a Discourse analytic approach to the doinstuff post, as a method intended to draw out the engaged youth perspective on games and instruction in this context, as well as to highlight the ways in which the framing of the activity by the youth participant in the affinity space reflects perspectives on gaming and on students' roles in game-based learning environments.

We broke parts of doinstuff's post into stanza form, first isolated by utterance per line. Our intent was to isolate patterns and shifts in the use of his or her language throughout the excerpt, as a means of identifying how language marks shifts in conceptions of *Minecra*ct. doinstuff's "experiment" paragraph was of most interest — and most clearly a prescription for a specific form of instructional experience based around *Minecraft* — and so we present it here, broken into four thematic stanzas, presented below:

Stanza 1: Setup

line 1 - Now for the experiment:

line 2 - Start the server

line 3 - and get all the players online.

line 4 - Then use the /spreadplayers command

line 5 - to distribute them evenly across a map.

line 6 - Then let the games begin.

Stanza 2: Social Experiment

line 1 - The students will have to

line 2 - gather resources to survive,

line 3 - which is normal to Minecraft,

line 4 - but the interaction between the players

line 5 - becomes a social experiment

line 6 - to see how people would survive

line 7 - in an anarchical society:

Stanza 3: Research Questions

line 1 - will they team up and start towns?

line 2 - Will they fight off eachother [sic]

line 3 - till the last man alive is all that is left?

line 4 - Will they burrow away

line 5 - and avoid all "human" contact?

line 6 - The interactions are all up to the students.

Stanza 4: Classroom Implications

line 1 - After whatever period of playing time,

line 2 - I suggest you have a discussion

line 3 - with your students

line 4 - about events and interactions ingame [sic]

line 5 - and the motivations behind them.

line 6 - This may not be as educational as you might hope,

line 7 - but it is very fun and interesting

line 8 - and about as educational as Minecraft can get.

First, even before Stanza 1, it becomes clear that doinstuff has a technical understanding of the game (described in detail in the paragraph deleted for space considerations), which carries through to the theme of Stanza 1, which we label a *Setup* stanza. It is interesting that, in Stanza 1, line 1, doinstuff casts this not as "instruction" or even as a class exercise, but as an *experiment*, one that could put youth in a role not necessarily as learners or students, but as participants. For doinstuff, one of the implicit values of using *Minecraft* in the classroom does not necessarily appear to be to impart knowledge or practices through the game, but to delimit some form of "experimental" space in which students can perform (and presumably also be studied).

Also note (in lines 2-5) that the focus is upon technical positioning, using at least three levels of technical knowledge about the game — (1) "starting the server" (line 2), requiring knowledge of installing and running the software that creates a *Minecraft* server; (2) "getting players online," involving managing not just the server, but each student's client software (line 3); and (3) then using "spreadplayers" within *Minecraft* itself, in order to arrange students's in-game avatars in ways that would be efficacious for doinstuff's scenario (lines 4-5). doinstuff very quickly runs through several levels of technical requirement that may be rudimentary for a player who has been involved with *Minecraft* servers in the past, but is perhaps a bit presumptuous regarding levels of technical expertise that a typical teacher may have.

In Stanza 2, the tone of doinstuff's discussion shifts away from setting up the game and experience, and toward describing a "social experiment" that provides the core of doinstuff's suggestions to the original poster. In Stanza 2, line 1, it's interesting that doinstuff originally frames the "experiment" in terms of what the students in the classroom will do, then switches to a framing of "players" (line 4) and with implications of what will be learned about "people" (line 6). The free-form "social experiment" proposed by doinstuff amounts to an interesting negotiation between these three plural nouns — it is at once clearly intended to be an instructional experience of some kind (hence Stanzas 1 and 4), while also valuing that it leverages something "natural" about *play* in *Minecraft*, with the intent to discover something about how people interact, in general. And, perhaps because of this valuing of play as modeling some element of an "anarchical society" (line 7), doinstuff's framing of the experience is as a "social experiment" (line 5) that will yield knowledge about their "interaction" (line 4), rather than about the imparting of knowledge to the students.

In Stanza 3, this "social experiment" takes on an even more directly scientific framing, with a number of overt "research questions" proposed. For each of the three distinct questions proposed (line 1, lines 2-3, and lines 3-4),

the questions are not “how do students learn X?” but “what will happen when players are put into this situation?” doinstuff implicitly views *Minecraft* play as, essentially, a platform to simulate social dynamics, reifying Stanza 2’s framing of a “social experiment” with questions that are descriptive in nature, and provide the potential of using the game to understand human interaction rather than to address an overt curricular need. Ultimately, “interactions are all up to the students” (line 6), again indicating his or her framing of the experience as “experimental,” but also notable in that it presents an extraordinarily *student-centered approach* to game-based learning. For doinstuff, apparently games such as *Minecraft* are implicitly useful to educators for what they reveal about how people play and interact, not for the delivery of content, nor even for their role in promoting more amorphous digital literacy skills. doinstuff privileges gaming over instruction with *Minecraft*, and then apparently seeks to find a way to advocate for taking a genuine gaming experience into a classroom.

In Stanza 4, doinstuff seems to acknowledge that literatemuse’s curricular need should be addressed, and that a social experiment is probably not what was sought when she started the thread. As a means to instruct in some fashion, doinstuff suggests a “discussion” (line 2) with students, regarding “events and interactions” (line 4) that occurred within the game environment. doinstuff seems genuinely interested in having the game foster a discussion of these interactions and having the gameplay serve as a shared experience that can drive a meaningful classroom discussion relevant to the students (e.g., discussing “motivations”; line 5). But, doinstuff is sanguine in his or her assessment as to whether or not this kind of experience fits an “educational” framework as much as the teacher might wish; using *Minecraft* “may not be as educational as you might hope” (line 4), and this is “about as educational as *Minecraft* can get” (line 8).

Let’s pause and review those last three lines in Stanza 4, which are remarkable statements in a number of regards. First, they reflect an assumption (perhaps false) of what the *teacher* will view as educational experiences — that a shared experience of a “social experiment” (in doinstuff’s terms) followed by an in-class discussion is “not as educational as you might hope” reflects an assumption by doinstuff that for an experience to be “educational,” something other than discussion of a play experience must be at the center. It is unclear if doinstuff’s assumption is that an “educational” experience is related to the delivery of academic content in some form, or is related more strongly to the forms of knowledge and practice captured on standardized test, or reflects some other assumption about instruction with games. Regardless, doinstuff implies that freeform play followed by discussion may *not* be seen educational to a teacher, and as a consequence this statement reflects a telling bias regarding the forms of instruction he or she expects within a school-based setting.

But also, doinstuff implies limits to the very applicability of *Minecraft* to a school setting. While doinstuff’s elaborate and detailed post seems to indicate that he or she is excited at the prospect of aiding a teacher in this enterprise, “about as educational as *Minecraft* can get” shows that he or she believe that there are limits to using *Minecraft* in classrooms, or at the very least, limits to the particular conception of “*Minecraft*” that he or she values. What is “*Minecraft*” for doinstuff suddenly comes into question — clearly, doinstuff acknowledges that people use *Minecraft* in classes. Is doinstuff indicating that what counts as “*Minecraft*” for him or her is different than for a typical teacher? That the valuable experience that is “*Minecraft*” play is not necessarily the same thing as the digital artifact “*Minecraft*”?

We argue that doinstuff’s conception of “*Minecraft*” must be much closer to the naturalistic forms of play with the game (based on his or her “social experiment”) than it is to many adult *Minecraft*-in-schools advocates (such as Levin, 2013; e.g., conducting experiments in *Minecraft* or using *Minecraft.edu* modifications to apply to instructional units). doinstuff consistently privileges naturalistic forms of play in his or her brief post; the “social experiment” framing of the activity around the game involves only minimal intervention by a teacher during its conduct, and the instructional locus of the experience seems to come only afterwards, where the teacher helps to unpack it with students. For doinstuff, *Minecraft* is an open-ended environment for players to interact in, first and foremost, and therefore one can only incorporate such spaces into instructional contexts so much and in limited ways, without somehow violating why *Minecraft* is. The phrase “about as educational as *Minecraft* can get” refers to “*Minecraft*” not as the digital game itself, but as the concomitant *forms of play* that are fostered by the digital game.

Finally, though not part of the formal Discourse analysis presented here (due to space limitations), please note the final full paragraph of doinstuff’s original post, listed above. Within it, doinstuff declares that his or her “whole idea is very similar to a public server i play on called Civcraft (/r/civcraft).” This supports the interpretation that doinstuff is not only suggesting an instructional use of *Minecraft* that matches informal play with the game, but that it is reminiscent of a specific server’s form of play. The informal-yet-formal approach to school instruction proposed by doinstuff is interestingly mirrored by a similar formal-yet-informal approach to *Minecraft*; Civcraft’s subreddit (linked to by doinstuff in the post) indicates that there are social structures that support social organization even in these “informal” forms of play. Civcraft represents a form of socially-organized play “in the wild” (Hutchins, 1995), and as such, we can intuit that doinstuff may view preferred forms of play and instruction as being those inspired by the

activities in existing online communities.

Discussion and Future Work

This brief analysis highlights several provocative insights that can further help us to understand (1) the instructional assumptions that some youth bring to the application of games in the classroom; (2) the forms that authentic game-based instruction take to some youth; and (3) the limits to game-based learning with games such as *Minecraft*. We will unpack each of these in turn, and then discuss future directions for this work.

First, doinstuff's assumptions about what are expected uses of games in classrooms and what are not reflects an experience with schooling that begs further empirical study. While the freeform "experiment" proposed by doinstuff is one that appears to have been inspired by experiences with Civcraft and previous instructional experiences, doinstuff seems (reasonably) wary that a teacher he or she encounters in an online affinity space will be immediately receptive to such an approach. That is, doinstuff operates initially out of caution — even in an anonymous, online discussion space — given, perhaps, his or her age and the presumed power differential between a 9th grader and a teacher. Or, perhaps, this simply reflects that, for doinstuff, the kind of proposal he or she is making regarding using *Minecraft* for a "social experiment" might be seen as too alien to a teacher not already versed in the game. While there is a consequential power differential between a youth and a teacher that may have affected this discussion, one could view doinstuff's statements as indicating acknowledgment that many teachers are tech-averse and unfamiliar with informal uses of games. The role of schooling and the instructional biases of teachers rears its head here as a feared impediment that doinstuff feels the need to account for and to acknowledge.

Additionally, the openness of the "social experiment" proposed by doinstuff is interesting. For many in the games and learning community, the utility of games for learning are often in the ways that games can serve as "educational technologies" and be connected to concrete learning goals. For doinstuff, a self-professed 9th grader, this seems to be of little interest. Rather than utilizing *Minecraft* to deliver academic content, *Minecraft* seems to serve as a "platform" (Author, 2012) that would allow a "social experiment" to occur. In other words, *Minecraft* may have its educational uses, but they seem to be as substrates upon which other experiences can be layered. For doinstuff, these other experiences are less about instruction and more about *experimentation* — using the game to provide a learning experience rooted in play and questions about behavior (Stanza 3, above).

To reiterate: doinstuff seems to mean something very different by "*Minecraft*" than literatemuse means, and that we as a games and learning research community often mean. doinstuff delimits discussion of the technical aspects of setting up the game, never referring to *Minecraft* in what we've broken off as Stanza 1. In subsequent Stanzas, the meaning of the term "*Minecraft*" reflects a perspective focused almost entirely upon the game as a means of fostering freeform play, and as a platform that will allow for social experiments to take place that can serve as the basis for inquiry into human interaction (Stanza 3's "research questions"). For doinstuff, *Minecraft* is not an "educational technology" by any means, but is a *game*, one that fosters its own unique forms of play and can reveal something about human activity, but is not a tool with which to *deliver* educational content.

Finally, doinstuff's post seems to indicate a perspective in which there are limits to game-based learning using games such as *Minecraft*. He or she states that the "social experiment" approach is "about as educational as *Minecraft* can get," again reflecting that his or her conception of *Minecraft* is predicated in some way on freeform play and social interaction. This clashes distinctly with many forms of advocated *Minecraft* play in formal and informal instructional contexts — Minecraft.edu's approach to layering instructional tools into the game through server modifications reflects a common intent to take the game and reshape it to fit within an instructional space. If one conceives of the game as the digital tool, this seems reasonable and feasible; for doinstuff, since the conception of "*Minecraft*" is about the forms of play fostered by the game, there are limits to this approach.

As we further develop this line of research, we wish to balance Discourse analyses such as these with "deep reads" of teacher posts in online affinity spaces, perspectives from the parents of *Minecraft*-engaged youth, and then the interactions between all three of these perspectives. Only so much can be gleaned through a view of online affinity space text, of course, but these do give an interesting look at "in the wild" conceptions of games, instruction, and the relationship between them that may be difficult to glean from other sources. While we aim to supplement these analyses with further interviews in the future, we note that the online affinity space presents as close as we have to understanding the conceptions of games and learning of children outside of interview contexts, in which interviewer, parental, and teacher influence may yield very different results. In an interest-driven, open space such as /r/minecraft, no one (apparently) is forcing doinstuff to share his or her thoughts on *Minecraft*, and we should acknowledge these volunteered opinions as a piece of the larger puzzle of understanding youth conceptions of games and learning.

And, while a Discourse analysis of a single post may have limited utility in terms of describing generalizable insights regarding attitudes of players, youth, and teachers toward instruction with *Minecraft*, it also serves a *generative* role in terms of defining questions to investigate for future analyses. One final insight that we found most provocative in doinstuff's proposal regarded not just the meaning of the word "*Minecraft*," but the particular path that he or she took in his or her brief proposal. We glossed this path in the Discourse analysis as four stages:

Setup → *Social Experiment* → *Research Questions* → *Classroom Implications*.

In future work, we wish to explore these potential stages, and investigate if there are generalizable patterns here in the ways that youth discuss potential instructional approaches with games and learning. Do youth focus on the technological impediments first? Do they frame the instructional activity before they frame the questions that will be yielded by the activity? Do they have common approaches to addressing classroom instruction with games? As we further refine and develop game-based learning, we find ourselves returning again and again to our conception of "games." doinstuff's argument reflects that there is still much work to be done in understanding youth conceptions of both games and instruction, but also there is much reflection to be done by games and learning scholars and practitioners to uncover the hidden assumptions about games that may be guiding the field.

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[http://explosm.net/comics/1022/Political Agenda: A Cognitive Game for Political Perspective Taking](http://explosm.net/comics/1022/Political%20Agenda%3A%20A%20Cognitive%20Game%20for%20Political%20Perspective%20Taking)

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In a democracy, overcoming societal challenges such as climate change, hyper-inequality and education requires an alert and knowledgeable citizenry. Researchers, educators and practitioners have recognized the need for a *new civics* that provides citizens with the abilities to effectively participate in the democratic process (CIRCLE 2003) and for learning technologies that help them become civic innovators. One ability citizens must develop to become effective participants is *political perspective taking*, that is, the ability to reason about the ideological values of others and themselves (Fitzpatrick, Hope, Barahumi, Krupnikov & Easterday, 2012). How might educational games help students learn such a complex and ill-defined skill?

Background

Games for civics. Games have great potential to promote civic learning, but it is unclear whether they can promote the complex abilities needed for civic participation. Recent reviews of educational games conclude that games can promote learning but also that high-quality evidence on games is scarce (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Federation of American Scientists 2006; Honey & Hilton, 2011; Tobias & Fletcher, 2011; Young et al., 2012). Furthermore there is relatively little research on games for civics. iCivics (2011), a non-profit organization founded by Justice Sandra Day O'Connor, has created nearly a score of civics games, but work presented at GLS questions whether learners can apply what they learn from the games to outside political realities (Stoddard, Banks, & Nemacheck, 2013). Raphael, Bachen, Lynn, Baldwin-Philippi and McKee (2010) argue that civic games should connect: content to gameplay, individual action to social structure, and ethics to expediency. There are examples of civic games that increase understanding of a citizen's role in addressing societal challenges (Chee, Mehrotra, & Liu, 2013), but for now, games for civics remains a largely unexplored territory.

Ill-defined domains. One of the difficulties of designing games for teaching civic abilities is that we are still trying to define the new civics (Gould 2011). Easterday (2012) argues that civics incorporates the disciplines of policy argument, civic journalism and activism. However, disciplines such as policy argument are ill-defined (Rittel & Webber, 1973; Voss 2005). That is, unlike domains like algebra with correct solutions and clear steps for solving problems, problems in ill-defined domains: do not have single correct answers, can be framed in different ways, require argument to justify, and so on. Easterday, Aleven, Scheines & Carver (2009) showed that we can address this issue of ill-definition in policy argument through a cognitive framework that makes policy argument well-defined enough to teach in games. However, they ignore an important skill: reasoning about political values. For example, when reasoning about whether to adopt a policy that will increase taxes to provide universal health care, citizens not only need to know that the proposed intervention will have the desired effects (a causal argument), they also need to know which outcomes are affected (greater tax burden, greater access to health care) and how different ideologies value those outcomes.

Political perspective taking. The complexity and diversity of approaches that different disciplines have taken with respect to understanding political perspective taking presents an additional challenge. Political science has done a great deal of work on polarization (Layman, Carsey, & Horowitz, 2006; Abramowitz & Saunders, 2008) although much of this work focuses on distinctions between Democrats and Republicans—parties composed of heterogeneous, conflicting ideological groups and that do not provide categories with enough nuance for political perspective taking. Political philosophy has spent thousands of years on questions of ideology and justice, producing theories such as Bentham's utilitarianism, Novack's liberty, Kant's categorical imperative, Rawls's difference principle, etc. (Sandel 2010). More recent work in moral psychology has explored the social, psychological and evolutionary basis of our moral intuitions upon which we base our political judgments (Haidt 2012).

Cognitive games. Even if we can define the ill-defined domain of political perspective taking and reconcile the different disciplinary approaches, we must still design a game that provides effective feedback. Situational feedback, of the type often provided by game environments, is not always sufficient guidance for teaching complex problem solving (Nathan 1998). At a recent GLS Fireside chat, Denham (2012) proposed that we might be able to increase the effectiveness of games by combining them with intelligent tutors that provide *step-level* feedback on each stage of problem solving (VanLehn 2006), as opposed to feedback only on problem solutions. A recent meta-study of intelligent tutoring systems shows that they can increase learning nearly as well as individual human-tutors in well-defined domains (VanLehn 2011). In fact, recent studies on cognitive games (that embed intelligent tutors in

game environments) show that they improve learning and interest better than games without tutoring (Easterday, Alevan, Scheines & Carver, 2013; Easterday & Jo, 2011). Of course, using cognitive games assumes that we can articulate the knowledge and skills for political perspective taking in the first place.

Purpose

The purpose of this design-based research study was to determine how we might design a game for teaching political perspective taking. Our design argument claims that we *can* teach political perspective taking to undergraduates using games that:

- (a) define perspective taking as a 5 step process requiring an understanding of moral foundations theory, the cultural attachments of different ideologies, and common policy interventions;
- (b) have fantasy environments where players achieve success through predicting policy positions and that obscure demographic information about characters; and
- (c) use embedded intelligent tutoring.

In this paper, we describe the evidence gathered through the design-based research process that led to this argument. This contributes to research on civic education, games and learning, and moral psychology by providing a well-defined model of political perspective taking, showing limitations of a traditional game design, and showing how we can design more sophisticated cognitive games that overcome these limitations.

Phase 1: Assessing political perspective taking

The purpose of the first iteration (described in Fitzpatrick et al. 2012 and summarized here for clarity) was to evaluate the need for a political perspective taking game by assessing students' political perspective taking skills. Survey responses were collected from 187 students enrolled in political science classes at a private Midwestern university. Students were given 4 different policy interventions (on gun control, immigration, health care, and national security) like that in Figure 1, and asked how five different political ideologies (Libertarian, Egalitarian, Utilitarian, Liberation-Theology, Confucianist) would respond, either: *support*, *oppose*, *it depends*, or *not sure*, and asked to explain why.

Policy: SB 1234: Health Care Currently 20% of the population does not have secure health care coverage. The government has decided to provide healthcare to all of its citizens. This system is funded by a progressive tax that runs from 0 to 3%. Households that make over \$150,000 per year will pay 3% tax. Households that make less than \$150,000 per year will not be taxed

Figure 1: Policy question

On average, students answered 62% (M=12.49, SD=.81) of the questions correctly, showing that there is great room for improvement even among political science students at an elite university. Not a single participant scored a 20 out of 20. 5 participants (2% of the sample) scored 90% (18 out of 20 questions).

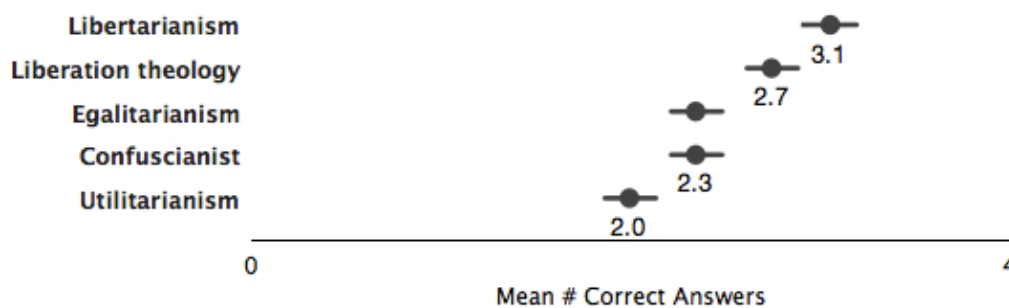


Figure 2: Some ideologies, like Libertarianism, were easier to reason about than others, like Utilitarianism.

Figure 2 shows the average number of correct answers for each ideology. An ANOVA of the differences between the scores on each ideology found that some ideologies were significantly easier to reason about $F(4,930) = 34.91$, $p < .0001$. Tukey post-hoc comparisons showed that the easiest ideology to reason about was: (a) libertarianism (M = 3.05, SD = .98); followed by (b) liberation theology (M = 2.74, SD = .86); then (c) Confucianism (M = 2.34, SD

= .95) and egalitarianism (M = 2.34, SD = 1.00); and finally (4) utilitarianism (M = 1.99, SD = .94). For each pairwise comparison except Egalitarianism and Confucianism, $p < .002$; and for the Egalitarianism and Confucianism, $p = 1.0$.

Phase 2: Field test of the Perspective Detective game

Given the results of phase 1, the purpose of phase 2 was to explore the feasibility of a game for teaching political perspective taking. The challenge is to design a fantasy environment where the learning task is tightly integrated with gameplay. Researchers have found that fantasy environments (Cordova & Lepper, 1996; Schell 2008) and integration (Habgood & Ainsworth, 2011) can increase learning. For civics games in particular, researchers speculate that connecting content to gameplay, action to social structure and ethics to expediency should also increase learning (Raphael et al., 2010). Other researchers have shown that interactively contrasting viewpoints improves moral reasoning (Cavalier & Weber, 2002).

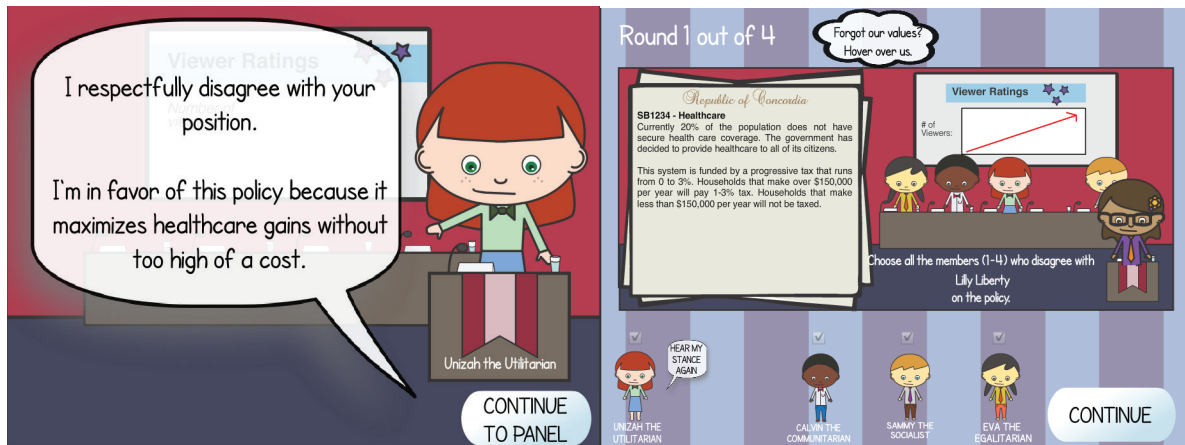


Figure 3: Screenshots from the digital prototype of Perspective Detective

Perspective Detective.

In Perspective Detective (Figure 3) players assume the role of a political talk-show host assistant whose task is to construct the most contentious debate panel possible in order to increase the show's ratings. The game begins by introducing 5 ideological partisans including: Calvin the Communitarian, Lilly Liberty, Unizah the Utilitarian, Sammy the Socialist and Eva the Egalitarian. The player chooses one character to be the show's "star." During each policy debate the player must: play the political perspective of the star character and choose the 1-4 partisans that are most likely to disagree with the star.

At the beginning of each round, the player must decide whether the star supports or opposes a particular policy (Figure 1). After the player chooses the star's position, the game explains the star's position in more detail. If correct, the player's score increases. If incorrect, the player must choose again (to ensure understanding of the star's viewpoint).

Next, the player must choose all members who will disagree with the star. In each round, the player is given the opportunity to use a hint by clicking on any of the members to hear his/her stance on the policy. The player can also ask each partisan to describe their ideology at any time and see the partisans' positions that were already described in the same round. After choosing the panel, the player watches as the animated ratings of the show go up or down (depending on whether the player chose the correct opponents) and hears the stances of one of the opponents. If the player is correct, his score increases and moves on to the next round. If the player is incorrect, his score decreases and he must attempt to choose the correct panel again. If the player repeatedly fails to construct the best panel after hearing all the opponents' viewpoints on the policy, his score decreases and he is shown the opponents he should have chosen. The player can optionally hear the stances of all members before moving to the next round.

The game has 4 rounds with policies on healthcare, national security, immigration and gun control. The player's total score determines whether he will keep his job, be fired, or promoted. By the end of the game the character would have taken on the perspective of their chosen star for all four rounds as well as learned about the viewpoints of the other character's ideologies from hearing their stances on the various policies. Perspective Detective was designed through many rounds of user-testing in which we iteratively refined the fantasy environment, character

personas, information availability, incentives, feedback, etc.

Method

To test the effectiveness and desirability of the game, we conducted a field test with the following:

- **Setting/Participants.** Students enrolled in an Introduction to Social Policy course at a private Midwestern university were given the option to complete an essay or participate in the study. All 19 students elected to participate in the study and 14 completed the study.
- **Research design.** We assessed the learning effectiveness of the game using a single-group field-test with pre- and post-assessments.
- **Procedure.** Participants were given 2 days to complete the pre-survey, 2 days to play the game at least once and 2 days to complete the post-survey.
- **Data collection & analysis.** The pre- and post-assessment included 20 questions in which learners determined how each of the 5 ideologies responds to 4 policies. Data were analyzed with a paired t-test. We also solicited positive and negative feedback on the game and logged times played.

Results

Learning. The group mean for content knowledge survey scores decreased from 14.57 (1.74 S.D.; 73% correct) in the pre-survey to 13.71 (1.59 S.D.; 69% correct) in the post-survey but was not statistically significant; $t(26) = 1.36$, $p = 0.184$. These results suggest no learning gains from playing the game.

User-experience. Three of the 14 participants reported playing the game twice although not required to, indicating a strong interest in the game. The average game score was 7/20 points, suggesting that the game was difficult. Participants reported enjoying the game and liking: the “proposed bills,” the “different characters,” the core mechanic of the game: “choosing oppositions,” and the “feedback given on each move.” Some thought the game was “easy to understand and play,” while others said that “it was too complicated,” and “I was a little confused as to what I was supposed to do.” The most frequent criticism was the need for additional feedback and practice: “I think the game could be longer,” “I did not like that the people did not explain/give more details of their position if you got it right,” “there was no feedback other than yes or no and you had to keep guessing combinations without that feedback,” and “the characters’ positions are very vague, it would have been nice to include examples of policies they would support.”

Phase 3: Design of Political Agenda, a cognitive game with intelligent tutoring

Perspective Detective’s fantasy environment seemed to engage students in political perspective taking but did not promote learning. We therefore designed a second version of the game, Political Agenda and altered our design argument in 3 ways: (a) the fantasy environment uses non-human characters to avoid interference from players’ stereotypes; (b) the game teaches reasoning strategies based on the more intuitive Moral Foundations Theory; and (c) an intelligent tutor provides more in-depth step-level feedback.



Figure 4: Political Agenda

Change 1: Fantasy environment. In early user-testing, participants indicated that their perspective taking was influenced by the character's appearance: "I viewed the younger looking characters as more liberal, and the older looking ones as more conservative." So in Political Agenda (the successor to Perspective Detective), learners continue to play the role of a political talk-show host assistant but the partisan avatars consist of animals in suits (Figure 4). Players find these characters humorous and, more importantly, they do not evoke the stereotypes that interfered with learning perspective taking seen in Perspective Detective.

Change 2: Moral foundations theory. Political Agenda teaches student to use an elaborated version of *Moral Foundations Theory* (MFT, Haidt 2012) rather than political philosophical concepts to analyze political values. MFT describes 6 moral intuitions (*caring* for the weak, *liberty* from oppression, *fairness* or proportionality in treatment, respect for *authority*, *loyalty* to the group, and *purity* of sacred entities). All individuals use all foundations when making moral judgments, but particular ideologies rely more heavily on particular foundations (e.g., liberals emphasize *care*, libertarians *liberty*, etc.). MFT provides a bridge from intuition to political perspective taking by making the common ground between ideologies explicit and showing how ideological differences are a result of emphasis, rather than a result of avarice, ignorance or cynicism. Furthermore, MFT is based on everyday psychological intuitions, so it provides a grammar for analyzing political perspectives that is easier to learn than the constructs of political philosophy. Unfortunately, MFT does not fully define political perspective taking because it does not define the cultural objects of our moral intuitions. For example, both liberals and libertarians care about liberty, but libertarians worry more about liberty *from government*, whereas liberals worry more about liberty *from concentrated economic power*. So political perspective taking requires understanding: (a) MFT, (b) the cultural objects of ideologies, and (c) how intuitions support/oppose policy interventions and outcomes.

Change 3: Intelligent tutoring. The feedback in *Perspective Detective* was insufficient—learners did not always understand why the character did not take the predicted position even given repeated explanations of characters' positions. Embedded intelligent tutors that provide step-level feedback in games can increase learning (Easterday et al. 2013; Easterday & Jo, 2011), but only if the steps can be well defined. We argue that basic political perspective taking can be broken down into 5 types of questions that rely on knowledge of the MFT of each ideology, cultural attachments, and policy. We have implemented this reasoning strategy in Political Agenda. Figure 5 describes how these questions are asked when tutoring the player on the libertarian character's position on health care policy (Figure 1).

1. Which moral values do libertarians care about most?

Options: Care / **Liberty** (correct) / Fairness / Loyalty / Authority / Sanctity

Feedback to "care": No—libertarians care more about liberty, not that all people are taken care of.

2. Which moral values does this ideology also care about? (Not asked for the libertarian character)

3. What do libertarians want freedom from? (Other ideologies, could also be asked about authority and sanctity in this step)

Options: **government** (correct) / corporations

Feedback to "corporations": No—libertarians care about freedom from government rules. Business leaders should be free to make their own choices and individuals to enter freely into contracts.

4. Does the value of liberty support this policy? (Asked for each of the characters' primary values)

Options: Pro / Indifferent / **Con** (correct)

Feedback to "pro": No—this liberty imposes a mandated responsibility (not necessary for upholding security, rule of law, contracts etc.)

5. Overall do the values support the policy? (This is relevant for ideologies with conflicting values)

Options: **Pro** (correct) / Indifferent / Con / Conflicted

Feedback to "con": No—this policy does not increase liberty.

Figure 5: Sample tutoring for libertarian position on health care. Feedback is for incorrect response.

Discussion

In this design research study, we asked: How might we design an educational game that helps students learn political perspective taking? Phase 1 showed that students find political perspective taking difficult and thus a learning need worth addressing. Phase 2 shows that we can design engaging game environments for political perspective taking but that typical game-based approaches to feedback are not sufficient for teaching such a complex skill. Phase 3 shows that we can define political perspective taking well enough to provide the step-level feedback shown to promote learning of complex skills.

These findings lead to the design argument that we *may be able to* teach political perspective taking by using games that: (a) define perspective taking as a process requiring an understanding of Moral Foundations Theory,

the cultural objects of different ideologies, and common policy interventions; (b) have fantasy environments that ask players to predict policy positions and that obstruct stereotypes; and (c) use embedded intelligent tutors. This work contributes to research on civic education, games and learning, and moral psychology by providing a well-defined model of political perspective taking; showing limitations of a traditional game design; and showing how we can design more sophisticated cognitive games that overcome these limitations. While there is still much work to do, this study brings us closer to our goal of designing games that teach political perspective taking, a necessary skill for an alert and knowledgeable citizenry.

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Finding the Journal of Odysseus: Making and Using Pervasive Games in the Classroom

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What is a Pervasive Game? And Why Should I Care?

A “pervasive game” is a game that exists across multiple mediums including the *physical* environment around the player. This genre of game is closely related to “alternate reality games” (ARGs) and is usually understood to only deviate from ARGs in that ARGs exist *only* within digital media; however, both utilize a core narrative that usually places the player in the explicit or implicit role of an investigator, who uncovers the narrative and subsequent content as they solve puzzles to bring the game to its conclusion. In addition, the narrative is often “archaeological” in nature: the story develops through “found documents” and media that the player discovers either directly or indirectly as they solve the game’s puzzles.

Pervasive games are a natural game “platform” to use in a classroom. Pervasive games do not require a pre-existing graphical engine, like a video game, nor do they require a static physical space and equipment, like a tabletop game. Pervasive games can be the best of both the digital and physical worlds. Even better for the classroom: *they can be designed by you to fit nearly any lesson, unit, curriculum, or student need*. It’s an educational reality that sometimes pre-existing games can be very exciting square pegs for the round holes of classroom demands. The custom and modular nature of pervasive games, combined with their relative ease of content creation, allows educators to design fun, engaging games that can directly support their unique curricular goals and learning outcomes. This paper will explain some of the basic elements of the pervasive ARG, demonstrate how educators can construct some of the major mechanisms, and illustrate how ARGs are a dynamic toolset for any classroom.

Dungeons & Dragons & Classrooms

I became an educator because over the years I had several excellent teachers who showed me that learning is not just medicine one has to swallow painfully and benefit from, but a joyful, powerful experience that one can - and should - guide your life with. If as a student I had a few lessons every year that I really enjoyed doing, surely I could, over time, design an entire year long curriculum that captures that joy from beginning to end. This was my starting point. As a lifelong gamer, I long ago recognized how much intellectual prowess, resilience, and focus games can demand from their players. Games clearly seemed like the vehicle to combine both experiences.

Like many teachers, I can get frustrated by the lack of engagement in many students and see it as a primary responsibility to design my lessons to be as impactful as possible. Some of this is a natural characteristic of adolescence, but much of it is a result of the antiquated way schools and curriculums are still structured. Perhaps ironically, games are an ancient way of overcoming this apparently modern problem. We are hardwired to learn by playing: *we learn to game and we game to learn*.

I knew games had potential because I had a few teachers of my own who used games in their classrooms to great success. My 9th grade English teacher (who inspired me to become an educator) used his love of role playing games like *Dungeons & Dragons* to help us dive deeper into our reading of Homer’s *Iliad*. He assigned every student a character and laid out the rules for what was essentially a collaborative creative writing exercise. By reading deeply into *The Iliad*, including chapters we skipped as a class and outside mythological sources, you could acquire information about your character - be it a legendary weapon, ability, ally, etc - and you could use that source to write your own version of the Trojan War, one week at a time. It was instantly one of the most enjoyable classroom experiences I ever had despite its relatively simple design. That unit rattled around the back of my mind during my first few years of teaching, but it wasn’t until I played Funcom’s Massively Multiplayer Online Role Playing Game (MMORPG) *The Secret World* (2012) that I was able to take this vague impulse for classroom gaming into a real executable unit. *The Secret World* places thousands of players in a shared online world where they, as agents of clandestine organizations (e.g. The Illuminati or The Templars), interact in a game universe full of supernatural dangers and conspiracy theories come to life.

What attracted me to the *The Secret World* was what they call “Investigation Missions”. I read an early review that lauded them as deep and interesting puzzle solving experiences, a large departure from the usual fare in MMORPGs which are infamous for including dull, repetitive tasks whose completion is often referred to as “grinding”, since they are necessary for progression but are generally considered boring on their own. The Investigation Missions in *The Secret World* required the player to not only use the information and events contained within the game but, primarily, the built-in Google browser to search the Internet for the relevant information and clues to solve

the puzzle. A few hours into the game I realized what they had done was include ARG style puzzles and weaved them into the virtual landscape of their game. It all hit me at once: the portability of cross-media ARG puzzles, the dynamic nature of using real world information in a fictional game world, and the ancient Siren song of puzzle solving. I realized I was spending hours researching arcane topics, decoding, and sweating over riddles just to play a game. I also realized that the game engine itself was not integral to the experience...I could make these puzzles! Immediately, *Dolus*, the game about the crafty thief who has stolen the journal of Odysseus, was born.

Begin at the beginning...

The most intimidating factor to creating a pervasive game is that you are immediately confronted with a fire hose of choices. However, that is also the game's greatest strength, as you have a nearly unlimited palette of tools to create your puzzles, very few of which require any type of expert design knowledge. The first piece of advice for puzzle creation is: *steal!* Start paying attention to puzzles and problem solving in your favorite games, movies, books, and TV shows (the mystery genre is particularly ripe for the picking). Ask yourself, "could this puzzle solving experience exist on its own or in another format?" Any challenge or puzzle that connects to your lesson outcomes or the skills you want your students to focus on can potentially be used. Using the scaffold of pre-existing puzzles will not only help you get started, but will help you branch out and create your own once you see how they tend to work. I like to think chronologically, so I started at the first puzzle for *Dolus* and worked from there.

The first puzzle in any pervasive ARG is what is referred to as "The Rabbit Hole". Like Alice in Wonderland, this is the first step into the fictional universe of the game. Most pervasive and ARGs operate under the ethos that "This Is Not a Game": part of the fun of ARGs is pretending that the player has accidentally stumbled onto a hidden reality heretofore unknown to them; the multimedia element of the game synergizes perfectly with this: suddenly the game world is *everywhere*, if one looks hard enough. The Rabbit Hole is the door into the ARG universe and the introduction to the game itself. A common way to create this "rabbit hole" is to use a popular mechanism of ARGs: the found document; for *Dolus*, that would be a fictional article purportedly from the BBC. I decided that a fake news article would be a great way to put the game at their fingertips and a perfect introduction into the "This Is Not a Game" mindset. I found Pages by Apple to be a great resource for document creation since I lacked experience in Photoshop or other professional level design programs. To create it, I went to the BBC World News site and by using screenshots, simply copy and pasted the different web page elements onto a blank page in the same style. I then formatted the article text to match the style on the original page. For simplicity's sake, I opted to make the document a PDF since I did not have immediate knowledge to plausibly render the article as a functional web page. In the end, the restraints ended up helping and I framed the Rabbit Hole narrative as a "cool article I found but seems to have disappeared from the BBC site (weird, huh?)." Once that document is sent, the game begins.

Early on I decided that the core narrative of the game would be relatively simple but hopefully engaging: a priceless document, the "journal of Odysseus" is stolen by a mysterious thief and he is challenging the students, a la The Riddler, to solve his puzzles in order to get them back. The BBC article is written as authentically as possible but does immediately drop some clues that Something Is Strange: the befuddled archaeologist is Dr Henry Jones III (Indiana Jones), for example. The inclusion of the text of a mysterious riddle begins the hunt and the riddle is worded to explicitly reference an element of my school's culture in order to draw their attention.

Compared to the types of ARGs found in the wild, *Dolus* was designed to deploy comparatively larger "sign posts", if you will, especially in the early game since this is a genre of game that few, if any, of the students were familiar with. Even then, some students needed a rather significant nudge to read closer and realize there was a riddle to be solved. The riddle eventually leads to a fake, but functional, school email address (dolus@fairfieldcountryday.org) that was set up with the help of the IT department. Once that email is contacted, the student is immediately sent a "welcome video" which sets up the antagonist, lays out the basic "plot" and some more narrative flavor, and offers the next puzzle. This was relatively easy to make as well. Armed with a laptop, a script, iMovie, and a quick tutorial on how to use the free program Audacity to scramble my voice, I laid down an audio track of Dolus introducing himself. In addition the audio track, I inserted a few relevant images into iMovie and uploaded it to a private channel on Youtube, under an account made specifically for this game.

While the email address helps add to the pervasiveness of the game, it did become a bit clunky since it required a response to each puzzle solving attempt and to forward each subsequent game element, one by one. Use of password protected videos and documents should help streamline the game more in future iterations.

Ignore the Man Behind the Curtain

Given the nature of the narrative, I decided it would be best to follow the traditional role of ARG facilitators: the

“Puppet Master”. Being the “man behind the curtain” augments the Not a Game element and forces the players to engage directly with the game in order to progress and gain information. In traditional Internet based ARGs, this is much easier. You simply remain hidden and do not directly contact any game player, only communicating through the “official” game elements and puzzles. In a pervasive game like this one it’s not as simple. I chose to remain Mr Fallon, Mild Mannered English Teacher, whenever possible and to claim ignorance of the mysterious Dolus and other game elements swarming around me. In many ways this worked, my students loved the wink-wink-nudge-nudge act and it helped channel them into the game elements instead of trying to short circuit the puzzles to get the answers from me. However, that did create some issues when students became authentically stuck. It is completely legitimate, particularly if you have a dramatic spirit, to put yourself into a character and facilitate the game not only through the explicit game elements, but yourself as well. However, the “invisible” Puppet Master role is perhaps easier to manage, but it all depends on your goals and narrative!

Curiouser and Curiouser: Making Puzzles

The heart of any pervasive ARG is going to be the puzzles themselves. This is the most daunting element to those who want to do an ARG for the first time. The customized element of ARGs also makes it difficult, but not impossible, to simply “share” the game. Since ARGs utilize so many different mediums, they often exist on your hard drive as a sprawl of folders full of documents, images, links and flowcharts, in varying states of organization. The goal of this paper and presentation is to help you create your own, however, and in that regard, let’s take a look at a puzzle created from scratch.

The foundation of many ARG puzzles are codes and ciphers. These not only offer intriguing and challenging thinking but they avoid a critical design flaw: *false negatives* (Foster, 2013). A false negative, getting the right answer and not immediately realizing it, is perhaps worst case scenario for an ARG puzzle. Nothing will demoralize a player faster than investing a large amount of time and not having that investment accurately rewarded. In my experience, students do not mind spending hours failing to crack a puzzle (in fact, they often love it!) but if they were to roll right over the correct answer they are likely to back out: no one likes to have their time wasted. Codes and ciphers, however, instantly and accurately indicate success. Once you solve the puzzle, the answer wholly or in part reveals itself. As a result, they are the bread and butter of many ARG puzzles.

In this puzzle I chose to use a book cipher because it would involve the physical medium of an actual book and I found an easily accessible example of the cipher in the Sherlock Holmes novel: *The Valley of Fear*. In fact, I decided to weave that directly into the clue. I used the free text to video site, xtranormal.com, to create another video clue. It uses a combination of preset animations and a voice synthesizer for text to speech. I used xtranormal to save time compared to doing a custom video in iMovie but also found it helped augment the pervasiveness of the game: the more mediums and formats the games incorporates the better. It also added to the narrative, which played into Dolus’ character as the mysterious thief that can be anywhere, at any time, in any form. The clue itself reads as follows:

When Doyle’s detective went to the Valley of Fear, he used this method to discover his first clue. So shall you. Your key, however, is 1 5 9 1 9 4 0 4 2 7. All you need, though, is 108. It is something that is close at hand, I assure you. Once you find your key the door below will open. Good luck!

220 246 4 223 121 4 225 121 57

In Dolus’ video clue he directly references *The Valley of Fear* which forces the student, at the very least, to find what that is and go to the Wikipedia entry. From there (or the novel) the students will realize that the “method” Sherlock Holmes used was a book cipher. Modeling their strategy after Sherlock’s, they will realize they need three things: a particular book, a specific page in that book, and specific words on that page. The book they need, the “key”, is their classroom copy of *The Odyssey*, identified by its ISBN number 1591940427 hence it being “close at hand”, and the page in question is 108. But what of the series of numbers? If they execute the cipher correctly, they discover that each number refers to a word on the page, e.g. 220 is the 220nd word on page 108. Once compiled correctly (they will realize if they’re doing it right very quickly because a sentence will form) they will see they are being asked to email Dolus the name of Odysseus’ father, something that memory or a quick search will remind them is “Laertes”. Once that name is emailed to Dolus, the next puzzle begins.

Hopefully, this example illustrates the “moving parts” of a pervasive ARG puzzle. From here, you can go anywhere. All mediums, digital or physical, are useable, and ciphers and codes are hardly a requirement, but they do set a very useful foundation. You can do something as simple as writing a mysterious code on a whiteboard and see who can crack it. You could “scale” the difficulty down by adding a hint, perhaps an unexplained bag of Caesar salad mix sits under it (a hint that it is a Caesar cipher). When it comes down to it, the average puzzle of an ARG

is some type of riddle or code whose pieces are strewn about different areas of the digital and physical world that the student can find. However, with your own unique narrative and tweaking, it can quickly take shape into almost anything your curricular goals require.

How is a Game Like a Lesson?

Dolus was designed to augment the reading of Homer's *Odyssey*. I didn't envision there to be - or perhaps I just failed to imagine - a *direct* facilitation of the text in a traditional sense. As of now, the game operates parallel to a more traditional discussion based unit that covers myths, epics and the character of Odysseus as a literary hero. Thematically, however, what makes Odysseus a unique hero in the Greek pantheon is that he is a tenacious problem solver that thinks his way through seemingly insurmountable challenges. I designed the *Dolus* game to require and develop a similar intellectual resilience. At my school, three of our institutional "core competencies" are resilience, collaboration, and critical thinking, and in that regard the game connects closely with my curricular goals throughout the year (See Table 1).

In addition, the challenge is not only the explicit intellectual hurdle of the particular puzzles but the greater "macro-puzzle" of problem solving in the modern world. In today's information age, virtually any piece of data is accessible in a few keystrokes; the real challenge is knowing what data or tools you need and when you need it. Half the challenge of ARGs is figuring out what tools you require and how to use them to solve the problem at hand. In that regard, pervasive ARGs dynamically combine an ancient element of puzzle solving with the modern demand of finding the right resources and using them to problem solve. However, ARGs' modular nature also uniquely positions them as an accessible game platform for classroom teachers.

The Advantage of Pervasive ARGs: A Bespoke, Accessible Experience

There are more and more gaming resources available to classroom teachers every day. Video games and tabletop games are leading the charge and they are likely to only grow in their educational utility as their quantity and quality increases. However, even games that are explicitly designed for students have built-in limitations that cannot be avoided, limitations that can often preclude them from classroom use. The best tabletop game built from the ground up for students can only be played in the same physical location when students are present. Even the best video game for learning cannot change its code to adapt to particular student needs. Pervasive ARGs are literally a custom game for your classroom. The narrative and puzzles can take any shape or form and as a result, so can the game. Any skill set or content knowledge can be utilized, so any curricular goal can be incorporated. The only impediment to implementing pervasive ARGs is that usually you will have to create them yourself; however, they are an investment that will return significant dividends as they create an immersive, challenging learning experience tailored to what you want. Included is a list of sample Common Core Standards, Learning Outcomes, and Essential Questions to illustrate how a pervasive ARG can be incorporated into today's curriculums (see Table 1).

However, one of the most significant advantages of the pervasive ARG is its accessibility; a game is useless if your students cannot actually play it when and where they need to. According to the National Center for Education Statistics (2009), there was only one computer in the classroom for about every five American students and only 39% of public schools had wireless internet connections available to the entire campus (2008). Clearly, there is still an accessibility problem when it comes to video games that either require a classroom internet connection or a dedicated computer, particularly if each player needs their own single device, as is often the case. However, if we take into account the number of mobile internet connected devices in general, such as tablets and smartphones, access improves dramatically. According to the PewResearch Internet Project (2013), 75% of teens had access to an internet connected device like a smartphone or tablet. Once all internet connections are taken into account, Pew found 95% of teenagers have regular access to the internet in one form or another. As internet access continues to proliferate, ARGs will only become more logistically feasible for students and teachers. It is this existing ubiquity that pervasive ARGs fully leverage. Since ARGs do not rely on a graphical game engine, by co-opting existing online media platforms, it is easy to design puzzles that interact with any internet connected device, not just a laptop or computer. ARGs give you a digital gaming platform that you can be confident that most, if not all, of your students will be able to reliably interact with in and out of the classroom.

Remaining Questions and Challenges

There are still many questions to be answered not only for *Dolus* but also game based units in general. For the vast majority of teachers the first question is: *how do I grade this?* As *Dolus* was new territory for my students, administration and me, I avoided having to answer this by formulating the game only as a sizable extra credit opportunity. However, as I add content and grow more confident in the game, I intend to make it required.

On top of the ancient tensions of grading group efforts, there is the novel problem of how to make game based learning mesh with traditional grading systems. For something that is designed to be an “old school game” - completion is not a foregone conclusion- because it is both challenging and thematically fits with the *Odyssey*, I have been hesitant to require it. Does the first group done get an A+? Does the second get an A? Third get a B+, etc? What if groups never finish? Do they “fail”?

I also struggle with the “difficulty level”, as many professional game designers no doubt do . I like the idea that this has a free ranging element despite being heavily scripted. Students are free to solve the problems however they can and use whatever tools they can find. This is also means that some groups may get stuck, and most groups do not finish. Should 100% completion be a goal and should I edit the game to emphasize this?

With both my age group (7th grade) and my geographic location (suburbia) I am limited by where I can make the game “exist”. Much of this is solved by sticking to the well trodden path of ARGs - the digital environment and media - since that is accessible anywhere with an Internet connection. At a 1:1 laptop school, this is a natural fit. However, some of the most successful moments in *Dolus* have been the times that the game goes “outside” the digital and becomes a fully pervasive game - both in the physical *and* digital world. For many students the climax of the game is tracking down a false rock by our school’s cornerstone with a QR code embedded inside. The experience so far suggests that increasing the physical pervasiveness would increase the quality of the game.

As a teacher of suburban students who cannot drive, the physical pervasiveness appears to be limited to just campus (and that has potential). Puzzles *could* be engineered to lead to local settings - and it would be quite fun! - but that could become complicated, especially if the game became mandatory. If I was in an urban area and/or with older students, I feel I would have the freedom to lead them anywhere they could ostensibly travel. Perhaps this is not as bad as I think? Should I not be afraid of a student begging his parent to go to a local spot so he can solve a puzzle? To me, the game obsessed teacher, it sounds awesome. But to a busy parent with limited time perhaps it is a ridiculous request.

The second major question: does the game *work*? After two iterations, I see clear “proof of concept”. The students love the This Is Not a Game ethos of the ARG style. The “Sherlock Holmes” type thinkers - who have to crack any puzzle given to them - get addicted fast. One student this year would routinely beg for the next step and then proceed to spend hours of his own time that night to solve the puzzle. The middle ground students are either interested in playing a “game” or are incentivized by extra credit, or both. There are some students who hit the first wall and stop.

However, what I like about this (and most game based learning) is that it *compels students who are normally not engaged*. Traditionally motivated students are still motivated and jump into it. However, there are students who are usually less enthusiastic about more traditionally constructed units that dive headfirst and do not stop. That is a crucial element and it illustrates an underappreciated concept: *games are a style of learning, if not learning itself*.

Final Thoughts

Pervasive ARGs are a powerful platform for game based learning and they offer a unique level of customization, access, and engagement that few other game types offer. Any teacher who knows how to tweet, copy and paste, or make a Youtube video is capable of creating a deep gameplay experience for their students that can rival what is found on any video game screen.

Common Core Standards and Ongoing Learning Outcomes

Key Ideas and Details	
CCSS.ELA-Literacy.CCRA.R1	Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusion drawn from the text
CCSS.ELA-Literacy.CCRA.R2	Determine central ideas or themes of a text and analyze their developments; summarize the key supporting details and ideas
CCSS.ELA.Literacy.CCRA.R3	Analyze how and why individuals, events, or ideas, develop and interact over the course of a text

CCSS.ELA.Literacy.CCRA.R4	Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
CCSS.ELA.Literacy.CCRA.R5	Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text relate to each other and the whole.
CCSS.ELA.Literacy.CCRA.7	Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
Ongoing Learning Outcomes	
SLO #1	Students will navigate, evaluate, and ultimately solve a series of problems similar to those Odysseus is faced within the epic in order to experience the critical thinking process of overcoming obstacles.
SLO #2	Student will identify, use, and manipulate media and media tools in order to problem solve using 21st century technology skills.
SLO #3	Students will analyze the choices Odysseus makes on his journey in order to model their own gaming strategy to achieve the same success.
Essential Questions	
#1	How can we learn to solve a wide variety of real world problems using critical thinking skills?
#2	How can we use media and media tools to solve problems similar to those present in the Odyssey?

Table 1: A list of example Common Core Standards, Ongoing Learning Outcomes, and Essential Questions for the *Dolus* game unit

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A World Filled with Darkness, Dungeons, and Dragons: Using Analog Role Playing Game Creation to Enhance Literature and Writing Instruction in High School English Classes

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Challenges of implementing game-based learning in K-12 education

Researchers studying learning and literacy have long stated that popular digital videogames can be used as effective teaching tools based on their capacity to provide students with multiple opportunities of “trying, failing, revising, and retrying various tactics and strategies” (Chen, 2010, p. 4-5), and that video games teach students vital skills such as decision-making, deductive reasoning, strategy creation, and systems thinking (Pensky, 2003). However, researchers have long struggled to encourage more teachers to incorporate games or game-based systems into their instructional practices (Squire, Giovanetto, Devane, & Durga, 2005).

Teachers unfamiliar with the scholarship of game-based learning often misunderstand the pedagogical practices. They believe that game-based learning is limited to using digital games in the classroom as auxiliary tools to motivate students to complete basic and often repetitive learning tasks in an entertaining way. As a result, teachers have often used games as rewards or motivational tools instead of instructional tools (Becker, 2007).

According to Kebritch & Hirumi (2008), another challenge teachers face is that many game designers have been unable to identify sound pedagogical foundations for their games. Without strong pedagogical justifications, K-12 teachers already pressured to increase their students’ test scores struggle to allocate the time and energy necessary to implement games in their classrooms. Such a limitation is particularly problematic in high school literature classes, where students are tasked with acquiring complex literacy skills that require gathering information by reading, analyzing, and synthesizing written material. While many administrators and parents may be able to see the benefits of STEM-focused games that often center on didactic and repetitive tasks, it is a harder sell for a literature teacher to justify using popular games like *World of Warcraft* (Blizzard Entertainment, 2004) or *Skyrim* (Bethesda Game Studios, 2011) to teach literacy skills. In addition, many schools still suffer from what is known as the digital divide that limits their ability to effectively implement digital game-based learning due to the lack of computer hardware and an unwillingness to saddle low-income students with the financial burden (Compaine, 2001; Chapman, Masters, & Pedulla, 2010). Both the technical limitations of institutions and the cost of the games themselves have prevented teachers from using digital games in their classes (Warschauer, Knobel, & Stone, 2004).

While many educational researchers and popular media outlets tend to focus on digital games aimed at improving STEM outcomes, this only engages with one type of game-based learning. Gee (2007), author of the groundbreaking *What Video Games Have to Teach Us About Learning and Literacy*, reminds us that he never argued for playing video games in the classroom but rather that good games do a great job teaching players how to play and eventually master them, and that educators would be wise to model their curricular designs in ways that leverage the same good principles that result in deep learning (Gee, 2007).

This paper describes an experimental 6-week approach to teaching *Beowulf* in two senior high school college prep English classes. The goal was to employ a low-cost, non-digital, tabletop role-playing game (RPG) in a way that would increase student engagement, encourage collaborative problem solving, and develop a range of student literacy skills. This paper describes the instructional goals, instructional methodology, and results, concluding with the instructor’s impressions of the experiment and plans for future iterations of this course structure.

Role-playing games creation as an instructional strategy

Many English teachers still adhere to a traditional instructional method of posing questions based on the materials read, students answering them, and the teacher providing feedback on those answers (Cazden 1998 as cited in Applebee, Langer, Nystrand & Gamoran, 2003). In such a classroom environment, students are often deprived of the enriching experience that they can gain from reading complex literature. Teachers who are unsatisfied with traditional instructional methods must look elsewhere for pedagogical models that encourage deep thinking about literary texts and will also inspire students to produce their own creative works to gain benefits from literature education.

Hergenrader (2011, 2014) faced a similar problem when teaching fiction writing at the college level, where students exhibited a tendency to look for answers about a story's "meaning" rather than analyzing aspects of craft. He states that instructors often use a workshop model that relies more on imitating literary aesthetics than giving students a deeper understanding of how narratives operate. He argues role-playing games (RPGs) are a viable, if not superior, instructional option for teaching creative writing since RPG stories are the result of detailed characters interacting with a rich environment. The narrative pieces available in the RPG catalog—the items, locations, and characters—can be assembled in innumerable ways based on player decisions. Thus RPGs foreground the openness and possibilities present in any given story.

His method is applicable to a high school English class. First, it naturally solicits student participation and deeper learning by allowing the students to create various artifacts such as the character descriptions and various game pieces. It clearly represents a sound pedagogical ideal central to Constructionism (Papert & Harel, 1991). According to Papert, students must become engaged in experiences of producing artifacts in order to truly gain the knowledge. By allowing the students to become the active story makers rather than passive story consumers, a teacher can now facilitate the acquisition of new literacy skills beyond decoding and summarizing. Second, it allows the students to become immersed in the writing practices that are highly situational and contextualized, which has been lacking in a conventional instructional method of questions and answers (Colby & Colby, 2008).

With such pedagogical considerations in mind, an RPG creation unit on *Beowulf* was designed in order to experiment with non-digital game-based learning at the high school level. Because *Beowulf*, an epic medieval poem, recounts a hero's quest to destroy various monsters to save a nation, the popular fantasy RPG *Dungeons and Dragons* was chosen as the foundation for the gaming portion of the course.

Goals

The flexibility and potential of this method are evident in the number of goals that this unit aimed to accomplish. Students were to create and play a role playing game based on *Beowulf*. Since this unit was designed to teach reading and writing, the assessments were to be based on the multiple writing products created by the students and not the quality of the game itself. However, I (1) also set several explicit instructional goals.

1. Students were to engage in an iterative process of writing, receiving feedback, and revising throughout the unit to gain and refine their writing skills.
2. Students were to engage in both creative writing as well as research writing.
3. Students were to use digital writing tools in order to develop their technical skills.
4. Students were to collaborate with one another during every step of the project.
5. Students were to incorporate additional artistic skills, such as drawing or game-piece production to demonstrate their skills.
6. Students were to practice additional academic skills such as computational skills, leadership skills, and decision-making skills during gameplay.
7. Students were to engage in additional STEM-related activities such as addition, subtraction, and division.

Historical Research and Game creation

The unit began with the historical and geographical exploration of *Beowulf*. Students used digital tools such as Wikipedia, Google Scholar, and National Geographic to acquire information about the Scandinavian Peninsula where Beowulf's story was set. Students wrote detailed descriptions of Beowulf's world based on their research. Students recorded their initial findings in their notebook and wrote additional reflections on their learning to improve their metacognitive skills (Mair, 2012). For example, they discovered that the longhouses or mead halls described in the poem were built high on cliff tops to provide protection against invaders, and that they built the hall around a large fireplace to provide relief from harsh winter conditions.

Once the students finished gathering the information, they described the settings of the poem using as much detailed information as they could find in the poem while adding additional facts from their initial research. They did so in three stages: they created their first drafts in their notebook, revised them, and then posted their revisions on *Edmodo*, a free education-oriented online social media site. After their second revisions, I asked them to create

a drawing that accompanied their final revision in order to help them to showcase their artistic skills (See Figure 1).

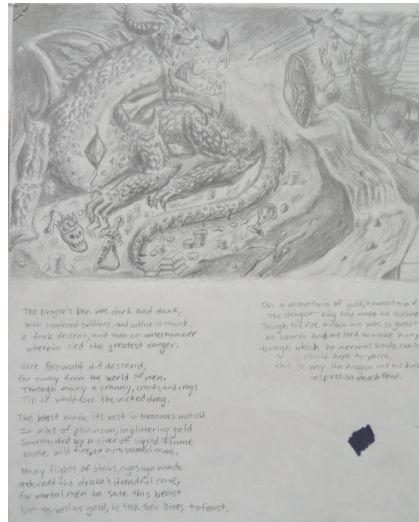


Figure 1: Drawing and a poem on the Dragon's Lair

Next, students described one character from the poem and an imaginary character that was related to one of the characters in the poem. Students had to use their historical knowledge as well as the information from the poem. For example, the characters' occupations or clothing had to relate to the time period. I did so to insure that they could demonstrate their knowledge in the most tangible way. This portion was my favorite section since I was able to read about so many wonderful imaginary characters that my students created. One student wrote the story of Beowulf's long lost sister who was separated from him at birth and became a formidable archer, and another wrote about Hrothgar's brother who abandoned the life of a warrior and became a poet. Once again, students created three drafts and a drawing to accompany their final draft. For this section, students were also required to select two descriptions that they thought were exceptional and provide feedback on Edmodo. After all the evaluation was done, students revised their final digital draft one last time to incorporate the information from others' descriptions of the two characters.

Finally, students wrote two plausible adventures based on their knowledge of the poem. Again, students created three versions and provided feedback to three others. Although this was the most open-ended, students had to utilize the information from the poem. Students selected their best adventure to be posted on Edmodo to be entered into a competition. The best adventure was chosen by class vote, giving the winners their bragging rights. Students also devised additional game pieces that they wanted to use for the gameplay. After much consideration, students chose to create chance cards to be added to the game to add additional mystery and suspense to the game that had a predetermined story line.

Once the descriptions were completed, students brainstormed to devise the rules that they wanted to add for the game. Each class decided to create a character sheet that included various character traits. Two students who were familiar with existing role-playing games led several discussions to create the customized rules (See Figure 2). Students discussed whether they should move as a group or not. They also chose which dice they should use and how many to use for each turn. They also decided which traits they should allow the characters to have based on the character traits offered in the *Dungeons and Dragon* character sheet. Their decisions to move as a group, to eliminate various races, and to add a sailor and a mechanic to the character list demonstrated that the students understood the emphasis on community in the Anglo-Saxon culture

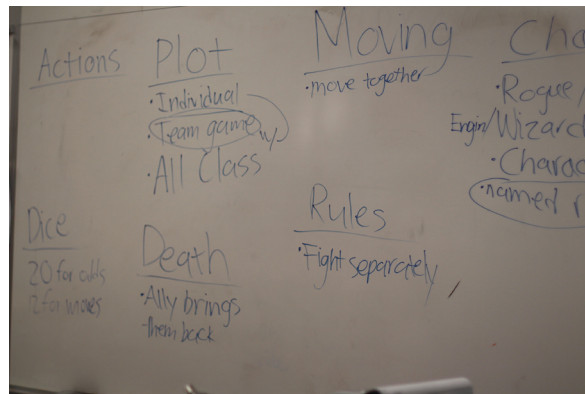


Figure 2: Brainstorm session

As we progressed, one of the students also volunteered to create a game board that depicted the four sections of Beowulf's world (See Figure 3 and 4): the Ocean between Beowulf's homeland and Heorot, the Great Hall at Horthgar's Kingdom, the Grendel's Cave, and the Dragon's Lair (Hall, 2005). He used the descriptions from the poem to inform his illustrate maps.

Playing the game

Once all the game pieces were created, I had a group of volunteers play a demonstration game in the middle of class, using an instructional strategy known as the fishbowl method (Priles, 1993). While the spectators provided suggestions and record their observations, the players recorded their points as they rolled three different dice with six sides, twelve sides, and twenty sides. Once the rest of the class became comfortable with the idea of playing their own game after two days of spectating, students form several groups with one student from each group volunteering to become the Game Master (GM) to lead the game. There were eight different GMs during the week that both classes played the game, giving students an opportunity to showcase their creative storytelling abilities as well as leadership abilities (Cover, 2010). Again, during every gameplay, I required the students to use their notebooks to record their scores, describe the journeys, and write reflections to ensure the instructional goals were being met.

This process has affirmed my belief in all students' abilities to become creative and productive in an optimal instructional environment. During the gameplay, I saw a huge increase in the amount of writing my students produced. I deliberately alternated the gameplay days and writing days, so that they were writing constantly in their notebooks during their gameplay and posting them on Edmodo the next day. This allowed my students to become active producers of instructional contents since some of the stories were used during the gameplay. Even though they were not explicitly instructed to do so, students prompted their GM to continue the storytelling, filling the gap. I also witnessed them collaborating while solving problems as they played the game. For example, one player asked his GM, "Can I share some of my points with him? He is about to die, which means we will be down a warrior for the next adventure," indicating that he was gaining computation skills of strategizing for the future and negotiation skills.



Figure 3: Game board front

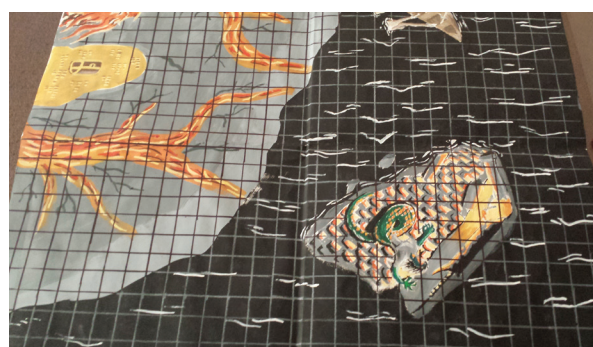


Figure 4: Game board back

Post gameplay

At the end of the unit I had students complete a survey on the project as well as the game-playing process to inform future iterations of the course. I asked students to describe their game creation experiences separate from their game-playing experiences using a mixture of Likert-like scale questions, multiple-choice questions, and short answer questions. Students were asked about their feelings about the amount of writing that they had to do, the requirements for collaborating with their classmates, and the amount of imagination that they had to use. They were also asked how often they had to solve problems, improvise, and communicate with their teammates. They were also asked to describe their most and least favorite parts of the game creation and gameplay.

The observation and the survey data revealed an increased amount of writing, increased leadership opportunities for students, and increased opportunities for collaborative learning among students.

When asked, "What was your favorite part about creating the game?" one student replied, "Being able to step outside the box of learning solely from the text and creatively learn and exercise imagination and collaboration," indicating that the game creation facilitated them to write creatively (Hergenrader, 2011). The answers to the question, "What was your least favorite part about playing the game?" revealed that the instructional method achieved several goals. One student answered, "My least favorite part about creating this game was how time consuming it was. It required a lot of research and time spent reading the story and searching the Internet." Another answered, "My least favorite part of the game was writing the background story of my characters. I didn't like that because it was like creating a story for the character." Statements similar to the above answers indicated that the students were gaining additional academic skills and writing practices.

However, what was most telling was that the students in general complained about how much writing they had to do. One student wrote, "Drawing out our character description was my least favorite part of the game. It was difficult to take the description and visually describe it." Another complained, "The least favorite part of creating the game was having to do character descriptions because they had to be really detailed." Time and time again, students reported the increased amount of writing they had to do as their least favorite part about the game creation, indicating that this process has achieved the goal of having them write more. Despite their complaints, students still produced vast amounts of writing per assignment and often described the creative writing as their favorite activities, indicating the superiority of this method to teach writing. Their feedback also showed their enjoyment of reading each other's writing. In their written feedback, students often suggested that fellow students should provide more details of their characters or adventures. I observed that the suggestions were often implemented in the next iteration.

The students also wrote that the GMs needed to become better storytellers. One student complained, "The least favorite part is when the game master runs out of ideas of how to keep continuing with the game." Because of such complaints, I witnessed several students including four female students, who were originally reluctant, ended up volunteering to be a GM, indicating that it allowed opportunities for students to develop additional leadership skills.

Many students also noticed the importance of collaboration. One student wrote, "As being the healer of the game, it was nice to see that some of the strong and tough warriors needed another person's help." Repeatedly, students described how tough yet rewarding it was to work in groups to play the game, indicating their increased awareness of the importance of working in teams.

Without repeating the process, however, a claim for its effectiveness would be premature. Survey results also revealed that adjustments should be made for future iterations. For example, one of the students suggested that the gameplay itself should not include imaginary characters to insure the instructional adherence to the text. Another student suggested that the discussion of various literary devices and the major themes should be added for deeper understanding of the piece. Based on the feedback from the students, a plan is being developed to repeat the process for the second semester using *Frankenstein* by Mary Shelly and *1984* by George Orwell (2). I chose these two novels to use *World of Darkness*, a post apocalyptic supernatural horror game that centers on modern issues, to help my students explore a futuristic aspect in our modern society as well as the role of science and technology. I expect this to facilitate enriching discussions on society's responsibility to its citizens and ethical dilemmas relating to technology.

Although balancing the acquisition of knowledge from the text and facilitation of creativity will be challenging, the benefits from this instructional strategy warrant its continuation. When asked whether they should create another role playing game, 35 out of 61 students who responded chose "Strongly Agree," and 19 chose "Agree." When asked whether this was a good way of learning, 30 out of 61 students chose "Strongly Agree," and 25 chose "Agree," indicating the students' desire to continue.

Conclusion and future implication

Clearly, game-based learning goes beyond playing digital games in the classroom. Effective game-based learning requires the proper use of appropriate games. More importantly, it requires the inclusion of game mechanics to help students become producers of new meaning (Gee, 2007). Therefore, game-based learning needs to include game creation and game mechanics that build student skills in collaboration, communication and creation.

However, without developing sound instructional practices, teachers and students are not able to take full advantage of game-based learning. Researchers and practitioners should collaborate on creating viable instructional steps to assist K-12 institutions to bring more game-based learning into their classrooms that teach other literacy practices not covered by STEM education.

Role-playing game creation, therefore, is one of the most robust and dynamic instructional strategies for all grade levels. A further exploration of the effectiveness of this strategy is needed to fully capture the benefits.

Endnotes

(1) The project was created by the first author with the continuous technical and theoretical support from the second author. We chose to use "I" in this section to describe the personal experience of the first author.

(2) As of June of 2014, the second iteration of this method has occurred. It took 4 weeks rather than 6 weeks, and the students were able to produce much more complex stories and games. Rather than relying on one student to create a board, all students volunteer to create the board. Students became more independent in each step.

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A Design-Focused Analysis of Games Teaching Computer Science

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Introduction

In recent years, there has been a growing call to teach programming and computer science (CS) concepts more broadly than in university-level computer science programs. Initiatives such as Computer Science Education Week (Computer Science Education Week, 2014) and localized development training academies (Ada Developers Academy, 2014) aim to empower people from non-technical backgrounds to learn to code. Motivations for improving competency in CS range from training people for in-demand jobs, to diversifying the workforce, to realizing the benefits and broader applications of computational thinking. The Association for Computing Machinery (ACM) has called for a greater focus on CS education in K-12 (Tucker et al., 2006) aiming to demystify the field and encourage a larger and more diverse group of students to pursue computing as a career.

Many of these efforts to bring more people, especially younger students, into CS are aiming to address the “pipeline problem” that contributes to a dearth of women in CS. CS faces significant problems with diversity; despite women making up roughly 50% of computer and Internet users, they comprise only 27% of the tech industry workforce (United States Department of Commerce, 2011). Girls are given messages that computers are for boys (Margolis & Fisher, 2003) and are both subtly and actively discouraged from entering the field from an early age.

There have been many interventions to teach CS to young audiences, in both schools and informal learning contexts, with the aim to increase young girls’ exposure to CS and foster shifts in attitude about the field. Many of these interventions have involved teaching students how to make games, using environments designed for younger audiences with no programming experience (Cooper, Dann, & Pausch, 2000a; Kelleher, Pausch, & Kiesler, 2007; Overmars, 1999; Resnick et al., 2009). Recent years, however, have also seen an increase in the number of games designed specifically to teach CS, as well as the use of games not designed for education as classroom activities.

This paper describes a preliminary study of how these CS educational games are designed in order to critically examine existing practices, given the importance of broadening participation in computing and especially improving gender diversity. With our research question “What are the common design features among games that teach computer science?” we have analyzed 36 games that have been used to teach CS, either in the classroom or in informal learning environments. We have identified 28 design features along which we compared the games. Several of these design features were chosen based on important features for gender-inclusive game design (Ray, 2004) as well as hypotheses for how women relate to CS, such as societal relevance (Denner & Campe, 2008; Denner, 2005).

As a result of the analysis, there are several common patterns that emerge from the games, ranging from the use of robots to the lack of collaboration. Our work has two main contributions to the literature on educational games for CS: 1) an analytical framework, grounded in theories of (educational) game design and CS education, within which any new game could be viewed, and 2) identification of a set of patterns in the design of educational games, which can be used in future work to evaluate the importance of design elements or to identify new opportunities for unique educational games.

Women and Gaming

There has been a great deal of research into the role of gender in games, in terms of issues in gender representation (Werner, Denner, Campe, & Kawamoto, 2012) and the games industry (International Game Developers Association, 2005), and how girls interact with games (Denner & Campe, 2008; Dickey, 2006; Fristoe, Denner, MacLaurin, Mateas, & Wardrip-Fruin, 2011; Kafai, Heeter, Denner, & Sun, 2008; Sykes, 2007). The notoriously poor representation of women and the use of violence as a common trope in mainstream games sustains the myth that women do not play games; however, 94% of teenage girls in the US play games compared to 99% of boys (Lenhart, Kahne, et al., 2008). Furthermore, 50% of adult women play games compared to 55% of adult men (Lenhart, Jones, & Macgill, 2008).

The concept of gender-inclusive game design is appealing due to its treatment of girls and boys as equals, rather than girls as a special, “niche” audience that requires special consideration and different kinds of games. Girls play every kind of game that exists, though there are cultural trends towards greater numbers of girls playing casual games, games addressing real-life issues, and games without a highly gendered or sexualized environment (Denner & Campe, 2008; Lenhart et al., 2008; Pugh et al., 2010).

Looking broadly at the literature, certain trends around what girls like and dislike in games begin to emerge (American Association of University Women, 2000; Gorriz & Medina, 2000; Hartmann & Klimmt, 2006; Schott & Horrell, 2000). One common theme is the enjoyment of puzzles, whether in support of a game’s story or as a preferred genre in itself (Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010; Phan, Jardina, Hoyle, & Chaparro, 2012). Story is commonly believed to be important to girls, and this is indeed another element mentioned often. In some cases, story is directly mentioned as a desirable game element. More often girls want to see more instances of specific elements in games that may be best illustrated through story, such as humor, identification with or mimicking of principal characters, and meaningful dialog and character interaction. Games with some type of social element are popular, such as those that allow players to engage with social interactions (Heeter, Egidio, Mishra, Winn, & Winn, 2009). Unsurprisingly collaboration appears often as desirable, but interestingly, competition is not always considered a negative aspect of games. It seems that girls enjoy friendly competition (Jenson, de Castell, & Fisher, 2007). Many of these features of games were used when determining codes for the games analyzed in this paper, as described in the following section.

Methodology for Examining Games that Teach Computer Science

We have gathered a list of existing games—digital and analog—that teach CS. This list has been compiled from news articles, conferences attended by the authors, and word of mouth. Additional games were sought out through academic search engines such as Google Scholar and Scopus (using a combination of the keywords “Computer Science,” “Teaching,” “Education,” and “Game”) and the game database MobyGames. This resulted in an initial list of 44 game initiatives to teach CS. Some of these games are explicitly designed as educational, while others are entertainment games that have been used in teaching CS (either formally or informally). Our next step was to determine whether those games were sufficient for consideration in our analysis, i.e. that they 1) are actually games; 2) have been used for teaching CS; and 3) are described in sufficient detail. In total 8 initiatives were excluded, resulting in a final list of 36 games (see Appendix). Choices were validated among the authors by cross checking the list.

The remaining games were more closely examined by coding them according to a list of codes developed based on our aforementioned literature review on women and games, CS education, and educational game design considerations (e.g., see Hartevelt, 2011). The coding co-evolved while we examined the games, which is typical for most coding processes (Saldaña, 2012). Breaking the data apart in analytically relevant ways leads to further questions about the data, which then leads to generating categories, themes, and concepts, grasping meaning, and/or building theory. We performed three coding cycles, from rough to fine, with primary, secondary, and tertiary codes. The primary codes involve characteristics that are often used to describe games, such as the release date, the developers, availability, hardware platforms (if any), target audience, game genre(s), number of players, and camera perspective. These primary codes do not reveal much about how the games are played, but do give the larger context about who has been developing these games, when, and for whom. The secondary codes are more extensive and are based on the literature on women and games and educational game design. Tertiary codes were used to characterize features of the game world, such as player interaction style, theme, and setting.

Gender-Inclusive Design

Based on the work on women and games we considered specifically if a *gender audience* was specified, and if so, if the game was targeted at males or females. Additionally, since inclusion of story or narrative seems of importance in how young women especially experience games (Denner & Campe, 2008; Ray, 2004), we coded how this was integrated into the game. For *story-based design*, we considered whether the game made use of no story, background story, cut-scenes, linear or non-linear storytelling.

Other gender-inspired codes concern the *problem-solving rhetoric* and the *problem context* that the game provides. For the rhetoric we considered if the game has an individual or collaborative orientation. In a game with an individual orientation, the player is the “superhero” who fixes the problem singlehandedly. In contrast, with a collaborative orientation the game rhetorically implies that CS is a collaborative field where the player’s efforts combined with the efforts of others will help to solve the problem. The *problem context* specifies the relevance of solving the problem that the player is confronted with by the game. Some games offer none. Others state explicitly an individual relevance such as “programming is good for you!” Then there are games with a social relevance: solving the

problems will enable the player to help other people. Finally, there are games that have a broader societal relevance, such as in *ToonTalk 3*, where the player is tasked to help Marty the Martian who is trying to save the world.

Educational Aspects

From an educational game design perspective we tried to extract what the *learning objectives* of the games are, if any, and how this would help in teaching CS. We further coded the *educational intentions*. A number of games were originally created for entertainment and happened to be useful for teaching CS, such as *RoboRally*. Among the games purposefully developed to teach this, some state this explicitly to the players and others adopted a stealth learning approach. We define a stealth learning approach as one where the designers make no reference to what is being learned to the players. The learning happens without the learners realizing it. *Machiners* uses a stealth approach because the designers felt that otherwise children would be less eager to play the game (Lode, Franchi, & Frederiksen, 2013).

A closely related consideration is the specification (if any) of the *educational setting*. Some games are developed for specific curricula or the classroom in general (i.e., formal learning), whereas others are designed for outside the classroom (i.e., informal learning). Designing for either or both puts certain constraints on the design (Young et al., 2012), such as the *playtime*, which we coded in addition. Literature shows that games are used most effectively in combination with other educational material (Harteveld, 2012), so we considered the use of *accompanying material*. Some games stand alone and others come with a book or website (with either a variety of learning activities or just information).

As the rhetoric used in problem-solving may have consequences on the player's attitude and perspective on CS, so does the incorporation of a *problem-solving strategy*. An essential form of computational thinking is *algorithmic thinking* (Cooper, Dann, & Pausch, 2000b; Futschek, 2006). Algorithmic thinking involves thinking about problems generally, abstracting common traits so they can be treated as a class of problems instead of a single instance, and building sequences of instructions as solutions. From an educational point of view, such thinking can be fostered if more than one solution is possible. Otherwise players could treat the problems in isolation from each other. As single instances, each problem would have its own solution and no demands are made on the player to abstract the common traits for finding that solution. Providing a single problem-solving strategy does not mean that no algorithmic thinking skills are learned; we only hypothesize that it may be less likely. The last design consideration concerns what kind of *programming mechanic* is used (if any), which reflects a particular educational strategy and philosophy. Games can make use of:

- block code: predefined "blocks" of textual code that need to be mixed and matched;
- visual code: players manipulate objects to program;
- pseudo code: high-level, human readable code;
- unique code: code specifically developed for the game; or
- actual code: use of an existing programming language.
-

Design and Narrative

The tertiary codes were introduced during the coding process. The first involves *interaction style*. On close inspection it seemed relevant to specify how players interact with the game environment. What style has been implemented likely influences how players experience the game. We noted quiz, point-and-click, drag-and-drop, real-time control, and create-and-test interaction-styles. For analog games this category was not applicable (N/A). We became particularly interested in the design of the setting, theme, and protagonist. With regards to the *setting*, we coded if the game environment was abstract, realistic or iconic. This design choice is a standard consideration for visualizing the game world (Swink, 2009). We further noticed the recurrence of certain themes and started coding the *theme* of the setting: none, science fiction, fantasy, computer science-y, real-world metaphor (e.g., *C-Jump Programming* uses skiing as metaphor for how software programs work), or cartoon. We considered something "computer science-y" when it was not science fiction but did involve elements that are normally associated with this field, such as computers, technology, and robots. In fact, the use of robots was so prevalent throughout all the games that we decided to make it into its own category. The *robots?* code asked whether any robots were in the game. The final tertiary codes were about the protagonist. With the *protagonist* code we observed if the player manipulates the game without any role or context (None); assumes a role of some kind but does not control a

character such as being a scientist (Role-based); takes control of a character in a game (Character-based); or does not assume a role or take control of a character but is portrayed as something in the context of the theme of the game, such as being a snowboarder in *C-Jump Programming* (Metaphor-based). We introduced the last code, *protagonist content*, to consider what type of protagonist the player controls (if any). The codes for this category are: abstract, robot (or cyborg), animal, male, female, non-gender specific, and choice.

Preliminary Results

With our methodology we were able to distill preliminary patterns that allow for reflection on how the games are designed. We will discuss ten of these patterns, in no particular order of importance:

1. *Robots rule*: The inclusion of robots was so pervasive that we ended up making it its own code. Robots are easily associated with the field of computer science, given the prevalence of robots in popular media and science fiction. While the design and programming of robots does involve some CS skills, in actual practice the development of robots is more the domain of mechanical, computer and electrical engineering, and encompasses only a small fraction of what computer scientists are preoccupied with.

2. *Puzzle instinct*: Almost all games could be associated with the puzzle game genre. Some were straight up puzzle games, providing the player a single screen with a puzzle to solve. Others combined the puzzle genre with that of the adventure genre, allowing the player to walk around and then solve puzzles occasionally. Puzzles lend themselves well to CS, as much of this discipline is about solving complex problems logically and rationally. Also, puzzle games are in the top two genres of games played by teens (Lenhart et al., 2008), possibly because humans have an innate “puzzle instinct” (Danesi, 2002). This puzzle instinct appears to exist for choosing a game genre for designing CS educational games too.

3. *The single hero*: Except for *Bots*, which is described as a social collaboration-game where players work together to solve puzzles using simple programming concepts, all *digital* games we included are single-player games. The analog games were all competitive multiplayer games. This choice for a single-player game may have consequences on how players view CS. One of the “myths” about computer scientists is that the work is solitary and boring (Drexel University Department of Computer Science, n.d.). In practice, computer scientists must work together and they (should) talk with users often (Nielsen, 1993). To be fair to developers, many puzzle games are single-player, so if an early design choice is to use the puzzle genre, it may automatically result in the game being a single-player game. In addition, multiplayer games are much harder to develop (Harteveld & Bekebrede, 2011). However, this design decision may have implications on problem-solving rhetoric: across all games, we observed that problem-solving was solely individually oriented. This rhetoric further undermines the idea that CS is about collaboration.

4. *Born late*: Games teaching CS are largely a phenomenon from the past decade (and especially the past five years), whereas educational programming languages have been around much longer. For example, *Logo* was designed in 1967 (Logo Foundation, n.d.). The development of games to teach CS has even lagged behind the design of educational games in general (Harteveld, 2011). This relatively recent interest may be due in part to the continued emphasis on using game design (not game play) to teach CS skills, primarily programming.

5. *University-led development*: Researchers and/or students have created almost all of the included games. Although this pattern reflects much of the development of educational games in the past years, for-profit companies have developed games about mathematics and language, for example. The difference possibly reflects the place and status of CS in society. The viewpoint that programming and computational thinking are necessary skills for the 21st century is increasingly popular but not yet reflected in most school curricula. Since for-profit companies’ priorities tend to be market-driven, a more widespread interest in the design of games to teach CS may not develop until computational thinking or CS concepts are more widely incorporated into K-12 and higher education.

6. *Broad and unspecific learning objectives*: The learning objectives of most games amount to “teaching programming” or the “basics of programming”. There are many concepts involved in learning how to program and, therefore, such learning objectives can be considered broad and unspecific. This is especially problematic for assessing student learning outcomes—either by the game or by a teacher. It might be that within the game’s design, these broad objectives have been decomposed into more detailed objectives, which (though implicit to the player) then have guided game design and, potentially, assessment. But it could also be, and this is not an unlikely scenario, that this lack of clarity is reflected in the game’s design, and then it becomes questionable if the game is effective at all. Games that have specific, detailed learning objectives typically are highly specialized and teach a particular CS concept. This is illustrated by *Not! The Simpsons Donut Drop* that teaches basic Boolean expressions only.

7. *Gender ambiguity*: Many games specify the target audience in terms of age, not in terms of gender. One of the tropes in commercial games is a strong emphasis on male characters, but if we look at the protagonists in the games we reviewed, we see a preference for non-gender specific characters. The one game with a female protagonist was led by a female game designer—but even for this game the intended gender audience was not specified.

8. *Lack of context*: Very few of the games studied feature any kind of story, even a background story. Though puzzle games do not need story, it can provide meaning and relevance to any actions the player makes. This may be important for teaching CS and building a favorable impression of the field, as social context and relevance is important for learners, especially women (Margolis & Fisher, 2003). The games with at the very least a background story often provide a problem with either societal relevance (e.g., *ToonTalk 3*) or social relevance (e.g., *Machineers*).

9. *Dominance of fiction*: Amongst all games, the use of fiction of any kind is predominant. Players set foot in a science fiction, fantasy, or cartoon setting and control an avatar that represents a character or something along the lines of the metaphor (e.g., turtle or snowboarder). This dominant use of fiction is not necessarily what all educational games turn to. Some realism may be incorporated by letting the player take the role of a scientist or a professional, or the setting may be depicted in a realistic yet iconic style. CS involves actions in a digital, abstract context (i.e., programming) and thus might be more challenging to represent in a compelling, real world context than, say, political science or biology. However, finding ways to contextualize CS in real-world contexts may be important to help students envision CS as a potential career.

10. *Proliferation of coding*: We have not found a strong pattern of programming mechanics. Of those games that include the ability to program, practically any variety of block, visual, pseudo, unique, or actual coding can be found. This is likely a result of different philosophies on teaching CS, the games having different target audiences, and some games being geared to teach a specific language. Nevertheless, this proliferation begs the question of what programming mechanic is most appropriate for particular learning objectives, and what mechanic designers should choose going forward.

Conclusion and Future Work

Our critical analysis provides grounded reasons to question how games teaching CS have been designed, especially in terms of gender-inclusivity. It also allows for identifying new opportunities for unique educational games. We identified opportunities to emphasize collaboration, include narrative, and provide a (social/societal) relevant and less fantastical context, all factors in designing a game that appeals to girls. Our work additionally encourages designers to become more specific about the underlying educational philosophy and associated objectives, and be more creative with the game genre and setting. CS is a far broader field than can be effectively portrayed with games that are just about individuals solving puzzles and programming robots, and while many educational games are including options for players to interact with a diverse cast of characters, there is a great need for diversity in the actual *mechanics* of the games.

Our methodology and accompanying results provide game designers and educators an incentive to adopt a critically reflective and creative attitude toward teaching CS through games. The methodology can be used as a checks-and-balances system during design, much akin to Flanagan's (Flanagan, 2009) critical play model that encourages the subversion of popular gaming tropes through new styles of game making. The difference here is that we encourage subversion of popular *educational* gaming practices. Our outcomes are specific to CS educational games, but we believe that our approach and insights can be extended to educational games on other topics and for considering other issues of inclusivity, such as cultural differences (Hofstede, 1984).

The work presented here is preliminary. We intend to extend and fine-tune our methodology with more categories and codes, consider more games, and use these patterns as part of future research into understanding the efficacy and design of CS educational games. Our team's long-term goal is to create a gender-inclusive game for an international audience of middle school-aged students (especially girls) that teaches a wide variety of CS concepts rather than simply teaching programming, and showcases the variety of ways in which CS can be applied to show the broader relevance of the field.

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Appendix: Games Used in Analysis

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Dense Worlds, Deep Characters: Role-Playing Games, World Building, and Creative Writing

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Creative Writing in the Twenty-First Century: Upgrade Required

The first decade of the 21st century has seen a rise in academics working in “creative writing studies,” an academic discipline that explores and challenges the traditional workshop method commonly found in creative writing courses (Donnelly, 2011). While creative writing studies is growing, creative writing scholars have yet to address online tools that promote a writing culture of collaboration and mass participation. Jenkins (2009) describes *participatory culture* as “a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one’s creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices” (p. 3). While the traditional creative writing workshop focuses on craft aspects of single-authored works, instructors can use their classrooms to structure a more democratized, socially aware community of student-writers working around common interests (Curwood, Magnifico, & Lammers, 2013).

In addition, the institutional space provided for creative writing can provide students with life skills beyond the production of a literary short story. Jenkins (2009) identifies eleven skills that will be required for citizens in the 21st century: *play, performance, simulation, appropriation, multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation, networking* and *negotiation*. Rather than focusing entirely on literary aesthetics, creative writing classrooms can be reimagined as experimental spaces that encourage students to work on projects that require collaboration and teamwork while also honing their skills with digital tools.

Using RPGs in Fiction Writing Classes

In order to address as many of these skills as possible in my fiction writing classes, I have incorporated collaborative and team-based writing projects using a variety of games: videogames, role-playing games (RPGs), parlor games, card games and combinations of each. While much critical attention in game studies has focused on how games tell stories, it’s important to remember that all kinds of games act as excellent story-generating systems (Aarseth, 2004) that can be used by instructors to encourage students to explore new directions in their writing.

In my own research using RPGs in fiction writing classes (Hergenrader, 2011; Hergenrader, 2014) I have argued that their combination of rules and aleatory elements provides an ideal balance of structure, unpredictability, and creative freedom for beginning fiction writers. Mackay (2001) describes the RPG as an episodic and participatory story-creation system that uses a set of quantified rules that help determine how characters’ spontaneous interactions are resolved. For writing classes, this means the RPG invites greater amounts of engaged participation from every student. The spontaneity of the game models how stories evolve from the decisions the students’ characters make, and the episodic quality of gameplay allows for natural breaks for class discussions pertaining to narrative craft. The rules provide both structure and boundaries for the players’ actions. Thus this game-based methodology provides a situated and embodied learning space, which Gee (2007) argues is an ideal combination for deep learning.

Though playing RPGs in fiction writing courses has numerous benefits, it also presents significant challenges in regards to time and complexity. Teachers with little or no experience with RPGs might be unwilling to invest significant time in learning how to play them, and in-class gaming sessions present other logistical challenges, particularly in terms of having students fill the role of game master (GM). In RPGs, control over the story is distributed unequally between the GM and players (Cover, 2010; Mackay, 2001) and this can create challenges in a classroom environment. Talented GMs possess an aptitude for improvisational narrative (Hindmarch, 2008) that not all students possess in equal measure, meaning that some groups may experience a narratively rich campaign while others may not. Furthermore GMs who act dictatorially or vindictively can frustrate players and make the RPG session a hostile environment (Fine, 2002). Also, rule-based representations of characters of different races and genders can unintentionally become essentialist in nature (Voorhees, 2009) if not corrected by a conscientious GM. GMs possess knowledge not available to players (Mackay, 2001) and thus unexpected GM absences disrupt the consistency of the players’ campaign. While no single challenge is insurmountable, each adds to a significant amount of managerial overhead for an already complex course structure.

Yet even without classroom play sessions, the RPG still provides an excellent model for collaborative work through the creation of an RPG-derived catalog. I have argued (Hergenrader, 2014) that RPGs allow players to assemble

highly flexible stories by selecting entries from catalogs detailing available items, locations, and characters. Catalog entries help create a coherent, rule-based world based on quantitative and qualitative information that gives the players context for how each entry might fit into their game. For example, the free *Dungeons & Dragons* module “Keep on the Shadowfell” (Wizards, 2009) describes the village of Winterhaven through a combination of quantitative and qualitative information, such as the demographic information (pop. 977) and its economy (agriculturally-based system using barter and trade) along with a map of structural features such as the locations of gates, inns, and shops. These are complemented by narrative descriptions (e.g. “the population of Winterhaven is predominantly human, with a scattering of dwarf families and a handful of individuals of other common races, including a couple elves” [p. 9]) and information about the village’s most important citizens and their dispositions.

The *quantitative* portion of the entries creates internal coherence for the world and allows in-game decisions to both be consistent and informed. For example, a character with strength value of 8 is weaker than a character with a 10, but either character could lift a crate that requires a strength of 6. The *qualitative* portion gives more subjective narrative information, for example whether the lord of the village is welcoming to or suspicious of strangers. Each entry carries its own storytelling potential; when combined with other relevant catalog entries, the storytelling possibilities increase exponentially.

The following sections detail how writing instructors may guide students through the process of constructing their own world and catalog of entries through *critical world building*, and how a series of *character creation exercises* adapted from RPG resources and fiction prompts can help students develop well-rounded protagonists for their stories. Both processes rely extensively on the balance of quantitative and qualitative information found in RPG catalogs of fictional worlds.

Critical World Building

In my RPG classes, students begin by collaboratively creating a large-scale speculative world that resembles those found in popular digital RPGs (DRPGs) like Bethesda Softworks’s *Fallout 3* and *Skyrim*. Students are enthusiastic about writing in science fiction and fantasy settings, but more importantly speculative fiction writers must think deeply about how the lived experience of characters will change when the rules of a world change, either slightly or radically. McHale (1987) calls fictional worlds that break from our consensus reality as “ontologically dominant” works of fiction, or ones that privilege the experience of *being* over *knowing*. He argues that such that ontologically dominant works present philosophical questions such as: What is a world? What kinds of world are there, how are they constituted, and how do they differ? What happens when different kinds of world are placed in confrontation, or when boundaries between worlds are violated?

In the class student writers must come to a mutual agreement about the rules of their world, which in turn raises productive questions about the relationship between the shared fictional world they’re creating and our subjective impressions of the reality we currently inhabit. While some questions about the world might be politically neutral, others are explicitly political in nature. For example, an innocuous question might be “does magic exist in your world?” whereas a more politically charged question would be “is magic equally available to men and women in your world?” The first question is one any novice writer would be expected to answer; however the second requires a good deal more unpacking to answer well.

I call this process “critical world building” (Hergenrader, 2014), which is a dialogic, recursive conversation between the instructor and students, and between students working in peer groups. It happens in four steps: *completing a world building survey*; *writing a metanarrative*; *populating a catalog*; and *plotting entries on a map*.

World Building Survey

In a pre-course survey, my students elected to create a post-apocalyptic world. In the first week of my fiction writing course I sent them a follow-up web survey that consisted of two parts: one that answered “big questions” about the post-apocalyptic world and a second that addressed more specific social, economic, and political concerns. Both parts provide a starting point for discussions about writing the world’s metanarrative. The “big questions” portion asked the following:

- How the apocalypse happened (biological warfare, nuclear war, pandemic, etc.)
- When the apocalypse happened (ancient, Renaissance, Industrial Revolution, early 20th century, present, near future, of far future)
- How long ago the apocalypse had happened (anywhere from yesterday to 100 years ago)

- Whether the world was an alternative version of our reality or an entirely new world
- The size of the this explorable world (a country, an average-sized state, large city, small city)
- The geographic features present (coastline, desert, forest, mountains, etc.)
- The season (winter, spring, summer, or fall)

The questions were quantitative, i.e. radio buttons and sliders as opposed to short answers. Such questions provide a general framework for the fictional world and also stimulate thinking about how answers might combine in interesting ways. For example, a world where a disease wiped out most of the population one year earlier will be quite different than a world 100 years after a nuclear holocaust. Beginning writers often fail to think about geography and season when starting a new story, yet shelter and travel are dramatically impacted based on the weather, and frigid winter and hot summers present unique challenges for characters, especially those living in a world with limited infrastructure.

The second and longer section was entitled “tricky social questions” and laid the groundwork for critical classroom discussions. Each features a rating scale of 1 to 5 and covered the following:

- Gender relations (from strongly matriarchal to strongly patriarchal with 3 being gender equality)
- Economic strength (from depression and scarcity to a booming economy)
- Economic distribution (from near total equality to extreme inequality)
- Race relations (from little tension between races to extreme levels of tension between races)
- Sexual orientations (from complete acceptance to zero tolerance of non-heteronormativity)
- Population size (from small (25k people) to very large (1.5 million+))
- Law and justice (from complete anarchy to robust system of laws, policing, courts, and jail)
- Political infrastructure (from “war of all against all” to strong democracy and free elections)
- Healthcare and education (from virtually nonexistent to widely available to all)
- Religious influence (from nonexistent to religion being central to all aspects of daily life)

The questions are intended both be value-neutral and though-provoking. For example, a world with a strong economy but high inequality could either be primed for a popular revolution against those in power, or it could be fragmented with gang factions fighting in the streets over scarce goods. Either option could provide a rich backdrop for storytelling.

Discussion, Debate, and Writing the Metanarrative

As we discussed the survey results in class, I asked students to answer the questions for our *actual* world. For example, I asked students where they thought our society is in terms of gender equity. While no one suggested we have a matriarchal society, some (usually young men) suggested we’re somewhere between equality and slight patriarchy. Predictably, other students (usually young women) took exception to that, and as instructor I moderated the conversation as necessary, keeping discourse civil while suggesting questions students perhaps hadn’t thought of themselves, such as, “What does it mean for a society to be *slightly* patriarchal?” When the class reached some consensus, or when I called time, the question turned back to how the issue should be handled in the fictional world and the conversation continued. I repeated the process for all 10 questions, a process that took several class periods.

The final decisions needed be narrativized for the qualitative portion of the process, which proved to be an interesting writing challenge for students, especially when they opted for pat answers. For example, if a class decides that the post-apocalyptic world has reached perfect gender equality, the logical question is, “How did that happen?” Such questioning across all categories prevents the speculative world from becoming mere escapist wish fulfillment and requires the authors to think hard about how social, political, and economic realities come to pass, and then express that in the form of a narrative. This is what Mayers (2004) calls “craft criticism,” or situating the act of creative writing within specific institutional, political, social and economic contexts. The quantitative

answers from the survey help pose these “tricky questions” and the qualitative narrative descriptions attempt to answer them.

During this process, appointed note takers recorded class decisions and posted them to the course wiki. Wikis have the advantage of being editable by any authorized user and each page features change logs and discussion threads. This prevents users from deleting content anonymously and also allows them to carry on conversations after class. I reserved class time for students to work in small groups and encouraged groups to consult with each other as they wrote. For example, the students working on the world’s economic system were in constant discussion with the group writing about governmental structures. As instructor, I remained actively involved to steer any content away from genre clichés or essentialist depictions of groups of people, and I also prompted students to create new categories as they saw fit. For example, I encouraged them to begin adding professions and political factions once the economy and governmental structures had been better fleshed out.

In a matter of a few weeks, the students produced roughly 8000 words or over 30 pages of collaboratively written metanarrative. While some students contributed more than others (which I tracked and assessed via the wiki page histories) no one could claim sole authorship for the work, since all parts of the world were inextricably linked to the others. Furthermore, students developed deep interests in certain aspects of the world and wanted to start filling in the narrative with more concrete details, which lead to the next phase: populating the catalog.

Populating the Catalog with Items, Locations, and Characters

Students determined what attributes were necessary for each of three entry types—items, locations, and characters—and how catalog entries should be quantified and qualified. I steered them toward comparative, rather than numeric, terms to increase an entry’s interpretive possibilities and resist essentialist claims (Arjoranta, 2011). For example, rather than a crate requiring a strength of 6 to lift, it could be defined as being “very heavy.” As long as entries use the terminology consistently—both an encyclopedia and grand piano cannot both be described as “very heavy”—then the descriptors can suggest more fluid, interpretive relationships. A “very strong” person might be able to lift a “very heavy” object, but a “weak” one could not; for a “strong” person it would be a spontaneous judgment call.

Once the class reached an agreement about how catalog entries should be quantified and qualified, the world built out very quickly. I took the requirements for each type of entry and created a page template to ensure entries were completed consistently. For example, every item required a weight, value, and rarity—expressed either numerically or descriptively—and a brief narrative that gave it some context for how it is used in the world. Assigning students even a modest number of entries results in a very dense world. If every student creates only 5 locations and characters, in a 25-student class the catalog will have 125 unique locations and characters available to them for fiction writing, all in a matter of a few weeks.

Plotting Entries on a Map

The world building survey establishes whether the catalog will be contained in a geographically small but dense urban area (e.g. Manhattan, Tokyo) or spread across an entire region like southern California. The density of entries on the map will also impact the narrative: Do characters have to travel 30 miles to see their neighbor, or simply walk down the hall? How might that shape character interactions? My first class chose the greater Milwaukee area, and the second chose the region of southeastern Wisconsin.

Using markers in Google Maps results in a map very similar to the ones found in DRPGs like Bethesda’s *Fallout 3* or *Skyrim*. Figure 1 shows a close up of more than a dozen map markers—some of which are locations and some are characters—in post-apocalyptic Madison. Note that the marker description contains a link to wiki entry so users can easily move between the map and wiki.

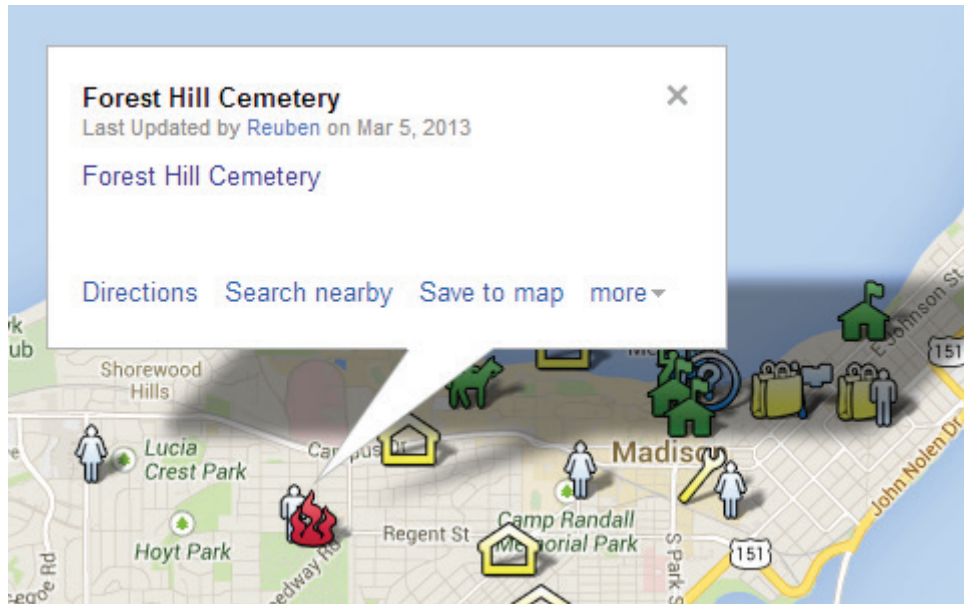


Figure 1. Map Markers in Post-Apocalyptic Downtown Madison in Google Maps.

Students also gain a better spatial and temporal relationship between locations and characters through plotting locations on an actual place. Mapping also encourages them use monuments and other culturally significant spaces in their fiction in meaningful ways, something that videogames already do with success (Bogost, 2011). The map portion can also be layered over the city where the students reside, giving them incentive to reimagine and explore their own communities through the lens of a fictionalized world.

Character Creation Exercises

With the completion of the critical world building portion of the course, the students should have a firm understanding of the multifaceted, complex world that will serve as an integral and active backdrop for their fiction. However good stories need emotionally well-rounded characters too, lest the characters wind up feeling more like a “conglomeration of stats and types rather than the richly complex character that is the stuff of literature” (Martin, 2011), a problem that can plague bland or generic DRPG characters.

Tabletop RPG players often create elaborate identities for their player-characters (PCs) and write stories about them that take place before, during, and after game sessions (Bowman, 2010; Cover 2010). For my fiction writing courses, I have adopted the term “perspective characters” to describe the personalities the players assume when writing their fictions, and I refer to them using the same abbreviation (PC).

First off, PCs should have at a minimum the same statistical categories as the wiki entries to ensure consistency across all characters in the catalog. Instructors will want to closely monitor the creation of PCs so students’ characters have weaknesses as well as strengths and do not become larger than life superheroes. Aleatory techniques can also be used, such as dice rolls to determine numeric statistics, or students can balance any of their characters’ above average attributes with below average ones.

Secondly, as an in-class activity, I ask a series of quantitative and qualitative questions inspired by creative writing textbooks (Bernays & Painter 2010) and RPG character prompts (Bowie, 2013). This begins with their PC’s “driver’s license” and “tax return” information—height, weight, eye color, race, gender, occupation, level of education, economic class, current living situation, etc. They then include more personal details such as tattoos, style of dress, or other distinguishing features. In summary fashion, I ask them how a stranger at a bus stop might describe the PC at a glance in 1-3 sentences.

Next we move to broader, evaluative questions. In 3-4 sentences, I ask them to describe their character’s home life growing up and their attitude toward education; then I ask for 3-4 sentences on the character’s social network, their attitudes toward the opposite sex, and their short and long term life goals.

Then we move into a series of quantitative aspects. I ask them to review a list of dispositions (Angry, Anxious, Apathetic, Ashamed, Calm, Contemptuous, Curious, Excited, Joyful, Melancholy) and choose the top two that best represent the character. I encourage them to offer any alternatives as well. Then I ask them to rank their

characters' following attributes on a scale of 0 to 100:

- Outlook* – from pessimistic (0) to optimistic (100)
- Integrity* – from unscrupulous (0) to conscientious (100)
- Impulsiveness* – from spontaneous (0) to controlled (100)
- Boldness* – from cowardly (0) to daring (100)
- Flexibility* – from stubborn (0) to adaptable (100)
- Affinity* – from cold/aloof (0) to warm/hospitable (100)
- Comportment* – from gruff/antisocial (0) to charming (100)
- Interactivity* – from reserved/loner (0) to engaging/outgoing (100)
- Disclosure* – from secretive (0) to candid (100)
- Conformity* – from conservative/orthodox (0) to heterodox/shocking (100)

I then have them give five-word catch-phrase answers for their character's opinion on religion, general political views, sex and sexual relations, war and violence, drugs and alcohol, and the government.

The next section asks them to select their characters' two primary motivations and assign them values between 1 and 99 that cannot exceed 100: Achievement, Acquisition, Balance, Beneficence, Chaos, Competition, Creation, Destruction, Discovery/Adventure, Domesticity, Education, Enslavement, Hedonism, Liberation, Nobility/Honor, Order, Play, Power, Recognition, Rebellion, Service, Torment, Tranquility, and Understanding. They are also free to suggest other motivations not listed.

The final section is a series of 24 questions I ask in 24 minutes, or one minute per question. They range from "what is your PC's greatest fear?" to "what's your PC's idea of a perfect date?" to "what animal would your PC be and why?" The full list can be found on my website <trenthergenrader.com/worldbuilding>.

The PC customization process can be completed in one class session. The time limit forces spontaneous thinking similar to that required during an RPG session. To mix things up, I also chose certain attributes for students' PCs. For example, in my post-apocalyptic class I had 70% of their PCs living in crushing poverty, which dramatically altered their relationship to the minority of wealthier characters.

Creative Play in the Critical Space

At the end of the process the class will have a sprawling, collaboratively built world complete with a detailed history plotted onto a map, and each student will have a unique PC. The entire process can be completed in about six weeks, based on three hours of class time per week. While students typically develop plenty of story ideas in this time, instructors can also add in more game variations like:

- Choose at random two characters, an item, and a location for each PC and have students write a story that prominently features each entry.
- Choose two locations and have the PC travel between them, describing what he or she experiences along the way.
- Ask PCs to give a detailed, personalized history of a specific location on the map.

Many students familiar with genre fiction will attempt to have their stories match the epic scale of the world they've created, but I strongly suggest they instead focus on the human experience of their PCs in smaller story arcs—stories that happen in afternoons rather than over lifetimes or generations. Through drafts and revisions, I remind them to think about their PCs' unique subject positions in this world and how that might impact their narratives.

Such a project is intensely collaborative yet allows students to pursue their own interests while foregrounding Jenkins's (2009) 21st century skills. The RPG-inspired quantitative and qualitative aspects make the process unpredictable and fun, yet also ensures consistency. Students not only learn about fundamental aspects of narrative but they also develop essential technical and life skills as well.

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Turn Up the Heat! Board Games, Environmental Sustainability, and Cultural Forms

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Introduction

Turn Up the Heat (tidal.northwestern.edu/greenhomegames) is a cooperative family board game that encourages reflection on tradeoffs related to money, comfort, and environmental sustainability (Figure 1). The game playfully confronts power dynamics associated with the use of residential thermostats to control domestic heating and cooling systems. In doing so, it addresses common misconceptions about how thermostats work (Kempton, 1986) and how they can be used to save energy and money (Peffer et al., 2011). Our game incorporates traditional elements such as cards, tokens, and a game board, but it also includes a tablet computer app as a central feature of play. The app simulates heating and cooling system based on factors such as outdoor temperatures, thermostat settings, and home insulation levels. It also gives all players (parents and children alike) the opportunity to adjust a thermostat on their turn.



Figure 1. *Turn Up the Heat* is a cooperative board game in which players make tradeoffs related to comfort, energy, money, and environmental sustainability. The game incorporates a tablet computer app as a central aspect of play.

In designing *Turn Up the Heat*, we were careful to balance the purely digital aspects of the app with the physical components of the board game. The tablet computer is only one part of the game as a whole, rather than the other way around. Our reason for doing this is to preserve advantageous social aspects of board game play (e.g. Berland & Lee, 2011; Guberman & Saxe, 2000; Nasir, 2005) and to involve entire families in thinking about household energy consumption. *Turn Up the Heat* is the result of a yearlong iterative process in which numerous prototypes were developed and tested. After seven months internal testing, we brought the game out to nine families for a total of eleven game sessions. In this paper we provide an overview of our design and a brief summary of results from our playtesting session. Our findings highlight the interplay between, children, adolescents, and adults, and the ways in which families drew parallels between the game and their real-world circumstances.

Background

This project is guided by the idea of building novel interactive systems based on existing *cultural forms* (Horn, 2013; Horn, 2014). The advantage of such an approach is that it provides users with a foundation for engaging in and interpreting an unfamiliar activity. In the case of our game, even though some of the representations are initially confusing, the board game form helps to anchor the experience in a familiar medium. People know that

there will be some basic structure that involves taking turns, rolling dice, moving tokens, exchanging play money for in-game resources, and so on. Importantly, they also know how to engage in game play with friends and family. In creating this game, we considered other approaches (such as a more conventional video game), but the board game seemed more appropriate for the types of whole-family engagement we were interested in fostering.

Board Games and Learning

Board games have been well studied by mathematicians, psychologists, and learning scientists. For example, Berland and Lee (2011) analyzed video of college students playing the cooperative board game, *Pandemic*, and found evidence that players made use of sophisticated computational thinking skills in the course of game play. Nasir (2005) studied children and adults from African American communities playing dominoes. Her analysis focused on the nuanced ways in which players sought and offered help as a way to improve the game experience. These strategies became increasingly sophisticated as she moved from observing children to adults. As a final example, Guberman and Saxe (2000) developed a game called *Treasure Hunt* for use in elementary school mathematics instruction. They found that children created thematic divisions of labor as they took on various roles in the game. These divisions of labor enabled children to accomplish mathematical problems that were beyond their independent ability. In our playtesting sessions we observed similar divisions of labor that seemed to allow families to enact more sophisticated strategies together than they would have on their own.

While not a study of board game play, Stevens, Satwicz, and McCarthy's (2007) study of children playing console video games in homes is notable for what it reveals about the complex and spontaneous *learning arrangements* that children form during play sessions. The study also suggested a mutual interplay between "in-game" and "in-world" experiences of children as they navigate between school, homework, and play. These findings inspire hope that family experiences playing Turn Up the Heat might translate to in-world decisions that families make about heating and cooling their homes. Throughout the game design process, we were guided by the notion of *intrinsic integration* (Habgood & Ainsworth, 2011; Kafai, 1996). Foremost, this means that our game should be fun to play. Additionally, we sought to integrate the core mechanics of game play—namely setting a thermostat in order to stay comfortable, while, at the same time, keeping energy consumption minimal—with our intended learning outcomes. Finally, the representations used in the game parallel the representations that players might encounter in real life.

Thermostats

Residential thermostats were first developed in the late 19th century but gained widespread use in the 1950s. The first thermostat that players encounter in our game (Figure 2, left) is modeled after a common mechanical thermostat introduced this era. In the 1990s, digital, programmable thermostats started to gain in popularity. These devices allow consumers to program different temperatures for different times of the day so that a house will automatically heat up or cool down at pre-set intervals. According to Energy Star, a joint program of the U.S. Environmental Protection Agency and the Department of Energy, "properly using a programmable thermostat at home is one of the easiest things you can do to lower your energy costs. It's as simple as set and save" (Energy Star, 2010). Despite this optimistic assessment, there are several serious usability problems with these thermostats that fundamentally limit their effectiveness (Karjalainen & Koistinen, 2006; Meier et al., 2011). As a result their programming capacities are widely underutilized (Meier et al., 2011). In response to studies demonstrating a lack of energy savings, the U.S. Environmental Protection Agency announced that it would no longer issue the Energy Star rating for programmable thermostats as of 2009. We now appear to be entering a new era of domestic thermostats that are *smart*, online, and controllable by mobile devices such as smart phones and tablet computers. The Nest thermostat (nest.com) is perhaps the most innovative of these new designs. The Nest incorporates sophisticated interaction techniques, machine learning capabilities, and connectivity to a Web portal. Our game's "Internet thermostat" interface attempts to provide users with an opportunity to directly manipulate temperature zones for their characters (Figure 2, right).

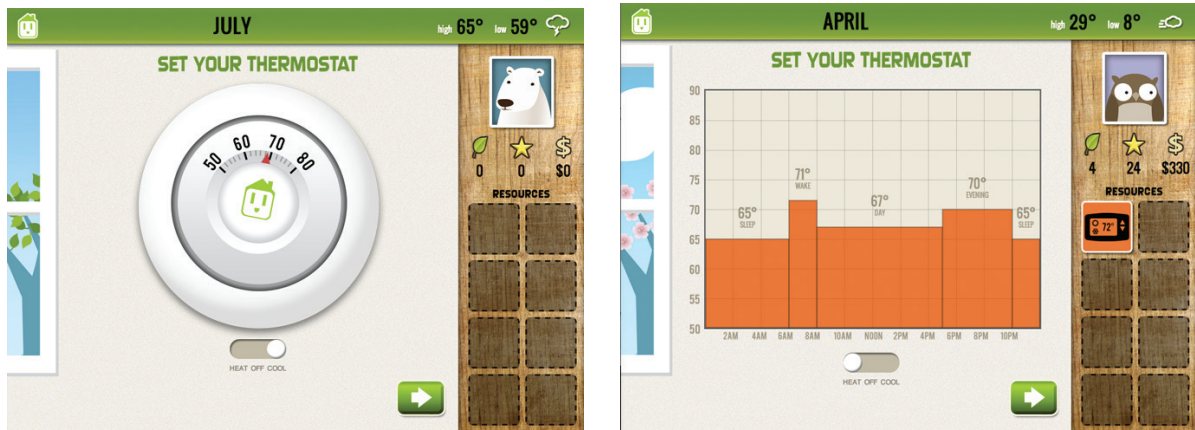


Figure 2. Players start the game with a manual thermostat (left) and can upgrade to a smart thermostat (right) that allows players to set temperatures for four different time zones.

However, even though thermostats are perhaps getting “smarter”, it does not mean that people will necessarily understand them any better than did in prior decades. The cognitive science research of Kempton (1986) highlights a number of “folk theories” that people hold about how thermostats work. For example, many people think that a thermostat operates like a valve and incorrectly assume that “cranking” the heat up to a higher temperature than necessary will warm up a home faster than setting the thermostat to the desired temperature. In fact, for most heating systems, turning the temperature up higher than necessary does not heat a home any faster and risks wasting energy.

Background Interviews

Much of the inspiration for Turn Up the Heat comes from a series of 23 interviews that we conducted with families over a period of two years around issues of domestic water and energy consumption. One finding from these interviews is that many youth rarely, if ever, touch the thermostat(s) in their home and that they have a minimal understanding of how thermostats work. Unlike other potentially dangerous (but important) household activities such as cooking and cleaning, there appears to be less of an opportunity for youth to get involved as they get older. Our data suggests three main reasons why this is the case. First, many adults seem uncomfortable with thermostats and use language like “fussy”, “tricky”, and “afraid I might mess it up” when describing them. Second, parents are often leery of the financial implications of thermostats and tend to believe that children will simply over-adjust for comfort without understanding reasonable temperature ranges, without considering alternative like “putting on a sweater”, and without considering broader impact on family finances. Finally, most thermostats are designed to blend in rather than stand out. They are usually beige or white in color with tiny controls that are uniform in appearance (or even concealed by small doors). They also tend to be mounted on the wall at adult height. One of the goals of Turn Up the Heat is to counter these fears and uncertainties and help families explore reasonable and safe ways for children to become involved in consequential household energy management activities. We also hoped to subtly draw attention to power dynamics around the use of residential thermostats by giving all players (children and adults) in the game the chance to set the thermostat for the team on their turn. In this way, we also intended to confront some of the usability issues and misconceptions surrounding thermostat use.

Design Overview

Turn Up the Heat is a family board game for 2-5 players ages eight and up. The game features a cooperative style of play, meaning that players must work together on the same team to beat the game. A more competitive style of play is possible—in fact, many families suggested that the game could be more fun if family members played against one another—but our play testing made it clear that the cooperative play style resulted in more reasonable game durations (45 minutes to an hour) and more interesting strategy discussions among players. To win the game, players must earn at least 20 Green Points and 20 Comfort Points over the course of one full year while staying out of debt. At the beginning of the game, each player draws a Character Card that determines his or her *comfort profile*. This profile affects how difficult and costly it will be to earn Comfort Points under different weather conditions. To play, team members take turns rolling a die and moving a single token around a game board representing the four seasons of the year. Some spaces on the board indicate special events. For example, when passing Pay Day the team collects \$400 to pay energy bills and to purchase resources. Using the tablet computer, players then enter the month of the year shown on the game board and spin for random weather conditions that

simulate the climate of the United States Midwest. For example, in January a player might spin a high temperature of 30° F (-1° C) and a low temperature of 12° F (-11° C). Players must then set the thermostat based on their character's comfort profile. The game begins with a manual thermostat that can be upgraded to a smart thermostat in the course of game play (Figure 2). The manual thermostat allows players to set only one temperature for the entire day, while the smart thermostat allows players to set individual temperatures for each of four time periods (sleep, wake, day, and evening).

Simulator: After spinning for weather conditions, the tablet computer simulates the home's indoor temperature over the course of the day based on the thermostat settings, the outdoor air temperature, and the home's insulation level. This simulation is shown as a temperature over time graph (Figure 3, left) that animates as the simulation runs. Players earn Comfort Points when the indoor temperature is within their comfort zone (orange area) and lose points when the temperature is outside of the "neutral zone" (light grey area). Of course, running the heating or air conditioning uses energy and costs money. An indicator to the right of the simulator graph animates the energy consumed over the course of the day. Players earn Green Points by using less than 300 kWh for their turn, and, correspondingly, lose points by using more than 400 kWh.

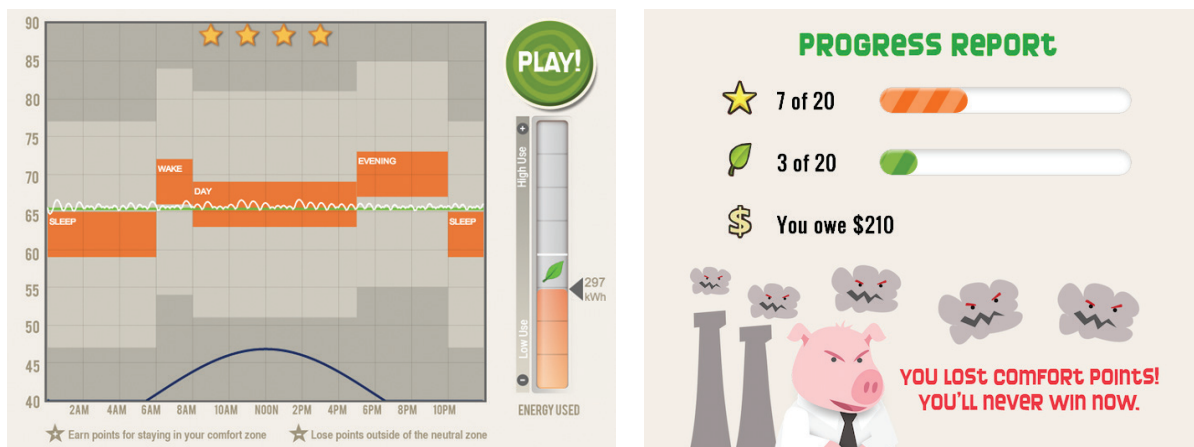


Figure 3. The app simulates a home's heating and cooling system, showing the indoor temperature on a graph over time. Players earn Comfort Points (stars) when the temperature (shown as a white line) stays within a player's comfort zone (orange). The energy hog (right) serves as the evil nemesis—an embodiment of the opposition posed by the game.

Resource Cards: After setting the thermostat, players have the option of using one of their Resource Cards to make it easier to earn points. Some resources (such as warm clothes, hot chocolate, and ice water) can be used to expand an individual player's comfort zone making it easier to earn Comfort Points while using less energy. Other resources (such as insulation, storm windows, and a smart thermostat) improve the home's infrastructure making the game easier for all players. These infrastructure cards cost money, so team members must decide together if a particular upgrade is worth the investment.

Paying the Bill: After running the simulator, all players must make a decision about paying the accrued energy bill, with options to pay nothing (and thus incur a late fee), to pay a minimum amount (computed as a percentage of the total bill), or to pay in full. In extreme weather conditions, the energy bill can be surprisingly high, although not unrealistic for a typical monthly bill.

The Nemesis: In many well-crafted collaborative games, there is a sense of impending doom or suspense that makes the players feel as if they are competing against a real opponent manifest by the game itself. As the rules of our game began to solidify, we noticed that while there was some suspense in game play, it felt too amorphous or disembodied. To address this, we added an evil nemesis character, the Energy Hog, who taunts players when they are performing poorly and broods over the success of players when they are doing well. As more energy is consumed during the game, small energy minions (pollution clouds) start to appear and multiply around the progress screen (Figure 3, right).

Evaluation

To evaluate our game we visited nine diverse families in their homes to conduct playtesting session. Participants included 13 parents (9 mothers, 4 fathers) and 18 children (ages 6 to 16). The families came from a range of social and economic backgrounds including one family who earned less than \$25,000 a year, four families who earned

between \$25,000 and \$50,000 a year, and three families who earned more than \$90,000 a year. The families all controlled their own heating (and sometimes cooling) systems and lived in a variety of building types, including apartments (2 families), standalone homes (5 families), and condominiums or duplexes (2 families). We began the first session with each family with a brief interview about family practices around board game play, thermostat use, and attitudes towards environmental sustainability. After the interview, we invited the families to play the game. For the first four sessions, substantial intervention was required to explain the rules of play and to work around glitches in the game. These sessions led to important iterative improvements to the design. In the following seven sessions, the researchers did not intervene. We instead gave the families a printed rule sheet and let them conduct the entire session.

Findings

Here we briefly summarize findings (an in-depth analysis will be shared in a forthcoming publication). Our analysis centers around the ways in which in-game experiences and discussions overlapped with families' real world circumstances, including how the thermostat interfaces in the game related to existing power dynamics around household heating and cooling systems. As we had hoped, the cooperative style of play resulted in family discussions around game strategy and the meaning of the temperature graph and thermostat interfaces. These discussions also led to instances in which family members drew connections between the game and various aspects of their real world circumstances in subtle and not-so-subtle ways. For example, family members often reasoned about the use of Resource cards in the game based on their experience with real-world analogs.

Family 107

Dad: How about storm windows...

Mom: Ooh, storm windows.

Dad: It costs you money, though.

Mom: They are well worth it, really, it's like putting plastic on the windows.

Here the mother draws a connection between storm windows and plastic insulation as a way to justify the expense of playing the card in the game. Similar episodes took place with other Resource cards including socks, hot chocolate, and smart thermostats. Other intersections between the game world and the real world came out as a result of the distributed use of the thermostat as the iPad was passed from player to player. For example, in the following excerpt the family is confronted with an unusually high energy bill.

Family 107: [30:40]

Boy15: I gained comfort points but I lost ... [green points]

Dad: huh. See what your bill is.

Boy13: [looks over boy 15 shoulder] Four hundred dollars.

Boy15: Four hundred dollars, how is that even possible?

Dad: How did you have a \$400 bill? What did you do?

Mom: Yeah, what did you do?

Boy15: I put on the heat.

[...]

Dad: Well, you got to put the heat on in the winters.

Boy15: Well, that's all I did.

Dad: Well, it's expensive isn't it?

Boy15: Yeah, it is expensive.

To interpret this episode, it is important to note that we decided to have the game start on Earth Day (April 22) after realizing that late spring and early summer tend to be much easier than winter and late fall. This gives families who have never played the game before a low-risk opportunity to experiment with the thermostat interface and the basic game mechanics. However, it also means that winter comes as something of a shock. As families round the board into December and January they are confronted with more extreme (and expensive) weather conditions, and they realize that they should have been more frugal. In the previous excerpt, the surprise of a high energy bill is an excuse for the father to share aspects of his experience managing the family heating system, presumably something he doesn't do often. It also highlights one of the ways in which traditional thermostat roles were inverted or tweaked through game play. Because the son was the one controlling the thermostat, it gave the father an opportunity to draw a parallel with his real world experience. As we had hoped when we were designing the game, moments like these also led to strategic breakthroughs. For example, in the following excerpts the father interprets strategy decisions of the family as they take progress around the board.

Family 104

Timestamp: 34:50

Dad: Kid, you got us 4 energy points. Way to go.

Boy10: I used no energy! Because I used my chocolate and I turned off the thermostat. I used NO energy, Mom.

Timestamp: 36:45

Dad: I don't need to be that warm. If I go in the mid-60s maybe it'll not be in my total comfort zone, but it'll be in my neutral zone, so I wouldn't spend as much money. [sets thermostat to 66]

Boy10: I'd rather spend less money and use less electricity.

Timestamp: 1:00:00

Dad: That was an interesting strategy. You set it as low as you could.

Mom: Like safety ... safety instead of comfort.

Dad: It wasn't super expensive and ...

Timestamp: 1:06:00

Dad: Now that we know how this works, I'll set the thermostat a lot lower because my goal wouldn't necessarily be to stay within the orange band, but just don't go below the negative. I didn't have that in mind when we started.

Boy10: And don't manage your energy in the game as you do in real life.

This example shows how family strategies could emerge in stages. We see this first in the breakthrough from the son who realizes that it is possible to use no energy on a turn (and thus earn Green Points). This is followed with the father's turn in which he actively interprets the temperature / comfort zone graph (Figure 3, left) and expands on a strategy of giving up on absolute comfort to save energy. Later in the game, the mother pushes this strategy further by using an approach that she calls "safety instead of comfort". Through game play the son comments on his father's real-world energy management ("don't manage your energy in the game as you do in real life"). It's difficult to interpret exactly what the son means by this comment, but he seems to be playfully critiquing some aspect of the family's heating situation, perhaps implying that the home is uncomfortably cold or that the energy bill is too expensive.

Although the father takes a leading role in the development of strategy for family 104, it was not always the case that a parent drove the discussion of strategy. One interesting thing we noticed through our testing sessions was the diverse roles that children and adolescents assumed through play. For example, as the following excerpt illustrates there were several instances in which adolescents took a leading role in both interpreting the game representations and mechanics and coaching other family members.

Family 106

Boy16: Oh no, mom.

Mom: What, I'm getting a lot of stars isn't that good?

Boy16: Yeah, but you're not being green!

Mom: I'm not?

Boy16: If you use a lot of energy you're not being green.

Here the mom employs a very common naïve strategy: try to earn comfort points without considering other factors. In many ways, the feedback provided by the tablet computer tends to encourage this approach for inexperienced players. As the temperature simulation runs, animated stars appear with sound effects when the temperature matches a player's comfort zone. The son, in this case, is trying to get his mother to look beyond the gold stars and focus more on the "cost" of comfort by drawing her attention to the energy meter on the right side of the screen (Figure 3, left).

On a related note, we were surprised that despite making many connections between in-game and in-world experiences, families rarely discussed environmental sustainability issues in the course of game play, except for off-hand comments. It could be that the feedback around the comfort vs. financial cost tradeoff (through the bill mechanic) was much more salient than the feedback related to environmental cost. In future versions of the game, we will play up the environmental aspects of the game, perhaps by making the Energy Hog and his pollution minions more aggressive. Other possibilities include imposing a "carbon tax" for high energy use.

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Cellviva! The Design and Evaluation of a Game to Teach Biology

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Introduction

Science labs and educational digital games can be very useful tools for dealing with the inherent challenges of science education. Among these, one key challenge is lack of engagement or motivation (Cordova & Lepper, 1996; Hidi & Harackiewicz, 2000; Kuh, 2001; Krapp, 2002; Carini, Kuh, and Klein, 2006) and another is dealing with naïve theories students have formed prior to instruction that affect how they interpret new information (Carey, 1989; Carey & Wiser, 1989; Gopnik, Meltzoff, Kuhl, 1995). There is also the general difficulty of getting one to change their current theory in more than a superficial way (Kuhn, 1962; Wiser and Carey, 1983; Carey, 1985; Vosniadou & Brewer, 1987; Ozdemir & Clark, 2007). Finally, there is the finding that students will have better outcomes with certain epistemologies (Songer & Linn, 2001), which means an educator must be mindful of tacit epistemology of their curricula and behavior to pursue optimal educational outcomes. While daunting, these challenges are not insurmountable.

When lab modules are well designed and integrated into a larger lesson, generally in a form similar to the “learning cycle” (Lawson, 1958; Karplus & Thier, 1967; Guzzeti et al., 1993), they can be quite effective at facilitating theory change and greater understanding (Hofstein & Lunetta, 2004). However, there are practical limitations to the use of conventional labs that renders some crucial content either too expensive, difficult, or otherwise impractical to demonstrate in the classroom. This is particularly true of phenomena that occur over long period of time or at large scale, such as speciation and relativity.

Well designed educational digital games are uniquely suited to cover these topics (Gee, 2003; Ryan, Rigby, Przybylski, 2006; Barab et al. 2009). The artificial worlds of video games can be designed to allow demonstrations and exploration that would be impossible in the physical world, but that can demonstrate concepts and provide information relevant to physical world (Shaffer, Squire, Halverson, Gee, 2005; Squire, 2006), and provide many other benefits. The experiential nature of games, and the ability to repeatedly test models and refine concepts and skills can lead to deeper, intuitive understanding.

In this project, these two tools are combined; the educational impact of a game about evolutionary concepts, *Cellviva!* situated within a lab-like module, was evaluated and compared to the impact of typical instruction on the topic. The module was self-contained and included lesson plans for the teacher and handouts and homework for the students, to facilitate instruction and effective use of the game.

Project Goals

The game *Cellviva!* was developed as part of a research project to be used in high school biology classes from intro to AP levels. The primary goals included:

- Design a game that communicates evolutionary concepts through the mechanics and gameplay. Meaningful choices and the dynamics that arise from them within the game should correspond to behaviors and dynamics that arise in real world systems.
- Increase student engagement and interest.
- Produce a valuable educational tool for teachers; one that would be easy to use in class, and higher impact than other approaches.

Research questions:

- How do the gains from the *Cellviva!* module compare to those of the standard lesson (both in terms of superficial content knowledge and deeper understanding of concepts)?
- Does the *Cellviva!* module facilitate deeper or more transferable understanding of the topic? A better ability to reason evolutionarily?

Background

ASSET

Cellvival! was developed in partnership with the ASSET program (Assisting Secondary Science Education with *Tetrahymena*), an NIH funded SEPA outreach program. ASSET is a collaboration of researchers and former teachers that develops high school biology lab modules that use a single-celled protist called *Tetrahymena* as a model organism. *Tetrahymena* has a number of properties that make it well suited to the program's needs as it is easy to cultivate, non-pathogenic, widespread in nature, and has a number of qualities that are interesting to high schoolers. For example, it has a cannibalistic variant, seven sexes, and can reproduce sexually or asexually. The ASSET program has a number of modules available, on topics from phagocytosis to population curves, that they train teachers to use and distribute to teachers in schools across the country.

The ASSET program was interested in developing video game content that would both engage students in new ways and reinforce other modules in their curriculum. We met and agreed on the project goals, then I developed the game's concept, design (mechanics and interface), and art direction.

Student involvement

Following initial design work, undergraduate programmers and artists were involved in the production and ongoing development of the game. High school students were also involved in the development process, particularly in creating art and music assets. This allowed the project to provide value before being ready for science classrooms, as students got some experience with the process of game development and the plethora of disciplines (art, biology, education, music, psychology, computer science) involved in educational game production.

Evolution education

While central to much of biology, evolution can be a controversial topic, and some work has been done on resistance to learning evolutionary reasoning and ideas (Evans, 2001). When there is resistance it tends to increase when the organism was perceived as being more related to humans, with insects being the least related things measured and thus seeing the least resistance. One-celled organisms should be perceived as even less related, so *Tetrahymena* should be even less likely to encounter resistance, making them an excellent model for this content.

Methodology

Game Design

Basic gameplay. The player guides a *Tetrahymena* cell through an environment based on the objects, substances, and organisms found in its natural habitat. Using simple one-button mouse controls, they must direct it to eat smaller bacteria and avoid being eaten by larger predators. Their goal is to eat enough food to reproduce without dying. The interface (Fig. 1) includes a prominent 'food-meter' to indicate progress, as well as several other elements that provide information on the current traits of their cell, and the size and health of the rest of the *Tetrahymena* population in the environment.

To provide an intuitive, readily identifiable player avatar, and to maximize the number of modules the game's content could be connected to, the organismal level of analysis, or control of a single cell, was used. It provided a middle ground between levels of analysis focusing on either the organelles of the cell's internal anatomy or populations of cells, which allows those levels of analysis to still be relevant and discussed in the module. For example, the avatar uses very noticeable cilia to move, and competes with other *Tetrahymena* for limited food. A clear avatar the player can identify with also helps increase investment and make that avatar's actions more personally meaningful; in this case it makes the cell's interactions with its environment more memorable and engaging. This allows information about *Tetrahymena*'s predators, prey, feeding behavior, and responses to substances (such as nicotine residue), to be both conveyed experientially and in a manner immediately relevant to the pursuit of the player's goals.

Reproduction. The "Reproduce" button appears when the food-meter is full, and allows players to access the reproduction interface (Fig. 2). This interface visually presents the history of the generations leading to the current cell, and allows the player to select either sexual or asexual reproduction (as *Tetrahymena* are capable of both). The screen also shows the cell history of potential mates for sexual reproduction, as well as their current traits, which would affect the traits of their offspring. Players can affect the traits of the next generation, either by selecting a mate, or slightly mutating if reproducing asexually. They are then given a choice of offspring and upon selection revert to basic gameplay in control of that new cell.

This system forms both a progression mechanic and meshes with the basic gameplay to form a way to communicate evolutionary concepts in a meaningful way to the players. One important piece of this system is the graphs that dominate this screen. On these graphs, the four traits of cells are organized in two opposing pairs. For example, the blue icons at the top and bottom of the graphs represent movement speed and maneuverability. If a cell gains speed it also loses maneuverability and vice versa. This pair forms an axis and the other traits form a second axis, defining a 2D space where the statistics of any given cell define a point. So if traits change, as they do through reproduction, a new point can be drawn, and a line can connect them representing the change between generations. For example, if a new generation has higher speed, its dot would be higher in the space. This allows the game to visually represent changes between generations to players and to show the accumulation of small changes. The four traits (speed, maneuverability, hazard resistance, and metabolism) all have direct impacts on gameplay, which make these changes relevant to the goal of survival.

Using these graphs, the reproduction interface provides information about the traits of the previous generations (which the player experienced when playing them) and reproductive choices, as well as information about possible mates. This allows players to reflect on the impacts of their choices and make informed decisions or revise strategies if it appears they are not the best way to pursue their goals.

Level selection The game includes two non-tutorial levels. These levels are designed to favor different sets of traits (one has many predators, hazards, and food bacteria, favoring high hazard resistance and speed; the other has many obstacles and little food, favoring high metabolic efficiency and maneuverability) rather than a difficulty progression. This is intended to show how fitness is contextual and traits may be an advantage in one environment and detrimental in another.

Additional notes To support and foster interest in learning more about the real world organisms presented in the game, all the organisms have both mouse-over tooltips with names and more in-depth entries that provide information both about the real world and tips that are useful within the game. These entries are accessible with a single right-click on the organism of interest.

One significant concern with this design, as with many other evolutionary games, is that the player's active role in the development of their organism may foster the misconception that an intelligent choice is being made during these processes in the real world. In practice, natural selection is a combination of mate selection (which may involve choice, but may not be 'conscious choice' as it is colloquially used, particularly not in single celled organisms) and probabilistic processes, where advantaged subsets of a population produce more progeny than other subsets, and over many iterations become more prevalent in that population. In simplifying this complex system to a more easily understood game design there was the opportunity to focus more on these probabilistic population level effects, but early in the design process this option was discarded in favor of the current design. There were two main reasons for this. First, the focus of the current design is more on how an individual interacts with its environment, rather than pressures' effects at a population level. This smaller scope provides a better entry point for unfamiliar students and can be built on to discuss population level effects later. Secondly, the goals of this project were and are not just to convey content to students, but also to increase interest in and engagement with science. As discussed under "Basic gameplay" there are a number of factors that make the current design approachable and engaging, and those benefits were deemed to outweigh the potential damage of the misconception fostered by the core mechanics. Ultimately, based on the reception of other similar games and discussions with teachers and students, it was judged that the current design was likely to have a more positive impact on students.

This is not to say that fostering a misconception of intelligent choice was not a major concern, merely that it was decided not to address it by altering the design of the game. As this game was designed for use in classrooms as part of a module, there were other opportunities to address this misconception in the associated instructional materials.

Game Module Instructional Design

Previous research (Squire, 2006) described the problems that can arise from teachers and students with little experience with video games in a classroom context, so it is important to provide adequate support for both parties in order for them to get the most out of such tools and experiences. Thus a lesson plan and student handouts, were developed to accompany the game. The lesson plan explained the game and its learning objectives to teachers and laid out two periods of play and discussion around the game. Student handouts were developed to go with these activities. These materials were developed in partnership with the experienced instructors at ASSET and based on frameworks such as the learning cycle. The general structure of the lesson is to repeatedly cycle between game session and class discussions. This structure allows the students to experience the game, develop intuitions and explicit understanding of it, then compare their experiences and understanding with other students,

and to connect game experiences to terms and larger concepts. The 'genespace' graphs from the reproduction screen also form a useful tool for these discussions. The graphs provide a common reference and way for students to describe their approaches and attempts to adapt. They then return to exploring the game again with these new connections and ideas in mind, building a richer understanding with each iteration of the cycle.

The suggested discussion points for teachers also allowed for correcting possible misconceptions the game could foster, such as the previously discussed a misconception of intelligent choice. In the lesson, teachers are advised to point out this discrepancy between how the game works, and the more complicated way things play out in reality during the discussion and, if possible, to even build on it to have students consider other ways the game is and is not like reality. In this way the lesson can both address possible issues with the content that could be communicated by the game design and foster critical thinking skills, by have students reflect on exactly what information is being communicated by the game.

Research Design

The research component of this project is ongoing. Currently, a pilot deployment to three local high schools has been completed and more schools are being recruited participate in a wider deployment in the fall. Here, the findings from that pilot, its implications, and the plans for the wider deployment are discussed

Assessment The impact of the different instructional approaches is assessed by a pre-post test. The pre-test consists of two pages, one page of multiple choice (MC) questions about content knowledge and a second page of open ended short answer (SA) questions that includes one asking them to apply evolutionary reasoning. The post test included these two pages as well as a third page with a more difficult series of open ended questions asking students to apply evolutionary reasoning to a novel situation (a sunless environment). The open ended questions were qualitatively coded by trained coders on a high number of dimensions, such as accuracy, length, depth, novelty, etc. The test items were developed in collaboration with ASSET and the content questions were also designed to be relevant to the Next Generation Science Standards (NGSS).

Participants and conditions The initial pilot gathered data from three local high schools. Two of the schools provided pre-post test only of classes that experienced the video game module (n=21, and n=36 at the two sites), while the third provided data on students in the video game module (n=28) as well as a control group that experienced the class's usual instruction on evolution (n=29).

Results Simple t-test analyses with an R statistical package of the MC total scores, indicated that the video game group improved significantly ($t = -2.70$, $p < .001$) as did the control group's ($t = -1.20$, $p = .021$). However the gains did not significantly differ between the two groups. This provides basic validation that the module is as effective as control in terms of factual knowledge. The SA items have shown no group differences, though analyses of these richer responses is ongoing as well.

Informal surveys, observations of, and conversations with students and teachers have also been very positive, with students enjoying the game and teachers seeing it as a valuable addition to their classrooms.

Future Directions

The pre-post measures are currently being revised based on the results of the pilot and teacher feedback. The SA items specifically are being refined to better assess deep conceptual understanding. Measures of engagement and interest in science are being added, to measure possible other benefits of the module beyond content knowledge. The reactions of the students and teachers indicate the video game module is perceived as more effective than standard instruction by both parties. The refined measures will aim to test if these participants are accurately perceiving some advantage (either in terms of learning or attitudes) or if these comments are the result of some kind of bias, such as an overestimation of the effectiveness of new technologies or more enjoyable activities.

Additionally, a larger sample from across the state is being recruited for the next deployment. This should provide both data on how the module performs with a greater variety of students and teaching environments, as well as greater power to examine those differences.

All the teachers in the current pilot wished to continue using the module in the future and if this trend holds for the upcoming larger deployment, *Cellviva!* could provide a good platform to examine a number of further research questions moving forward. Among these are its effects on long-term retention, the persistence of any effects on attitudes, what effect mechanical differences between versions have on the impact of the game, and, similarly, what effect different approaches to using the game in classrooms have on impacts. These effects may all interact with other factors as well, such as interest in science, SES, age, etc. providing even more potential research questions.

Ultimately the core of this project is an effort to develop a meaningful game design and test its effectiveness; beyond that, it aims to provide insights and best practices to improve the effectiveness of subsequently developed games and games based instruction.

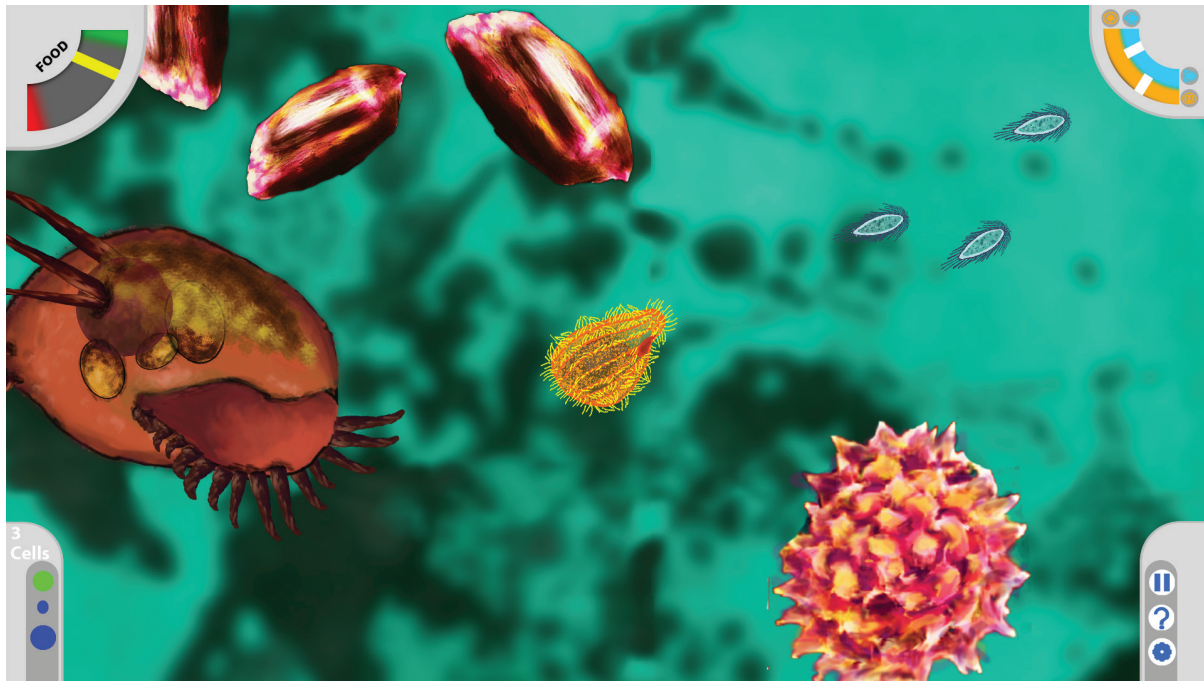


Figure 1: Gameplay as a Tetrahymena cell.

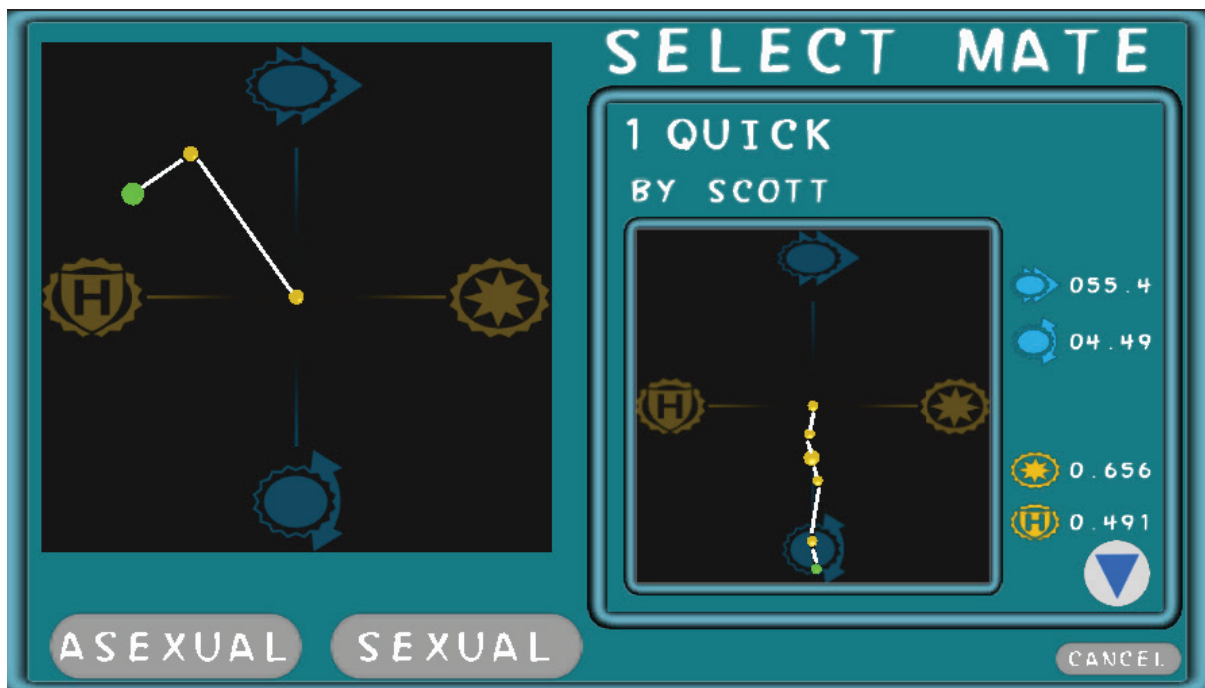


Figure 2: The reproduction interface.

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Facilitating the Discovery and Use of Learning Games

William Jordan-Cooley, Columbia University and BrainPOP

Challenges Creating a Need

Interest in video games for education (Gee, 2009), the number of available titles (JGCC, 2013), and the learning games industry have grown rapidly over the past 10 years, and this growth is expected to continue (Adkins, 2013). However, there are a number of tripping points between the creation of a learning game and its successful implementation, especially in the classroom. In particular, there exists a need for better a) distribution (Mayo, 2009); and b) materials supporting integration into existing curricula and practices (Kebritchi, Hirumi, Kappers & Henry, 2009; Baek, 2008; Kinzer et al, 2013). There are currently few opportunities to connect end users (students, parents, and, especially, teachers) with good contextually-appropriate educational games—or, conversely, for developers to make their games visible to the right audience (Freitas & Oliver, 2006; Rice, 2007; Alhadeff, 2011; and Baek, 2008).

There are a variety of barriers to implementation in the classroom. Though there is still some ideological resistance to games in education (Rice, 2007), most of these barriers are related to access, distribution and teacher support (Kebritchi et al, 2009; Kinzer et al, 2013; Baek, 2008). Kebritchi et al (2009) identified curriculum integration; technical and logistical concerns; and teacher training as the three major issues. In a recent survey, teachers described the primary barriers for implementation as cost (50% of 300 respondents); access to technology (46%); and emphasis on standardized testing (38%) (JGCC, 2012).

On the other side of publishing, many developers are having a difficult time putting their games in front of the *right* audience. App markets are overflowing with titles and educational game sales are dominated by a few big-name publishers. Though this may be overcome by marketing, this expenditure comes from an already spare development budget (Adkins, 2013; JGCC, 2013; Mayo, 2009).

The learning games community has begun to develop its own marketing and distribution vehicles. Some sites offer browsable game databases. These include the Games for Change website and *The Educational Games Database*. Review sites such as the Common Sense Media site and Institute of Play's *Playforce* vet for quality and sort by content and use scenario. They may also rate attributes such as violence, safety and learning potential. Sites like *Playful Learning* and *Educade* provide support materials to help teachers discover, explore and use educational games. In the following, I'll discuss BrainPOP's GameUp - a curated collection of games with related materials and alignments - focusing on the selection process and teacher supports that ensure successful implementation in the classroom.

A Solution: BrainPOP's GameUp

The needs of teachers and developers across the industry call for a systematized collection of educational games that can connect the best and most appropriate content with the individual teacher's classroom (JGCC, 2013, Kinzer et al, 2013; Rice, 2007; Alhadeff, 2011) and supporting materials for integration (Baek, 2008; Kebritchi et al, 2009; Kinzer et al, 2013). Over the past three years, BrainPOP has been curating educational games for educational content, engagement level; alignment with education standards; and usability in the classroom. We showcase games that meet our selection criteria and provide supporting materials to facilitate implementation within a teacher's curricula.

This supporting content includes:

- Lesson Plans – Vital for helping a teacher integrate games into their daily curricula (Kebritchi et al, 2009). They help teachers tie games into broader lessons that which support critical reflection and transfer of in-game learning beyond the game (Squire, 2011). Materials also cover assessment tips, essential inquiry questions and common misconceptions. They provide both a starting point for the teacher “new to games” as well as opportunities to grow best practice for “seasoned gaming teachers.”
- Animated Movies – Each game is linked to about 3-6 relevant BrainPOP topics which build background and related knowledge.
- Assessment– Short quizzes allow the teacher to validate learning outcomes via an external assessment of the student's achievement of learning objectives, particularly their ability to transfer learning to written forms, which is useful in our current exam culture (Kebritchi, 2009).

- SnapThought tool - For some games, there is the ability for students to take a snapshot of the game screen. To these, they can write notes and submit to their teacher. This further supports critical reflection, a vital component of game-based learning (Squire, 2011)
- Standards – Games are aligned to state and national standards, including the Common Core.

As of April 2014, GameUp showcases 103 games from 41 different partners. In 2013, games on GameUp enjoyed approximately 24 million unique game sessions and 2 million hours of gameplay. The game content spans 396 BrainPOP topics - all aligned to core curriculum.

Curating the Collection

We have cast our nets far and wide around the Internet and the learning games community in the search of engaging and pedagogically rigorous games. We scour compiled lists, ed tech news sites, developer blogs, and search engines by search term. We also have a method for users of our site to “suggest-a-game” to an email that we check regularly. Over the past four years, we’ve discovered and played well over a thousand games, seeking the best educational games to promote and host on GameUp.

In order to identify games that can be easily integrated into a teacher’s curricula and deliver deep and engaging learning experiences, we have created a set of criteria—logistical, technical and design—with which to evaluate potential additions to our site. A primary purpose of this paper is to make our selection criteria known in order to invite feedback, particularly on the considerations for successful implementation.

Technical Requirements

Inability to solve small technical issues, whether by administrative restrictions or lack of know-how, can prohibit use for many educators (Kebritchi, 2009). In fact, a Futurelab survey suggests that technical constraints are *the primary barrier* for implementation of educational games (Sanford, Ulisack, Facer, & Rudd, 2009). Teachers often don’t have money for additional software and hardware (JGCC,2012) or even administrative privileges to install new software. In order to make games easily accessible to the widest range of teachers, we look for games that are playable without any software or hardware not already available for the majority of classroom computers.

Regarding platform, our users are very interested in games for mobile; however, the majority of our users are using desktop and laptop browsers, and the technical hurdles for distributing mobile games to the classroom are considerable. Many older browsers are still in use in the classroom and cause problems with more recent games. In November 2013, fully 30% of visits to the GameUp site were made via Internet Explorer version 9.0 or older. To best serve our audience, we look for games that are compatible with PC (Firefox, Chrome, IE 8, 9, 10 and 11) and Mac (Firefox, Chrome, and Safari) browsers.

In terms of development tools, Flash is a near-universal plug-in for the large majority of our users and has historically been a good bet when picking a platform for the current K-12 market. However, with the rapid projected growth of mobile (Adkins, 2013), many developers are exploring alternatives that can build for both mobile apps and browsers, particularly HTML5 and Unity. Currently, the canvas HTML5 element does not work in Internet Explorer 9.0 or older, and HTML5 in general has limited performance, especially on mobile. These browsers will be upgraded over time, but for now this segment of our audience is substantial. Unity has started gaining some traction with the development community and can build to multiple platforms, but still usually requires a download and/or plug-in which teachers often can’t install. It will likely be a few years before either platform is as widely adopted as Flash.

Logistical Requirements

There are a few best practices from a logistical perspective.

- We ask that all games include sound controls to ease classroom management and support use in a variety of classrooms and learning environments.
- Games that offer an experience that is completable within 20-30 minutes are highly valued. If the game lasts longer than approximately 30 minutes, then some way to save progress is important. In general, this can be accomplished by a) locally saving to the cache; b) using codes unique to each particular game state (like the NES Metroid!); or c) using individual user logins. The first two options are great, but for reasons involving the Children’s Online Privacy and Protection Act (COPPA), we have not allowed third-party games to set up and request individual logins. However, we have started integrating some save-state features with BrainPOP student logins.

- To facilitate classroom management and remain COPPA compliant, we encourage developers to limit external links within games. Exceptions are links to supplementary materials (these are also easily included with the teacher materials).

Legal Requirements

Since a large part of our audience (and that of educational games in general) is under 13, we ensure that games are compliant with COPPA by not prompting the student for any personally identifiable or contact information. Adherence to these rules also restricts social features of games like chat windows, leaderboards with student-entered names, Facebook, Twitter, etc. We also prohibit external links leading to commercial sites that might prompt the student to purchase something or enter personal information.

Evaluating Design: A Heuristic and Qualitative Analysis

Determining what it means for a game to be among the “best” is has many challenges, including the diversity and inter-relatedness of evaluation criteria; the nature of the experience to change with user and environment; and limited extensibility of existing evaluation methods. Ideally, evaluation of any product involves a case-control study with individually designed success metrics and end-users in an authentic environment (Law et al, 2008). We give preference to developers providing this rigorous proof of efficacy.

Without resources for empirical validation of each game, we’ve developed a shorthand mixed-method evaluation process as advocated by the literature (Law et al, 2008; Bekker et al, 2007). BrainPOP testers employ a rubric of heuristics (described below and in the Appendix) and a brief qualitative analysis. The playtest is generally conducted by two to four persons within the company. The base two reviewers consist of one trained instructional designer and one experienced teacher. If there are differences of opinion or uncertainty as to quality of the game, then the game is playtested by additional persons such as other teachers, content experts and some children.

Heuristic Analysis

A number of rubrics exist for evaluating educational games (Educational Gaming Reviews, 2011; Fish, 2010; Mohamed and Jaafar, 2010; Rice, 2007; Kinzer et al, 2011). Our rubric borrows from these but focuses on criteria relevant to browser-based games that tie to specific K-12 learning objectives. Some potential attributes like “integration of learning objectives into whole-tasks” or “allows players to roleplay professional identities,” are valuable (Driscoll, 2007) but not considered necessary in each game. These kinds of criteria are considered in the qualitative portion of the evaluation.

In our view, good educational games instill interest in a content-specific challenge and support construction of knowledge to achieve that goal. Games support constructivist learning by allowing and encouraging active experimentation within a topic (Gee, 2006; Galarnéau, 2005). To experiment within a system, a game must create an interactive **Representation of the Content**. For math games this is often straightforward; all calculators have the logic for a dynamic representation of the real number system. For physical systems, it is also fairly straightforward, though some push the limits of computational power (i.e. simulations of multibody systems). For social systems and language, this becomes a real challenge.

No simulation of reality is perfect and, as a system becomes more complex, it is necessary to create more abstractions and simplifications. However, it is ideal to create a model of reality that is as complex and nuanced as the mental model of the topic that one wishes for a game player to develop. In our rubric, we assess the **Accuracy** of the game model with respect to the target learning objectives.

Players should have as much *control over the relevant variables* of the system as possible. For example, in *Citizen Science*, students learn how a lake ecosystem might be damaged by pollution and cleaned up after it has been polluted. Players can select and adjust the various types and levels of pollution; particular mitigation strategies for cleanup; etc (Squire, 2011). We measure this as **Interactivity**.

Whenever a player changes a variable in the system, he or she should get **Feedback**. This feedback should go beyond indicating “correct” or “incorrect.” Feedback should be content-specific and corrective in nature (Marzano et al, 2001) i.e. if an input is wrong then convey *why*. This allows continuously forming and testing hypotheses in a loop that drives learning (Merrill, 2001) and engagement (Schell, 2008).

Once you've created interactive representations of the content of the system, you must create interesting objectives and ways for the player to interact with that content or **Gameplay**. A primary difference between a simulation and a game are **Compelling Objectives**. These are ideally nested and building upon each other from simple, immediate goals to more complex and complete (Schell, 2008). For example, in Nintendo's *Mario Brothers*, immediate objectives include jumping over a hole or onto a mushroom. Longer-term goals include completing levels and rescuing the princess.

For an educational game, it is not enough for game mechanics to be fun; they must also support the learning objectives of the game. **Integrated Content and Gameplay** measures the degree to which the cognitive dynamics engendered by the game mechanics align with the desired learning objectives. Davidsons' *Math Blasters* gave kids practice with math operations. However, the jumping and shooting of the game introduced extraneous cognitive load, which is detrimental to learning (Driscoll, 2007).

An incredible potential of games is the ability to provide **Embedded Assessment** (Gee, 2009; Shute, Ventura, Bauer, and Zapata-Rivera, 2009). If completing in-game objectives necessitates achieving the learning objectives, the game scores high on this criterion. Games that can be won by trial and error, or that contain gameplay that does not require relevant skill mastery, rate low on this criterion. A game scores yet higher if it can collect and present data on the player's achievement of learning objectives, especially in the form of a summary screen or teacher dashboard.

We use **Bloom's Taxonomy** to rate the depth of interaction with the content. Rice (2007) offers an index and scoring rubric for assessing the tendencies a video game demonstrates toward encouraging higher order thinking. The rubric measures elements including storyline, roleplaying, dialogue, puzzles, 3D graphics, open-ended completion, avatars, interactivity, gathering and synthesizing information, fidelity of simulation, AI, and replay value. Rice (2007) reasons that possessing more of these elements will make a game more likely to encourage higher-order thinking. Our rubric includes some of these elements in other criteria but asks the expert tester to independently assess the cognitive processes involved in playing.

The **Pedagogy** criteria assess the role of instruction within the game. It has been demonstrated that instruction is most effective when activating prior knowledge or experience, so in-game instruction is most effective when first allowing a player to interact with the content (Bransford and Schwartz, 1998; Merrill, 2007). The criterion **Just-In-Time, Adaptive Instruction** measures the timeliness of this instruction and whether it is uncovered by player exploration. **Amount of Instruction** measures the volume of instruction relative to what must be conveyed, regardless of when it is presented.

The **Interface** is certainly the most simple of the five in the current iteration, with one graded item, **Intuitive Interface**. Heuristics focusing on usability are considerably more granular on this topic (Mohamed and Jaafar (2010) detail 10 criteria) but a less structured analysis works well for our purpose.

Multimedia contains criteria for both **Artwork** and **Audio**. These criteria are essentially identical to those of an entertainment title. The only additional consideration is their appropriateness for the audience and classroom setting. The third criterion is the **Narrative and Theme** of the game. The subjective entertainment value of these aspects is considered, and, more importantly, how the theme supports the content and affective objectives of the game. Does the fictional world seem tacked on and a distraction from the content? Or does it provide a useful context or metaphor for thinking about a field? For example, in iCivics' *Do I Have a Right?*, you play a managing partner of a law firm. This provides a compelling context for learning the Amendments and allows the player to inhabit the role of a practicing professional.

Qualitative Analysis

The written portion of the evaluation is used for discussing the experience of gameplay and features not covered in the standardized heuristics. Here we consider uncommon or non-standard but beneficial features, such as how the game enables role-playing, exploration of moral and ethical dilemmas, or working together as a team of highly specialized individuals (Kinzer et al, 2011). Additionally, the in-game experience and the reflection that takes place in the classroom are equally important and the latter can be especially difficult to predict based on the game (Freitas & Oliver, 2006; Squire, 2008). The qualitative analysis is often the beginning of ideation on how the game might be incorporated into a broader lesson.

Discussion

Educational games present tremendous potential for deep and engaging learning. However, there are significant barriers for successful distribution and implementation. GameUp shines a spotlight on top quality games that satisfy practical constraints for adoption and implementation. In doing this, we hope to enrich the experience of our users and bridge the gap between the development of great educational games and their successful use in classrooms. Determining “quality,” important considerations for implementation, and effective teacher supports for educational game is an ongoing conversation in the learning games community. In this paper, we’ve presented the results of our research and practice from the three years of development and use of GameUp, in order to invite feedback and advance discussion.

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Appendix: Educational Video Game Evaluation Rubric.

Time to fulfill learning objectives _____ Are there supporting materials? _____
 Sound controls (Yes/No) _____ Is the game browser-based? _____
 Is it cross-browser compatible? _____ Are there external links? _____

Representation of Content

Accurate

- 1 – The physics of this game are all screwed up and buggy! And what about friction?
- 3 – The model is reasonably accurate but neglects some factors important for the learning objectives.
- 5 – You could cite experiments within this game in a research paper.

Interactive

- 1 – Content is largely static with very few ways to manipulate; basically, flash cards.
- 3 – Mixed static and dynamic elements, some limited feedback.
- 5 – Fully interactive, player can manipulate all parts of the system that are relevant to learning objectives.

Feedback

- 1 – Little or no feedback. I'm not even sure if I got it right or wrong.
- 3 – Some feedback. Mostly an indication of right or wrong.
- 5 – Immediate, content-specific, and corrective feedback. If it's wrong, then I'm told why.

Gameplay

Compelling Objectives

- 1 – I'm not engaged to complete the objectives. They're either too far off and vague or too simple.
- 3 – It's fun. I'm not sure I'd play it longer than a half hour or so.
- 5 – Easy to get started but a lifetime to master. The Chess of educational games.

Integrated content and gameplay

- 1 – It's like Go-Fish with multiple choice questions stapled to the backs of the cards.
- 3 – Pretty good. The educational aspects of gameplay seem a little tangential.
- 5 – The content and game are ONE.

Embedded Assessment

- 1 – You could easily beat this game without learning a thing about the content.
- 3 – Some kids might learn the content but others could probably fudge their way through.
- 5 – Beating this game without achieving the learning objective seems really difficult.

Bloom Action Verbs

- 1 – Memory – Player memorizes facts, rules, etc.
- 2 – Comprehension – Player translates, interprets, identifies examples, etc.
- 3 – Application – Applies rules, methods, and principles to unique problems or puzzles.
- 4 – Analysis – Breaking wholes into parts, comparing and attributing.
- 5 – Evaluation – Hypothesizing, experimenting, and testing, reflecting, validating.
- 6 – Creation – Designing, programming, drawing, etc.

Pedagogy

Just-in-Time, Adaptive Instruction

- 1 – Out of context, text-heavy instructions and little in-game feedback.
- 3 – The directions were heavy at the beginning but you could learn ok from just playing too.
- 5 – I messed up a lot but it wasn't frustrating because each time I learned a little more.

Amount of Instruction

- 1 – Stop telling me what to do! OR I'm completely lost!
- 3 – Sometimes there was too much or too little instructions. Usually it was just enough.
- 5 – I always felt like I was on the verge of discovering something new!

Interface

- 1 – I've been clicking around for 5 minutes now and I can't figure this thing out at all.
- 3 – This is relatively painless to use. There are a few things I wish they'd done differently.
- 5 – This is as easier to use than my iPad, watch out Apple.

Multimedia

Audio

- 1 – This is worse than Christmas carols in April
- 3 – Not bad. I wanted to turn it off after playing for a while.
- 5 – Completes the experience.

Artwork

- 1 – Seems hastily done. Could be better used to illustrate content.
- 3 – Cool concepts but a little rough around the edges.
- 5 – Imaginative and well-produced. Excellent visualizations of subject material.

Narrative and Theme

- 1 – Uninspired and poor executed. What does it have to do with the content?!
- 3 – Pretty cool story. It's a little stretched how the content fits in.
- 5 – Engaging and meaningful context for thinking about the content.

Breeding Dragons for Learning Genetics: Redesigning a Classroom Game for an Informal Virtual World

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Introduction

Serious gaming research is leveraging the principles gained from playing digital games for learning games in schools (Gee, 2003). Hundreds, if not thousands, of educational games and simulations have been designed to support learning (e.g., NRC, 2011; Squire, 2011). A recently completed meta-review was cautiously optimistic about the benefits of digital games to promote competencies and pointed out the need to better understand particular gaming designs and scaffolds for learning (Clark, Tanner-Smith, Killingworth, & Bellamy, 2013). Virtual worlds can provide such designs in the form of environments that simulate historical or fantasy contexts to engage and support students, alone or in teams, in various aspects of science inquiry. Several of the virtual worlds designed for use in science classrooms have demonstrated promising learning and motivation outcomes when compared to conventional instruction (for an overview, see Dawley & Dede, in press).

Outside of schools, however, it's a different story when virtual worlds are used for learning purposes, not only because of the voluntary nature of participation, but also because of the significantly larger number of participants (Kafai & Dede, in press). Virtual worlds are among the fastest growing online communities, and younger players in particular have adopted virtual worlds such as *Club Penguin*, *Habbo Hotel*, *Minecraft*, *Neopets*, and *Whyville* as their new playgrounds, reaching hundreds of millions of participants, far more than their adult counterparts (Grimes & Fields, 2012). Research suggests that informal virtual worlds can provide rich learning opportunities for science inquiry and science conversations, for instance, when players not only experience, but also study epidemic outbreaks in real time (Kafai & Fefferman, 2010). While such epidemic simulations engage large numbers of participants, players also benefit from having access to tools such as simulators that support and direct further science inquiry. The challenge, then, is to figure out how to combine and leverage the best of both worlds: the structured and guided activities found in many school virtual worlds with the voluntary and social participation found in informal virtual worlds.

In this paper, we address this challenge by examining the redesign of an established classroom simulation called Geniverse for integration into an informal, virtual world called Whyville. In Geniverse students breed dragons to learn about genetics in a game-like environment that helps them to see biology as an active, inquiry-driven enterprise and enables them to interact as scientists and build essential skills and understandings both in genetics content and in the nature and process of science (Horwitz, Gobert, Buckley, & O'Dwyer, 2009). While the virtual world Whyville.net already offers many science games and activities to its currently more than 7 million registered users—predominantly girls (77%) between the ages of 8 and 16—the integration of Geniverse could provide additional opportunities for online players to engage in learning genetics. Our central research question was: Could the integration of an instructional tool developed for the more formal environment of classrooms be successful in the informal environment of a virtual world? To answer this question, we examined two levels—participation and play—in breeding dragons and learning about genetics in Whyville. The first level focused on understanding the nature of participation: *Do Whyvillians visit the dragon labs and lairs? Who comes? How much time do they spend using Dragons?* The second level focused on understanding the nature of play: *How many labs and lairs do they visit? How many dragons do they breed?* We used a combination of different data sources, including log files and pre/post surveys to examine how Whyvillians participated, played, and learned about genetics by breeding dragons. In the discussion, we address the quality of participation and learning about genetics in informal virtual worlds, how science inquiry software tools that previously only were used in teacher-scaffolded and supported classrooms can be redesigned for use in more informal virtual learning contexts such as Whyville, and next steps for further research.

Background

Virtual worlds enable participants to simulate economic, social, and scientific phenomena to explore various issues (Bainbridge, 2007). The immersive nature of virtual worlds also supports social interaction, identity exploration, and motivation because players can decide how to explore the environment, which avatars to interact with, and what to do rather than follow a pre-designed path (Boellstorff, 2008). Virtual worlds designed for use in science classrooms such as *EcoMUVE*, *Quest Atlantis*, and *River City* have incorporated many of these features and have demonstrated promising learning and motivation outcomes compared to conventional instruction (Barab, Scott, Siyahhan, Goldstone, Ingram-Goble, Zuiker, & Warren, 2009; Dede, 2009; Metcalf, Kamarainen, Grotzer, & Dede, 2012). These school-based versions, however, often lack some of the key features, in particular the voluntary and open-ended nature of participation and learning found in the massive informal communities, as well as the social and economic dynamics that are essential dimensions of interactions in informal worlds. In the case of *Whyville*, players can accrue virtual “currency” by playing science games successfully, currency that they then can use to accessorize their avatars and socialize with others (Kafai & Fields, 2013), thus combining social and educational play.

Most research on informal worlds has focused on science inquiry and learning by engaging players in educational science games or by initiating scenarios that invite scientific investigation and leverage the massive number of participants (Kafai & Fields, 2013). For instance, the launch of a virtual epidemic in *Whyville* provided a compelling context for players to learn about infectious disease inside of classrooms with the guidance of teachers (Neulight, Kafai, Kao, Foley, & Galas, 2007), as well as outside of classrooms using simulators and discussion forums to engage thousands of online players (Kafai & Wong, 2008). The epidemic simulators within *Whyville* allowed players to experiment with different parameters and make predictions about the spread of infection while they were experiencing in real time the outbreak among their avatars. A more in-depth study of a simulation tool also revealed that players on their own became engaged in systematic iterations rather than random experimentation (Kafai, Quintero, & Feldon 2010). This successful integration and use of epidemic simulators suggests that other instructional tools such as the genetic simulators previously only used in classroom settings could be integrated into virtual worlds.

Genetic simulators such as Geniverse build on a long legacy of educational technology developments, starting with GenScope in the early 1990s, that recognize the importance of teaching students about the relationships between phenotype and genotype (Horwitz, Gobert, Buckley, & O’Dwyer, 2009). Learning about genetics is an increasingly important area of K-12 science education for personal and political reasons with the availability of genetic testing for the public, the use of genetics for medical care and ethical considerations, and political discussions around genetically modified food. But teaching genetic principles is not so straightforward. Instructional interventions have focused on providing hands-on experiences, insofar as it is possible, or using simulation tools. For instance, Fast Plants allow students to study breeding and development within rapid cycles to help them better understand inheritance principles (Williams, Debarger, Montgomery, Zhou, & Tate, 2012), while online simulators such as Geniverse help students understand key principles of genetics and make the impossible possible by allowing students to peer into chromosomes, control meiosis, and change the alleles of virtual genes. As surprising as it may be, dragon breeding offers an authentic context for learning about genetics: for one, dragons are used as a simplified model organism, based on real genes, to examine different traits, and the fantasy context of dragons offers the narrative thread common in many gaming contexts. Students breed dragons and observe how the offspring’s genotype affects its appearance, or phenotype. As they move through the Dragons game they must choose trait variants for parents that will result in a prescribed set of traits in the offspring. These initial activities familiarize students with the basic dragon traits and their mapping to genes, testing student understanding by having them manipulate the genes of one dragon to match a target dragon. In studies of high school classes, using Geniverse has been found to be successful in helping students learn about key genetic ideas (Reichsman & Lord, 2012). In all research done so far, a teacher trained in facilitating the use of Geniverse in the classroom has been present. In adapting Geniverse for *Whyville*, we considered the absence of a teacher and designed a game called Dragons that provided many, but not all, of the same features found in Geniverse with added support for independent use. To understand if, and how, these new features of Dragons were successfully integrated in *Whyville*, we examined two different levels of engaging with Dragons and learning about genetics in *Whyville*. The first level focused on the participants and Dragons the nature of their participation, while the second level focused on understanding the nature of play with.

Context, Participants, Data Collection, and Analysis

Our study was conducted in collaboration with Numedeon, Inc., the company that hosts *Whyville*, performed the technical integration of Geniverse, and collected the tracking data and online surveys. After pilot testing with a select group of experienced *Whyville* players, we launched the Dragons game in August 2013. We released Dragon

activities to the Whyville community in two stages. The first stage offered a subset of labs and lairs that focused on basic dominant/recessive traits; the second stage introduced more complex patterns of inheritance. Currently, Dragons offers 37 activities: 21 labs and 16 lair challenges (see Figure 1).

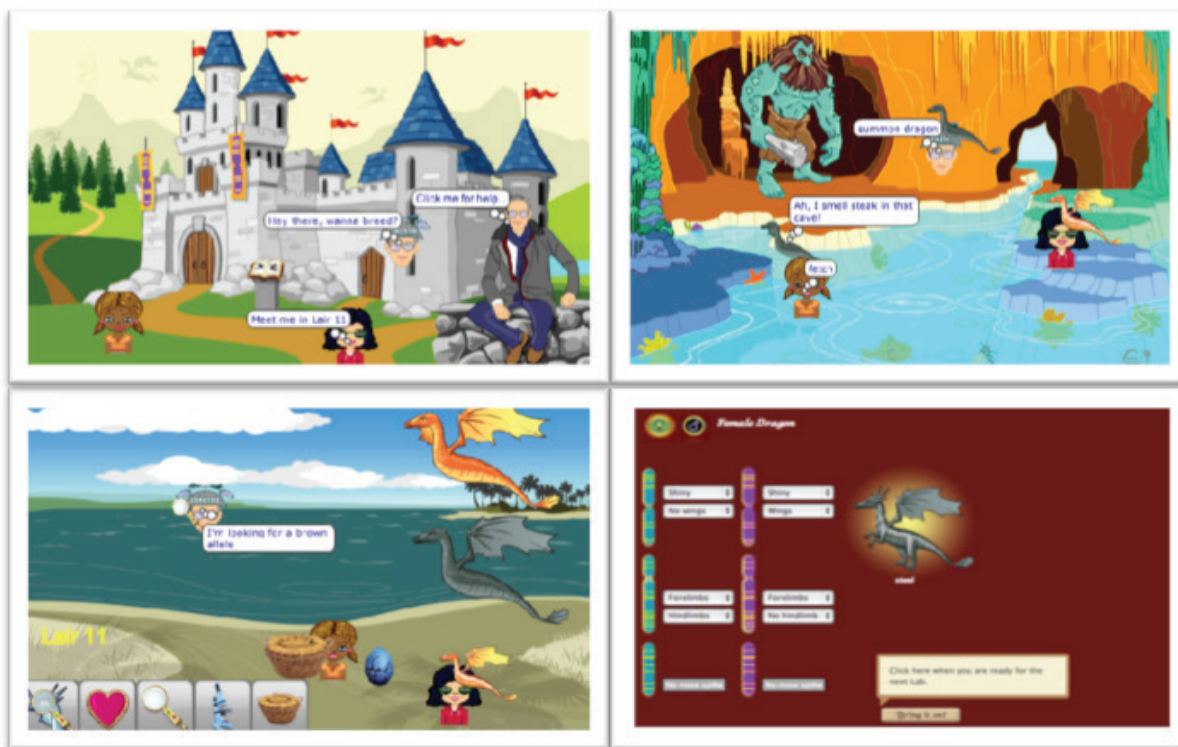


Figure 1: Clockwise from upper left: Dragon Castle where players can enter the lairs or labs, or check their progress in the Dragon Book. Players meet in the Grotto to fetch their treasures. Lab challenge illustrates how a change in genotype may affect the phenotype of the dragon. Players breed their dragons in a lair.

Players start *Dragons* with a tutorial that introduces them to the process of breeding dragons and the different interface elements. Through a series of guided challenges, players learn how to scope a dragon's chromosomes, reveal the alleles in an unhatched egg, hatch a dragon, and breed their dragon with other dragons. Once players have completed the tutorial, they are sent to the Dragon Castle where they can begin solving Dragon challenges in the lairs (where the wild dragons roam) or delve more deeply into dragon traits and inheritance through the Dragon labs. As players complete each challenge and lab, their progress is recorded in their Dragon Book, which includes all available Dragon activities. The Dragon activities are listed by level of difficulty, though players can attempt them in whatever order they choose. As players move through 16 challenges, they are presented with progressively more complex patterns of inheritance such as incomplete dominance, sex-linkage, and polyallelic traits. Each challenge focuses on a specific concept and has one or more labs associated with it. The labs provide highly scaffolded, game-like challenges that highlight genotypic to phenotypic relationships, the process of meiosis and fertilization, and the selection of parents based on the need for certain alleles in a pool of offspring. Labs provide players with both instruction and feedback as they introduce the new alleles and patterns of inheritance that players must understand to complete the lair challenges.

In Dragon challenges, players are asked to produce a dragon with a specific set of traits that will enable it to fetch treasure. For instance, to find a dragon that can fly to the top of a palm tree and grab the golden coconut, players must enter a lair where dragons have the alleles needed to produce wings and arms. While the labs are single-player activities, players can work alone or collaborate in the lairs to breed offspring that have the required traits as lairs are essentially Whyville "chat rooms" that support multiple player interactions. Within each lair, individual players can perform several actions. They can use the scope tool to examine the chromosomes of the parent dragons living in that lair, or they can scope an egg produced by two parents, before it hatches, to examine the offspring's alleles and determine if it will have the trait(s) they need. A player is not allowed to take a dragon once it has hatched and its phenotype is revealed. A player can also bring his or her own dragon (whose phenotype—and even genotype—they know) into a lair and breed with one of the resident dragons. This is especially helpful when

the challenge requires genetic material from dragons residing in more than one lair (not all alleles are present in the resident dragons of every lair). Finally, a player can breed his or her dragon with another player's dragon. In pilot testing, it was not uncommon to hear one player say to another, "Come to Lair 5 and breed with me, I have a nose spike!" Each challenge ends with fetching treasure that is hidden throughout the Whyville virtual world in popular chat rooms frequently visited by Whyvillians like the beach, grotto, or waterfall. Once in these locations, a player can summon their dragon and fetch the treasure. All actions performed in these public areas are viewable by other players, providing "advertisement" for the Dragons game.

Our data collection included a variety of different measures from the following sources: (1) log files that recorded all Dragon-based actions of Whyville players, including information about locations visited in the labs and lairs, and chat content, and (2) online pre- and post-surveys. In September 2013, we released a pre-survey consisting of 13 items with one question about prior experience with genetics in school, five questions about interest in genetics with five-point Likert scales, five multiple-choice questions that presented various scenarios involving specific parental genetic traits, chromosomes, and results of breeding, and one open-ended response question. Two of the genetics content questions used hypothetical scenarios. Whyville players received 120 "clams" (Whyville currency) for answering the pre- and post-surveys. While 4,379 Whyvillian players answered the pre-survey during September - December 2013, we focused our analysis on the 1,265 players who did one or more Dragon activities such as completing a lab or visiting a lair. Seventy-four percent of this sample (or 937) were girls, representative of the gender distribution in the larger Whyville population. A preliminary examination of the player data revealed that participating users ranged in age from 8 to 99 years (!), a rather surprising range given that Whyville is most popular with a tween audience. The wide spread of age, however, was likely to be explained by some players not identifying their actual age when having registered on the site. At the time the analysis was conducted, not all players had completed the post-survey (these were made available only to players who had completed at least six challenges or labs), thus this section of our findings is based on a subset of 81 players who had complete pre- and post-surveys.

Findings

In the following sections, we present first main considerations in redesigning the classroom-based simulation Geniverse into Dragons for the virtual Whyville, then report on the nature of participation in Dragons, the nature of play in Dragon labs and lairs, and finally, players' interest and understanding of genetics.

From Geniverse to Dragons: Redesigning a Classroom Game

The Dragons activities borrow several key elements from the classroom game Geniverse, but also differ in terms of content design and coverage, player features and incentives, and the connection to the larger Whyville community. Like Geniverse, the "labs" in Dragons challenge individual players to solve genetics puzzles of increasing difficulty. Indeed, the labs are the portion of Dragons most similar to Geniverse. Dragons created in the labs do not persist in the rest of Whyville and cannot be "owned" by players. However, to integrate Geniverse into Whyville as the Dragons game, the content was reduced, covering only two-thirds of what is addressed in Geniverse. The reading level of the text was also adjusted for a middle school rather than high school audience. In contrast to Geniverse, Dragons also features "lair" where multiple players can adopt "pet" dragons by gathering and hatching eggs. Players can only "own" one dragon at a time, which they can summon in any other location in Whyville. Each lair is home to a small group of resident male and female dragons, which differ genetically from lair to lair. By visiting several lairs and breeding their dragon judiciously with the resident ones, players can acquire a genetically diverse range of dragons. If two players occupy the same lair, they can also breed their dragons with each other in order to produce a dragon with traits useful in the greater Whyville virtual world—either for its intrinsic value to "show it off" or for the extrinsic value of fetching treasure.

The addition of lairs and the multi-player feature are unique to the Dragons game as is the access to the rest of Whyville, where players can use their dragons to obtain various treasures, but only if the dragon possesses the appropriate set of traits. As mentioned, a dragon with wings can fly up into a tree and grab a coconut while an armored dragon can brave falling rocks and retrieve a diamond from behind a waterfall. The challenge of Dragons, then, is to breed many different kinds of dragons that can retrieve treasures from different "rooms" in the greater Whyville virtual world. When players summon their dragon for this purpose they are in full view of any other Whyvillian in that room. This exposes non-players to the fact a "dragon game" is going on in other parts of Whyville, and encourages them to participate. These changes in the design were intentional to give Dragons a more game-like feel with incentives that mirror other Whyville games, leverage the massive and collaborative nature of Whyville activities, and embed instructional elements such as visualizing traits in lair activities.

Participation and Play in Dragon Games

The Dragons games were launched at the end of summer 2013 with an announcement on the main Whyville portal, along with an invitation to players to complete a short pre-survey in exchange for earning 120 clams. The visits to the Dragon game took off and lairs were visited by multiple players at the same time. The examination of log files revealed that the lairs received a total of 10,655 visits and a total of 8,350 dragons were bred by Whyvillians during this time period. Certainly, the rise in increase of certain terms in chat, such as “dragon” and “gene,” is due to the presence of the Dragons game. Our further analyses focused on a subset of 1,265 players who chose to take the pre-survey and thus provided us with information about their interest in and knowledge of genetics.

Who came to play Dragons? Over the course of five months, 1,265 players visited a lab or lair. Of those, 937 were girls (74%) and 328 (26%) were boys, representative of the Whyville community at large. With approximately 20,000 active player visits in Whyville per month, the Dragons games reached about 6.3% of those players, most likely coming from the group of “core users” in virtual worlds (Kafai & Fields, 2013). The average self-reported age of the Dragons players was 19.9 years old, and thus far older than the average Whyville player who is around 12.4 years old. Because we know that players differ so dramatically in frequency of their activities (Kafai & Fields, 2013), we divided the 1,265 Dragons players into two groups: heavy and light players. Heavy players were those who successfully completed at least one lair challenge whereas light players might have visited multiple lairs or labs, but were never successful in completing a lair challenge. Boys and girls represented both heavy and light players at approximately the same ratios as throughout Whyville.

What did players do in Dragons? Of the 1,265 players, 390 completed at least one lair challenge, successfully retrieving a treasure while 363 completed a lab. Note that players did not receive clams for completing lair challenges; instead they received a “treasure” (e.g., magic chalice or diamond), which appeared in their Dragon books as a record of their accomplishment. Both labs and lairs were popular activities. Labs are single-player activities while lair challenges can be completed alone or with other players. Some players preferred one mode of play over the other while others participated in both equally. On average, players completed 3.3 labs and 4.9 lair challenges. Breeding dragons—to solve the challenges or to create a different “pet” as the reward—was an engaging activity for most players. Light players bred 3.3 dragon pets on average. Heavy players bred an average of 18.7 dragons. The maximum dragons bred by one player was 173!

Interest and Learning in Genetics

After all this activity in *Dragons*, what impact did it have on players’ interest in and understanding of genetics? The assessment was divided into seven survey questions focused on background, motivation and attitude toward learning genetics and another six test questions focused on genetics content. The answers from the pre/post survey revealed that interest in genetics was high to begin with, with an average of 3.65 on 5-point scale, and this level of interest did not change significantly after playing with Dragons. Not surprisingly, those players who completed the most Dragons activities started with a significantly higher interest in genetics. In addition, while 64% of all players stated in the pre-survey that they had some prior experience with genetics in their schools, we found that 72% of heavy players reported having prior genetics experience as compared to 61% of light players, a statistically significant difference at the $p=.05$ level. In addition, the heavy player group’s motivation and attitude toward learning genetics was significantly higher than those of the light player group. All these findings indicate that the Dragon games were most attractive to those players who had already prior interest and also a background comparable to secondary biology class given their self-reported age.

Our assessment of players’ understanding of genetics was hampered by the fact that of the 1,188 players who completed the pre-survey, only 81 players also completed the post-survey, and only 10 of those were light players. Not surprisingly, the pre-survey scores on content knowledge portion for those members of the heavy player group (3.2 of 5) was significantly higher than the pre-test scores of light players (2.8). Even though heavy players bred nearly six times more dragons than the light player group, they did not show a significant gain in content knowledge after taking the post-survey. To truly gauge players’ content learning, we need an increased number of Whyvillians in the light player group to complete the post-survey. This suggests that we might need to provide additional incentives to increase participation in order to meet this goal.

Discussion

We started this paper with an overarching research question: Could the integration of an instructional tool developed for the more formal environment of classrooms be successful in the informal environment of a virtual world? We redesigned Geniverse, a simulation tool developed to help high school students learn about genetics, for use in the virtual world of Whyville with a predominantly middle school player group. Some of the design changes—

providing incentives and including multi-player options—were a nod to the traditions of virtual worlds at large and to achieve a better fit with the existing gaming activities within Whyville. We know from the number of visits and play that some players were more drawn to the single-player labs while others were more interested in creating dragons and solving lair challenges. There was also a large group of players who created dragons without completing any challenge, presumably for the “coolness” factor of having a dragon pet.

Further analysis is needed to examine to what extent individual players learn genetics content by engaging in systematic investigations of inheritance by breeding dragons in lairs or completing lab activities. This performance could be gleaned from multiple data sources. We could explore patterns of play for those players who fail challenges initially and improve over time as compared to those who succeed early in earning treasure. Additional research will attempt to detect growth in a player’s understanding of genetics by analyzing actions that reveal evidence of genotypic thinking. For instance, we can look at whether players use the special “scope” tool to peer into a dragon’s chromosomes to determine if an egg contains the alleles necessary to complete a specific challenge, and if they “hatch” that egg or reject it based on what they see. Such focused analysis of play patterns could reveal whether players engage in more intentional rather than random inquiry (Kafai, Quintero & Feldon, 2010).

Redesigning instructional games for informal virtual worlds is a promising first step to enrich learning opportunities for a wide variety of science topics outside of school. Children are drawn to massive online communities for multiple social benefits, including collaborative play. By adding science games to these environments, we can provide extended opportunities to engage with complex concepts such as genetics. With *Dragons* in Whyville, we have shown that players can become highly engaged in science outside of school. Reaching more children by making these tools accessible in informal contexts may be a key to engaging more children in science learning, but it is also no guarantee that many of these inherently complex concepts will be fully understood through play alone.

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Gamification for Online Engagement in Higher Education: A Randomized Controlled Trial

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Abstract

A randomized controlled trial was used to test if gamification tools can increase engagement and improve learning outcomes in a blended (online and in-class) second-year university course. Students in control and experimental groups accessed separate course management systems (CMS). On the gamified site, students earned badges and points for online activity and showed increases (versus control) in the personalization of online avatars; a doubling of visits to the CMS; and a reduction by 1.3 days in the time before deadline to complete weekly blog assignments. Female students used the gamified site more than males. In a post-class survey, 82% of students believed gamification was an effective motivation tool. However, there was no evidence of improved learning outcomes on graded assignments. This trial provides evidence that gamification can offer incentives for online activity and socializing but, on its own, may have little impact on quantifiable learning outcomes.

Introduction

Both “gamification” (game mechanics applied to non-game settings) and “blended learning” (the mix of online and in-class learning environments) have emerged as major trends in educational technologies (Baker, 2012). Blended learning, via online course management systems (CMS) such as Blackboard and Moodle, holds “the potential, human and technological, of accommodating students with distinct learning needs” (Dias, 2014). Likewise, gamification has witnessed growth in the commercial and non-educational spheres to engage and retain customers and clients on enterprise websites (Zichermann, 2011). In Google Scholar, “gamification” generated 6,830 results (as of May 26, 2014). Advocates have demonstrated anecdotally the power of game-based technologies and gamified pedagogies to motivate a broad range of participants, from students in institutional classrooms (Sheldon, 2011; Kapp, 2012), to crowd-sourced scientific research (Eiben, 2012), to “alternate reality games” aimed at non-academic general audiences (McGonigal, 2011).

Gamification has generated debate over its definition, its benefits, and its pitfalls, “broadly opposing marketing professionals vs. designers and scholars of serious games” (Rughinis, 2013). The basic definition of gamification entails “the use of game design elements in non-game contexts” (Groh, 2012), although a refined definition focuses on educational contexts: “simple gameplay to support productive interaction for expected types of learners and instructors” (Rughinis, 2013).

There are many examples and case studies of educational games, play-based classrooms and gamified online educational environments. However, there is little experimental evidence of the efficacy of a gamified educational space when compared to a control group under similar conditions using randomized trial. As Groh cautions: “for a good academic summary the hype has to cool down before and proper scientific studies about the benefits as well as the side-effects of gamification are needed” (2012). Our experiment attempts to bridge that gap in the scientific literature by testing whether basic gamification tools can increase online activity in a blended classroom and, if so, whether improved learning outcomes will be reflected in the extra communication and time-on-task.

Previous Research

A literature review of experimental studies done on educational and “serious games” found that only 10 per cent (12 out of 121) used a randomized controlled trial approach (Connolly, 2012). The review’s authors called for “more well-designed studies of games in developing higher order thinking and soft skills” (Connolly, 2012). One control-variable experiment compared groups of students using a gamified course management system (Domínguez, 2013). The authors discovered that students in the gamified online environment scored better than the control group on practical assignments and total scores, but they performed more poorly on written assignments and participated less in class activities. Technical hurdles of the gamified online interface coloured this study’s findings, so the authors divided results between students in a control group, students in the experimental group who used the gamification tools, and students in the experimental group who eschewed the gamification tools (Domínguez, 2013).

Another series of experiments added game-based learning simulations to three large-intake university courses (first-year business, third-year economics, third-year management) and compared grades in gamified sections with non-gamified control sections of the same courses. The authors found increases in final grades in courses that used games; the positive effect occurred equally for students of different genders and ethnicities, but was reversed for students 41 years and older (Blunt, 2007). The experiment offers more evidence of the potential benefits of gamified curriculum; however, the results depend on motivated instructors who can integrate higher-order simulation-based game designs into their curriculum. Other research emphasizes the importance of “meaningful framing”—embedding activities in a narrative that supports goals—to improve the results of point-based gamification systems in general (Mekler, 2013).

The literature review highlighted an opportunity to create an online component for a university course that would integrate the most basic level of game design elements in a transparent and mostly automatized format, thereby removing the influence and bias of the instructor from the experiment as much as possible. In this way, we hoped to test whether rudimentary gamification—so-called “game interface design patterns,” such as badges and leaderboards (Groh, 2012)—can enable students to duplicate the positive learning outcomes demonstrated in courses that used deeper levels of game design, or at least perform better than a non-gamified control group.

System Design

For the experiment, our research team constructed a course site using open-source WordPress software, with the BuddyPress plug-in, which added social-media functionality. The CMS site included an Assignments page that outlined requirements and deadlines for the various assignments (weekly blog posts, mid-term exam, in-class group pitch, final essay); a Syllabus page, with weekly readings from a textbook and hyperlinked stories and videos; a Forum page, where students posted 10 weekly blog assignments; and a General Discussion forum, where students could start threads, post links and engage in online discussions.

The research team duplicated the control CMS under a separate domain URL and created a gamified experimental CMS by installing two plug-ins, BadgeOS and myCRED. A research assistant designed and uploaded 20 virtual badges via BadgeOS. Student users of the experimental website could earn the badges by completing online activities. The BadgeOS plug-in awarded most badges automatically for online activities, including the following:

- Signing into the website for the first time (badge title = Welcome)
- Changing the default avatar (Facelift)
- Sending Friendship requests (Networking)
- Creating a Forum topic (Contributor)
- Replying to a Forum topic (Commenter), 10 replies (Communicator Basic), 20 replies (Silver), 30 replies (Gold)
- Joining a Group (Members Only)
- Logging into the website 50 times (Information Overlord)
- Posting an innovation pitch idea to the group project forum (Thinker) and getting three other students to support the idea (Innovator)
- Submitting a draft of the major essay (Rough Draft)

The research assistant awarded certain badges for meeting course benchmarks:

- Getting perfect scores on reading quizzes over one month (Jeopardy Jedi)
- Attending the essay workshop class (Workshop)
- Completing the group project (Presentation)
- Completing the major essay (Major Essay)
- Completing all the course work (Complete)
- Complete the course with exceptional participation (Wizard)

Once achieved, the students received an email message, and the badge appeared beside students’ user profiles on the CMS (see Figure 1). Students in the experimental group could see each other’s badge collection as they progressed, but they had to log into the CMS, using student ID and password. Outsiders and students in the control group could not see the badge collections. Students were told that badges would have no direct impact on their marks or final grades for the course.

Facelift

[Edit](#)

You have earned this achievement!

Thank you for building a better environment not filled with faceless grey zombies



Add personality to your user account by changing the boring default avatar to something more identifiable to you

1 Required Steps

- Change Profile Avatar

Most Active Users

#1	1 234.00
#2	1 058.00
#3	1 020.00
#4	839.00
#5	713.00
#6	660.00
#7	635.00
#8	627.00
#9	612.00
#10	581.00

Figure 1: Facelift badge via BadgeOS (left), leaderboard via myCRED (right)

Using the myCRED plug-in, the research assistant assigned “Points to Award” for online activities. The myCRED plug-in automatically tabulated and associated points with a student’s username. On the CMS, myCRED generated a Top Ten leaderboard listing the students, by usernames, who had accumulated the most points (see Figure 1). The number of points per task remained unchanged throughout the term. Students in the gamified group did not know which tasks earned points or how many points they could earn for each. Again, they were told that points had no bearing on final course grades. The myCRED software issued points as follows:

<input type="checkbox"/> Becoming a member of the site (one-time)	10
<input type="checkbox"/> Logging into the site (maximum three times daily)	1
<input type="checkbox"/> Creating a new post	5
<input type="checkbox"/> Replying to a post (maximum three per post)	1
<input type="checkbox"/> Clicking on a hyperlinked reading (once per URL)	3
<input type="checkbox"/> Clicking on a hyperlinked video	1
<input type="checkbox"/> Creating a new Forum topic	1
<input type="checkbox"/> Replying to a Forum topic (maximum 3 per day)	2
<input type="checkbox"/> Creating a new BuddyPress Group	10
<input type="checkbox"/> Joining, posting to or commenting in a Group	1
<input type="checkbox"/> Leaving a group	-5
<input type="checkbox"/> Updating Profile (maximum twice daily)	1
<input type="checkbox"/> New avatar	1
<input type="checkbox"/> New friendship	1
<input type="checkbox"/> Earning a badge	50

We also added a list of “quests” to the gamified site, which outlined the stages to complete the three major assignments. The quests were descriptive add-ons, however, rather than integrated into the curriculum, in contrast with other courses that instructors have designed and overseen as narrative-inflected, quest-based “games” (Sheldon, 2011).

Data-Gathering Tools

On both the gamified experimental website and the control site, the research team installed the SlimStat plug-in to track users’ online activities, including the date, time and number of log-ins, and the amount of time spent per visit. Students in both groups completed pre-experiment and post-experiment surveys to gauge general attitudes toward gaming, interest in the course content, experience with online course management systems, levels of procrastination, and other factors.

Experimental Design

After several revisions, the research team received Human Research Ethics Board approval for a randomized controlled trial in a second-year interdisciplinary elective course of 50 students that studied technology and soci-

ety. During class, the course instructor (also the principal investigator) explained the purpose of the gamification project. A research assistant distributed and collected consent forms to maintain anonymity from instructor. The research assistant eliminated students from the trial who declined consent, failed to sign the form, or registered in the class after the experiment began. (These students could access the control website, but their data was not collected.) The research assistant randomly distributed students who had signed consent forms into control and experimental groups of 21 and 20 students respectively. The research assistant emailed website addresses for the control and experimental CMS to the appropriate students, with instructions to log in via student IDs and passwords.

No further explanation was given to students about the gamified site. Throughout the term, the instructor avoided mentioning the experiment. Students were simply told to “visit the course website” to access readings and complete blog assignments. If students had questions about the gamified site, they were told to contact the research assistant via email and not ask the instructor. The gamified website was not designed to embody best practices of gameful design or to turn the course into a game, as outlined by proponents of game-based learning (Sheldon, 2011). The system of badges and points was meant to act as a simplified metric and feedback loop of course activity for students. It was set up to operate as easily and transparently as possible, with a user-friendly interface and few interventions from the research assistant or instructor. The research team wanted to set up a rudimentary gamification system, common to commercial enterprises, in a controlled environment, and measure how users interacted with the course website. By isolating two randomized groups of students online, the research team could compare interactions with a similar cohort using an identical website, minus the gamification plug-ins, to analyze as objectively as possible the tools’ effects.

Results

The course concluded after 85 days, when students handed in final assignments. Initial analysis has focused on identifying and quantifying differences between the online activity of students in the experimental and control groups. Future analysis will probe deeper, using the qualitative survey data, into explanations for the correlations identified.

1. Avatar Adoption

The most conspicuous difference between the two groups was in the students’ adoption of new avatars within the CMS. On both WordPress sites, new users who logged into the site began with a default avatar: an anonymous gray-and-white silhouette. As with other social networking sites, students could click on their profile and upload a photo or image to personalize the avatar that appeared beside their Forum posts and replies. In the experiment, students were neither instructed nor required to alter their online avatar. In the gamified site, however, students could earn a “Facelift” badge (as well as 50 points) by replacing the default avatar with a new image.

In the gamified group, 16 out of 20 students (80%) replaced the default avatar with a personalized image, either a photo or found art. In the control group, none of 21 students who had signed consent forms replaced the default image. The research assistant and the instructor had personalized their own avatars, so students in both groups were aware of the option. Given the evidence of the importance of avatars in building trust in online gaming communities (Smith, 2010), the difference between the two groups of students in the personalization of their online presence (80% vs. 0%) is a reminder of the value (as many commercial social networks recognize) of simple feedback incentives, like badges or completion bars, to encourage users to humanize their digital presence.

2. Assignment Deadlines

The main required use of the online CMS was for students to write short (150-250 words) blog posts on specific questions or readings and upload each post before a weekly deadline. Students received one mark for finishing each blog on time (up to 10% for the course), but no marks for failing to post or posting after the deadline. There was little difference in the number of missed blogging assignments between the two groups; the experimental group missed 1.4 out of 10 assignments on average versus 1.3 for the control group. However, based on SlimStat tracking, the experimental group posted their assignments on average 1.3 days earlier than the control group on the weekly deadline cycle.

3. Repeat Visits

Another correlation between the gamified CMS and online activity was in the total number of visits to the course website. Measured by the SlimStat plug-in, the class average for logging into the site was 79.1 over the term, a little less than once per day. However, students in the experimental group logged into the gamified site more than

twice as often as students in the control group, as mean (112.6 visits vs. 47.1) and median averages (95 vs. 45). The median corrected for one student in the gamified group, who logged in 244 times and whose online communications revealed a conscious effort to “game” the system for maximum points. The doubling of online activity held up when analyzed by the gender of students in both groups (see Table 1).

	Com- bined	Experi- mental	Control	P value
Total: (N) mean / me- dian	(41) 79.1 / 63.0	(20) 112.6 / 95.0	(21) 47.1 / 45.0	<0.0001
Male: (N) mean / me- dian	(21) 63.0 / 50.0	(7) 96.1 / 91.0	(14) 46.4 / 45.0	0.003
Female: (N) mean / median	(20) 96.0 / 70.5	(13) 121.5 / 99.0	(7) 48.6 / 48.0	0.005

Table 1: Total CMS visits / term

The SlimStat plug-in also tracked the length of time of each visit to the CMS. The experimental group logged in twice as often as the control group, but these students spent neither more nor less time per visit on the site (see Table 2). This finding suggests students were not simply logging in to accumulate points or badges, and even though they did not spend extra time on the CMS during each visit, students doubled the time they spent in the online space due to their increased number of visits.

	1-5 min.	5-10 min.	10-20 min.	20+ min.
Experi- mental (N: 20) %	18.6	8.5	12.3	12.5
Control (N: 21) %	19.3	8.2	12.0	14.8

Table 2: Mean time per visit (% range)

4. Discussion Forum

Students had to use the CMS to check the syllabus for deadlines; to access online readings; to review assignment requirements; and to post weekly blog entries. Other activity was optional. Students were allowed (although not explicitly encouraged) to post to a forum non-mandatory “General Discussion” forum that had been set up on both course sites alongside the mandatory blogging forums. In the experimental group, students started 47 separate topic threads, which generated 220 discrete replies; topics ranged from links to course-related articles or videos, discussions of videos shown or topics mentioned in class, and questions about assignments or requests for research help. (On a “News & FAQ” forum, two students started a thread to discuss how the site awarded points and badges.) By contrast, on the non-gamified control site, only one student started a topic on the Discussion Forum; it got no replies. The social-networking potential of the control site remained almost entirely dormant.

5. Gender

While video games have been traditionally associated with young men, the data from this experiment demonstrated that women can also be motivated by gamification techniques. In the experimental group’s leaderboard of points, the top five users (and eight of the top 10) were female students. The female student with the most points (1,234) earned nearly twice as much as the top male student (660). Female students earned a higher mean (705) and median (627) than male students (507, 572).

6. Learning Outcomes

By adding new pedagogical tools, instructors hope to see a positive impact on that most quantifiable measure of learning outcomes: grades. (And so do students.) While our experiment demonstrated a correlation between gamification tools and an increased use of the CMS, the extra online activity did not translate into a rise in grades for the gamified group, either as a whole or when examined by gender. The marginal differences in the average grades for the midterm, major essay and final course were outside of statistical significance (see Tables 3 to 5). On the Midterm, where the P value was lowest, the experimental group actually scored a lower than control: 77.2 vs. 81.1 (see Table 3).

	Experimental	Control	P value
Class: mean %	77.2	81.1	0.21
Male: mean %	75.3	79.7	0.27
Female: mean %	78.5	83.9	0.31

Table 3: Midterm marks

	Experimental	Control	P value
Class: mean %	78.1	76.1	0.38
Male: %	74.5	74.0	0.89
Female: %	81.1	80.1	0.81

Table 4: Final assignment marks

	Experimental	Control	P value
Class: %	81.5	79.4	0.37
Male: %	78.2	77.8	0.91
Female: %	83.6	82.4	0.71

Table 5: Final marks

7. Surveys

We have only begun our analysis of the pre-experiment and post-experiment survey data. Eighteen of the 20 students in the experimental group completed all or part of the exit survey. The following results stand out: 10 students (56%) felt the badges had a “mildly positive” effect that “encouraged [the student] to spend more time on the course site,” six (33%) indicated the badges “made no difference,” while one student felt they were a “mildly negative distraction” and one felt a “positive” motivation to “collect the most badges possible.” As for the leaderboard and point system, one student said it had a “negative” demotivating effect, two felt it was a “mildly negative” distraction, seven (39%) said it “made no difference,” while five (28%) cited a “mildly positive” and two a “positive” effect. When asked, “Do you feel that gamification tools can be effective for motivating students?” the gamified group replied as follows: No (0%), Probably not (6%), No opinion (12%), Probably (53%), and Definitely (29%). In the control group, 35% of students said they were “very interested” in what was going on in the gamified site (which they could not access), 40% were “mildly curious,” 10% “rarely thought of it” and 10% were “relieved not to be in that group.”

Discussion

Numerical grades are an imperfect measurement of learning, especially in a course based on evaluating students’ ability to think and write critically about abstract concepts related to technology and society. The diverse student body of this interdisciplinary elective course (which included undergraduate students in every year of study, from almost every faculty on campus) perhaps confounded the sample at the outset with a wide range of student knowledge and abilities. At the same time, the fact that the basic gamification tools of badges and points were associated with such statistically significant increases in the personalization of avatars, inter-student social networking and visits to the course site in general suggests that badges and leaderboards cannot be dismissed as motivation tools in an online educational setting. The depth of this “engagement” remains to be explored given the absence of any

increase in quantifiable learning outcomes. To bend an aphorism: You can game a class to your course website, but you can't (necessarily) make them think.

Some of the extensive data from this experiment, including in-class quiz and attendance results and qualitative surveys, remains to be analyzed in the light of our central findings about the effect of gamification on online engagement (a doubling of activity) and assignment grades (no impact). In this trial, the gamified experimental group used a website that intermingled both badges and a points-and-leaderboard system. A future iteration may separate the class into two groups, with one site gamified via badges and the other via points, to compare the impact of these two tools. A version of the course may be constructed that connects online resources and discussions more directly to the factual knowledge tested on the midterm and the critical and literary skills evaluated on the take-home assignments. This version might foreground assignment-based "quests" to create "meaningful framing" that links the raw gamification metrics with the course curriculum. Questions remain: Is the increased online engagement, enabled via gamification in this experiment, merely a superficial "checking in" by students to collect badges and points and to socialize online? Or is it an untapped resource in the attention economy of their academic lives that could be focused, within a blended course, on more purposeful activities directly connected to final learning outcomes?

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Making People Fail: Failing to Learn Through Games and Making

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Introduction

From high-stakes measures to tracking students, the structure of the formal education system in America stigmatizes failure as a negative result of the learning process. In traditional school settings, failure is seen as inadequacy based on an inability to meet a specified standard; it is an unfavorable endpoint to learning that should be avoided at all costs. This view of failure has resulted in detrimental tracking systems through which available opportunities are determined by performance.

Within our current education system, because failure is interpreted as an unsuccessful attempt to achieve a learning outcome, poor performance may deny learners access to certain opportunities. Papert (1980) expounds:

“Our children grow up in a culture permeated with the idea that there are ‘smart people’ and ‘dumb people.’...“As a result, children perceive failure as relegating them either to the group of ‘dumb people’ or, more often, to a group of people ‘dumb at x.’” (p. 43)

The label of failure in education also commonly leads to misidentification of learning disabilities, which has devastating effects on how students are viewed by themselves and others-(McDermott, Goldman, & Varenne, 2006). Learners labeled as “not smart”, “unsuccessful”, or “learning disabled” are also diverted from accessing certain learning opportunities (e.g. taking AP classes) (McDermott & Varenne, 1995). The pressure of this high-stakes system is also breeding a fear of failure in high performing learners (Pope, 2001). In much the same way, these students are under constant pressure to maintain their standings because of the opportunities that are afforded to them. They believe that any sort of failure will render them a less competitive applicant and will limit their opportunities. With this connection between performance and opportunities, it is no surprise that students often have a deep-seated fear of failure in their learning.

Current interpretations of failure focus on the negative implications such as not meeting a desirable, or intended, objective. This interpretation of failure is limiting. Research in the learning sciences suggests that failure is actually a key to innovation and discovery (Dunbar, 1999; Schank, 1977; Kapur, 2013). For example, Kevin Dunbar (1999) studied four biochemistry labs at Stanford University in order to understand how they conducted research. To his surprise, he noted that over half of the experimental results were unexpected. Rather than being classified as failures, researchers analyzed these findings in order to explain the unexpected outcome. This revision led to refinement of methods, better control of variables, a deeper understanding of the problem, and innovation. (Dunbar, 1999). Ushering learners to avoid failure may come at the cost of innovative risk taking and discovery.

Despite our best efforts to design learning environments, at some point, a learner will fail in it. But failure, in and of itself, is not a bad thing. We argue that what matters more is how we, as educators, plan for that failure, and how we encourage learners to interpret that failure. In this paper, we leverage two areas of educational reform, games and making, to demonstrate a need to broaden our definition of failure and reconceptualize it as an integral part of the learning process. Rather than defining failure as a detrimental endpoint to learning, we discuss how these domains (games and making) expect and design for failure as part of the mastery process. We offer implications for learning and assessment with the hope of sparking a conversation among policymakers, educators, designers of learning environments, and learners.

Failing to learn through games and making

In recent years, scholars have looked to learning through games and making as viable alternatives to traditional learning environments. Thus, using games and making as illustrative examples, we argue that some of the deepest learning happens when we fail, and we, therefore, must adapt our perspective and understanding of the learning process accordingly. Next, we demonstrate a need to broaden our definition of failure and reconceptualize it as an integral part of the learning process. Both games and making are activities that we, as humans, have participated in and learned from for centuries, yet educational reformists have relatively recently taken up these domains to expand our traditional conceptions of what it means to learn. To gain a better understanding of the breadth and depth of the relationship between failure and learning, we examine these two worlds (games and

making) embedded with them.

Learning

As learning scientists, we ascribe to a constructivist perspective of knowledge supporting the idea that meaning is something to be *made* whether through our interactions individually with an environment or socially through culture (Piaget, 1956; Vygotsky, 1978). Moreover, we take up a situated perspective of learning where learners develop understanding in the same context in which it is applied (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). Accordingly, we believe that learning cannot happen void of context and that we should constantly connect what we learn to real world situations. When considering failure in this way, we immediately run into the crude fact that, in the world, there are sometimes serious consequences for failure. While we recognize that some failures have detrimental consequences, we argue that not all failures are created equally; some failures actually promote learning. Thus, we need to broaden our definition of failure in relationship to learning to realize the rich process of which they are both part.

Games

Dating back to the time when arcades were popular, games have been challenging players to revise strategies and revisit conceptual models in order to progress. In fact, game scholar Jesper Juul theorizes that failure is actually directly related to enjoyment of a game (Juul 2009). This is not to say that you must fail to enjoy a game, but that games somehow allow for failure in a productive way. A growing body of research suggests that digital media, such as games, can provide powerful mechanisms for learning (Steinkuehler, Squire, & Barab, 2012). Specifically, good games encourage players to “take risks, explore, and try new things” by reducing the consequence of failure (Gee, 2006). We argue that games encourage learning through the way they handle failure; games incentivize players to confront and rework their failures (Squire, 2011). Players don’t stop playing the game when faced with an undesirable outcome, in fact, “in a game, failure is a good thing” (Gee, 2009).

Making

In response to President Obama’s call to design learning environments that “encourage young people to create and build and invent - to be makers of things, not just consumers of things” (The White House, 2009), educational researchers and learning scientists are considering makerspaces as viable alternatives to traditional STEM learning environments. As a result, making and makerspaces have gained traction in more formal and public contexts, and this has materialized as the maker movement (Anderson, 2012). This movement is defined by the mobilization of makers around the world through venues like World Maker Faire, MAKE magazine, and the Internet. Hence, the maker movement is fundamentally changing the way we envision teaching and learning. Particularly, this movement contends that *making*—an active process of building, designing, and innovating with tools and materials to produce shareable artifacts—is a naturally rich and authentic learning process (Martinez & Stager, 2013). As scholars (e.g. Anderson, 2012; Honey & Kanter, 2013; Martinez & Stager, 2013; Sousa & Pilecki, 2013) continue to explore the relationship between making and learning across a variety of contexts, they point to the significance of permitting failure and mistake in making activities.

Broadening our definition of failure

One of the biggest misconceptions of failure is that it is evidence one did not *learn* something correctly. The assumption is that learning is not present in failure. Rather than assuming that *in* our failed state we have not learned, we suggest that *from* our failed state we can learn. In this section, we use examples and data from learning through games research to argue that we need to broaden our definition of failure beyond the dichotomous outcome formula currently used in traditional formal learning environments.

A popular view of game based learning suggests that if goals overlap correctly, completion of the game indicates mastery of the subject (Gee, 2006). This is true when content goals, games goals, and player goals are aligned, but cannot be assumed if they differ. In a game, failure can be considered a function of the goals of the designer and the player. By allowing players to negotiate outcomes and consequences (Juul, 2003), a player’s goal can actually differ from that of the games resulting in situations where failure and success may be a matter of perspective. Games offer many ways of playing (Bartle, 1996), including modes of play that involve playing *with* rather than *by* the rules of the system, such as “subversive” play (Tocci, 2012). Some players find success in finding exploits or causing the game to stop functioning. Modding, The popular activity of reprogramming a game to do something other than what it was originally designed to do, is a more explicit way of modifying a game’s goals.

Likewise, modding in games parallels hacking in makerspaces. Particularly, makerspaces have redefined hacking from the traditional conception of an exploitative predator taking advantage of weakness for malicious purposes to a more general understanding of using or mashing physical or digital materials together in ways that were not originally intended by the designer. Tinkering, hacking, and making are becoming well-accepted trajectories toward innovations (Levy, 2010; Martinez & Stager, 2013). From projects like hacking a computer mouse and a race car together to create a “mousecar” to modifying mobile phones and launching them into space to take photos of the Earth, hacking is changing the way we engage with the world. Santo (2012) argues that these “hacking literacies” are not only present in makerspaces, but are also vital in our daily lives as we create and make our worlds. Though negatively stigmatized behaviors, like hacking, appear to be evidence of failure to meet certain expectations, in reality they are evidence of a fresh perspective fueling innovation.

When there is a disconnect between the goals of a learner and the goals of a designer, it is a mistake to automatically assume there is a problem. Simply because a learner does not succeed, as defined by the designer, at a given task may not mean they failed. Rather, the performance may be the result of the way the learner chooses to engage with the task. Take, for example, a game of *Super Mario Brothers* (Nintendo, 1985) in which the primary goal of the game, as intended by the designer, is to save the princess. While most players attempt this goal, some may not consider this a success; instead they might define success by a high score or best time. Accordingly, understanding how a learner interprets and interacts with a given task may be the best way to determine if learning objectives have been met.

Failure as a process, not an endpoint.

During the creation of knowledge there are bound to be moments where our understanding doesn’t accurately portray the system in question. As Karl Popper suggests, these misconceptions are common and we must therefore subject our understanding to rigorous test of falsification in order to better our understanding of the phenomena (Popper, 1959). If we maintain that knowledge is constructed by the individual, we must allow for incomplete constructs and revisions. In other words, we must allow for failure and in order to learn *from* our failure, we must work *through* it. We argue another misconception of failure is that it is an endpoint. In this section, we use examples from learning through making to demonstrate how learning is best conceptualized as an iterative process propelled forward by failure.

Preparation for future learning (Bransford & Schwartz, 1999) and productive failure (Kapur 2013), both offer methods of addressing misconceptions while still allowing for failure. Bransford and Schwartz attempted to draw attention to the deep structure of problems by providing contrasting cases that drew attention to the important similarities, or deep structures. This resulted in less attention being focused on surface features (Bransford & Schwartz, 1999). Kapur, on the other hand, followed a period of discovery learning with direct instruction to address these misconceptions. As Kapur states, “students are rarely able to solve the problems and discover the canonical solutions by themselves...yet this very process can be productive for learning provided an appropriate form of instructional intervention on the targeted concepts is subsequently provided” (Kapur & Bielaczyc, 2012). Both of these approaches lead to fewer misconceptions and gains in learning (Bransford & Schwartz, 1999; Kapur 2013).

In games, preparation for future learning, is reflected in the well ordered problems found in videogames, while productive failure may be found in a game’s just in time feedback. Well designed games allow a player to solve similar problems in different contexts in order to draw attention to their commonalities. Game designers take great care to order their problems so that they’re difficult, but not impossible for the player to overcome allowing players to use what they learned in other contexts (Schell 2008; Koster 2010). Well ordered problems also serve to keep the player challenged while discouraging player attrition. Failure in a game with well ordered problems, doesn’t stop players from playing. Instead, “Game failures led to recursive play, play where students devised a strategy, observed its consequences, and then tried another strategy” (Squire, 2011). Just-in-time feedback (Gee, 2004) allows the learner to play a game without interfering until a certain condition is met. For example, while playing *New Super Mario Brother U* (Nintendo, 2012), if a player had died several times during a level the game offers to show the player how to complete the level. This is similar to the idea behind productive failure in that it allows a player to develop skills and build hypothesis and then presents an exemplary case to address any misconceptions they might have that may be leading to their repeated death. Both of these these approaches are quite common in contemporary games and allows for failure to be an integral part of the learning process.

This iterative approach to learning is not unique to gaming. Papert (1980) describes learning as a process by which a learner builds a deep relationship with knowledge. Much like cultivating a relationship with another human being, it takes time and effort; it requires a commitment to work through challenges. Borrowing a term from computer science, Papert describes debugging as a being the “essence of intellectual activity” in learning (Papert, 1980, xiii).

Put simply, debugging *is* failing. Interestingly, the art of making is its deeply iterative nature.

In makerspaces, the mindset toward failure echos Papert’s idea of debugging. In interviews with makers at a local makerspace, they explain that “most people don’t give up on the stuff they’re working on here” even though “you have the instances where something blows up”. Specifically, Jack (1), a member of the makerspace, explains the typical mindset toward failing found in his makerspace:

“Well, usually what happens is when we work on something, you try something then you fail, you try something and then you fail, and then you just tweak it and work on it and figure stuff out until it eventually does work.”

This mindset bleeds into all of the making that happens at this makerspace. For example, another member, Bruce, explains that, “a lot of the [maker] competitions I helped out with... they got critiqued by some of the bigwigs and they know where they messed up and what they can do to fix it, so it’s not like an endpoint.”

As these makers extrapolate, when approaching learning with this iterative mindset, the failure emerges as a valuable tool on which they rely to “fix” and “tweak” ultimately making a better product. Just as in gaming, mastery is deeply tied to revisions of past failures. In other words, when we are permitted to work *through* our failure, we can learn *from* it.

Implications for assessment

When designing learning environments, whether one realizes it or not, designers are instantiating their beliefs and values about knowledge and learning (Bruer, 1994; Bransford, Brown, & Cocking, 2000). If we take seriously the idea that failure is a productive process from and through which we can learn, then this raises important challenges for assessment. Specifically, broadening our definition of failure and reconceptualizing it as an integral part of the learning process directly shapes and informs the goals we set for learning. Accordingly, we suggest employing assessment tools that identify hot spots of goal misalignment between designer and learner, yet don’t immediately penalize the learner for this misalignment. Furthermore, we also propose taking a cooperative approach to developing assessment tools carefully considering *whose* learning goals are being assessed.

Aligning goals in assessment

In games, identifying the difference between activities that fail to achieve the games goals, but serve to further the player’s understanding of the subject, or game world, from actions that do not yield a positive result, is the major challenge facing game based assessment. In order to better understand the players of *Fair Play*, a game about implicit bias (GLS, 2013), we collected player’s movement data and constructed heatmaps. A player’s positional data is recorded and superimposed onto the game map, or UI, and is then color-coded for frequency. Applied to learning games, like *Fair Play*, heatmaps can provide powerful insight into play patterns which can be used to determine or assess player goals and game goals. A final map can reveal patterns like points of interest, points of attrition, unused resources, popularity of NPCs, and locations of interest. This information give us a better idea of what the player did and avoids classifying an intervention as a success or failure based solely on an outcome measure (see Figure 1).

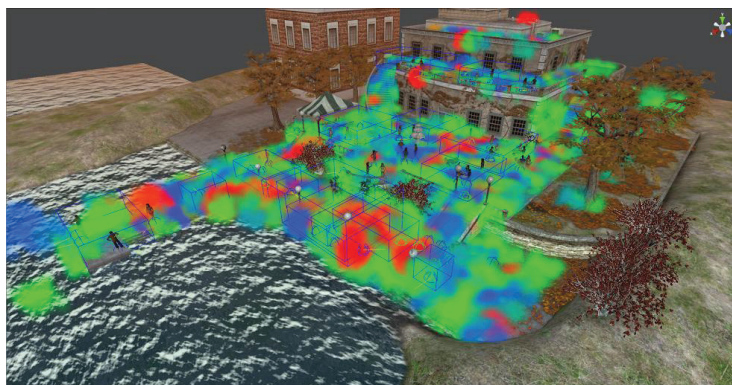


Figure 1: A heatmap created for the educational game, *Fair Play*. This map has recorded multiple users’ movements highlighting areas most traveled in red, and least traveled in blue.

If heatmap data is segmented along an outcome variable of interest, say the difference between a pre and post score, researchers can try to identify what places were frequented by low achieving players and what places where frequented by high achieving players (Figure 2). If, for example, most low achieving players seem to be exploring an empty part of the map (perhaps confused by the game's objectives) the game design could place a hint in this location to direct the player towards a more fruitful part of the map. In contrast, the places frequented by high achieving players could indicate interactions that were considered useful by players and efforts could be made to move some of these interactions to the critical path (the parts of the map frequented by all players who finish the game). These patterns can give us key insight into the behavior of players; points of attrition, for example, might reveal a lack of engagement, an especially difficult problem, or an area of confusion.

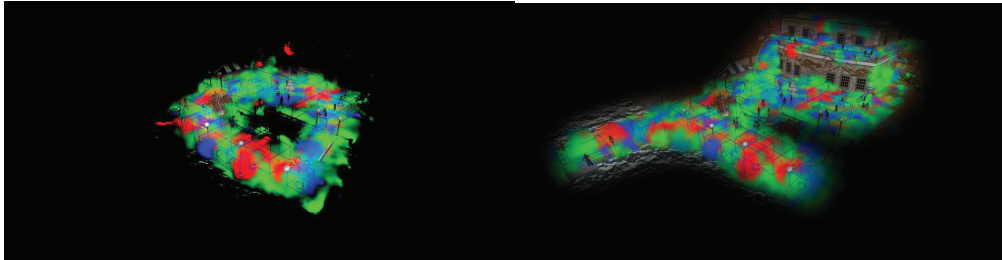


Figure 2: A comparison of low achieving players (left) and high achieving players (right) paths throughout the game Fair Play.

The same information used to create heatmaps can also be made to create predictive models which can serve as vehicles for just-in-time feedback. Positional data can be converted into states within a game, while player movement can be expressed as a transition from one state to another. The resulting data structures can then be analyzed as a network diagram or Markov model. If a sequence is identified as being highly correlated to failure, as determined by the outcome variable in question, the game may show the player a hint similar to the way that Cognitive Tutor offers help to learners it believes are exhibiting misconceptions (Anderson, Corbett, Koedinger, & Pelletier, 1995).

Cooperatively assessing learning

At makerspaces, members often grapple with (re)defining failure. For example, when asked to describe a failed project, one member, Charles, explained that he once tried to build a better scuba diving mask, but never finished the project, because it had achieved the goals he set and it wasn't to complete a product, but to learn about the components. This response echoes the ethos found in makerspaces: unfinished/abandoned/broken project does not mean failed project. In applying this approach to assessment, we suggest that cooperatively assessing learning by considering both the designer and learners goals will yield a more accurate picture of learning.

One way to cooperatively assess learning is through understanding the *stance* a learner takes up toward the task. For instance, in a spring break maker program where youth were prompted to “make flow”, Alice, a second-grader, was inspired to make a “sugar mill” for her town from a glass jar, cardboard rolls, sugar, tape, and scissors. Darren, another participant, had used these tools earlier to create a modified hourglass—his interpretation of flow. Alice transformed the initial tool use into an artifact that fit into her already existing design and translated the concept of flow from a functional stance (sugar flows through an hourglass) to an artistic stance (Alice explained her sugar mill was art and did not need to work). Tracing her process over time reveals her (self-described) artistic stance in contrast to Darren's functional stance.

With this understanding of stances, we suggest using a stance-specific assessment measures to avoid mislabeling learners attempts as failing. In other words, in the above example, we would assess Alice on whether she achieved her own artistic goals (i.e. does it represent what she intended?) and Darren on whether he assessed his own functional goals (i.e. does it work as he intended?). Appropriately, we would construct these assessments using well-established methods of experts: assess Alice's sugar mill as an artist would and assessing Darren's hourglass as an engineer would. Cooperatively assessing learning in this way gives learners their own voice in the assessment process and, thus, ensures that the assessment aligns with the intended goals of the learner.

Conclusion

The concept of failure as an endpoint is detrimental. To better understand a learner's trajectory, we need to

expect and value failure as part of the learning process. We can look to existing learning activities and environments that embrace and encourage failure, like games and making, to inform our re(design) of learning environments. Now, let's make people fail to learn.

Endnotes

(1) Names changed to maintain anonymity

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Talking With Kids on Game Design, Computer Programming, and Taking Over the World With Dragons

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Introduction

Computer programming is among the most in-demand skillsets of the 21st Century. Unfortunately, many K-12 schools are unable to offer classes on computer programming due to lack of resources or qualified staff and because of the strong emphasis placed on curricula that adhere to Common Core standards. After-school programs that focus on game design to engage students in introductory programming and computational thinking skills have emerged as a popular alternative to formal classes during the school day. This paper examines one of these after-school groups. Called the Cyberlearning Club, students at a rural middle school in the Midwest design games and practice programming using programs like *Scratch*, *Kodu*, and *Code Academy*. This research explores how middle school students in an informal after-school programming and game design club think about their game projects, their ability to learn programming, and their trajectories as future designers. In this paper, we report on the results of semi-structured qualitative interviews conducted with students and outline profiles of students who exhibit distinct goals and trajectories for learning programming.

Why young people should learn to program

In his 2014 State of the Union speech, President Obama argued that among the most pressing issues to address over the next few years are the trends of deepening inequality and stalled upward mobility (Associated Press, 2014). Hiring statistics suggest that computer-programming skills can position young people to attain that upward mobility. STEM and computing jobs almost universally dominate lists of most in-demand college majors and top-paying degrees. A *Forbes* article explains, "Not only are computer scientists and computer engineers the most sought after candidates on the market but—fittingly, understandably—they're among the highest paid entry level hires that we know of" (Adams, 2013). The National Association of College Employers recently listed computer engineering and computer science in the top four for average starting salary across all college majors (National Association of College and Employers, 2014). Those skilled in computer science and programming are in high demand and there is no reason to expect that demand to decrease soon (Grover & Pea, 2013). Recent estimates project that by the year 2020, of the 9 million STEM jobs in the US (science, technology, engineering, and mathematics), more than half will require computer science skills (Lang et. al, 2013). Proponents of computer science education recognize that students will need computer science skills to thrive in the global information-driven society, yet the K-12 system has not been able to keep up. Many students, particularly in low-income and rural communities, do not have access to the classes they need to acquire programming skills (Lang et. al, 2013; Margolis et al., 2008).

Beyond providing youth with reliable career options, one of the popular arguments for supporting children in learning computing skills comes from Papert (1980). He claims that the iterative process of learning to program and debug code enables children to reflect on their learning process more critically. This constructionist approach to learning also emphasizes engaging learners in the process of constructing or creating artifacts that have personal and social significance (Papert, 1980; Kafai, 2006). Inspired by constructionism, the Computer Clubhouse after-school program (Kafai, 2009) was conceived as an informal learning space for at-risk youth to design their own media and gain valuable experiences with computing. The Computer Clubhouses were not specifically intended for teaching game design or programming, but many of them utilized *Scratch*, a programming tool for kids. The Cyberlearning Club that served as the setting for the research presented on in this paper is not a direct descendent of the Computer Clubhouses, but the Cyberlearning Club shares many of the Computer Clubhouse values while focusing more specifically on programming digital games.

Games matter

The prominence of video games in the lives of young people has made them one of the more popular pathways for teaching programming. Ninety-seven percent of youth report playing videogames on a regular basis (Lenhart et. al, 2008). There have been a number of after-school programs for engaging kids in game design and programming, including but not limited to: *ToonTalk* and The Playground Project (Kahn, 1996; Hayes & Games, 2008), the Computer Clubhouse's use of *Scratch* (Maloney et al., 2008), the Girls Creating Games Program (Denner, Bean, & Martinez, 2009), the Imaginary World Campus using *Alice* (Adams, 2007), the use of *Storytelling Alice* with middle school girls (Kelleher, Pausch, & Kiesler, 2007), and the Studio K curriculum using *Kodu* (Anton et al., 2013). For a more comprehensive review of game design tools and their educational applications with kids through

2008, see Hayes and Games, 2008. Studies of youth designing and developing their own games have showed gains in a wealth of literacy and critical thinking practices (Peppler, Diazgranados, & Warschauer, 2010; Peppler & Kafai, 2007; Carbonaro et al., 2010), and suggest that these practices facilitate the development of computational thinking skills like logic, debugging, and algorithm design (Berland & Lee, 2011). Overwhelmingly, these tools and programs have been shown to provide an ever-evolving environment for forming creative representations, building expertise and mentorships, and learning without fear of harassment or judgment (Resnick et al., 2009).

Methods

The Cyberlearning Club

For this study, we conducted our research with a group called the Cyberlearning Club, an after-school technology club for engaging middle school students in game design and programming. Meeting at the school library in a rural town in the upper Midwest, about 15-20 students attend the Cyberlearning Club each Friday afternoon. The majority of students attending the club are male, a topic that we will discuss further when we discuss future directions and initiatives. In addition to the middle school students, the facilitator of the club—the lead Media Specialist at the school—has enlisted the help of four high school students who act as teaching assistants. The facilitator is not a proficient programmer herself, but feels passionately about supporting kids in learning what she considers to be increasingly important skills. She formed the club in the summer of 2013 to foster these practices and it was an immediate hit with students. At Cyberlearning Club, students are introduced to programs like *Scratch*, *Kodu*, and *Alice*, books like *Python for Kids*, and online recourses like *Code Academy*. For the uninitiated, *Scratch* (Maloney et. al, 2008), designed by the MIT Media Lab, is a programming language and tool designed for kids ages 8 to 16. While many *Scratch* projects are games, it is also designed for making interactive stories and animations. Designed by Microsoft, *Kodu* utilizes a visual programming language to teach game design and computational thinking. *Alice* is a programming environment first conceived at the University of Virginia and then further developed at Carnegie Mellon. *Alice* incorporates narrative aspects into the teaching of programming. Each of these tools are freely available and are utilized by the Cyberlearning Club with varying frequency. Code Academy is a free online tool where users can learn programming languages like html, JavaScript, and Python directly from their web browser. During meetings, students explore the provided resources and programs as their interests guide them, interacting independently, in pairs/trios, and sometimes in larger groups to learn collaboratively. The students who attend the club are primarily, though not exclusively, drawn to the club because of their interest in videogames and spending time with other kids with like interests.

The research outlined in this paper is not a report on use of a specific tool or curriculum. Rather, the students in the Cyberlearning Club use a variety of different software programs and resources. Some of the more advanced students have branched out to make use of complex tools to learn new programming languages. Invited by the club's facilitator to consult on ways to engage a wider student audience, our research team at UW-Madison began attending Cyberlearning Club meetings in the fall of 2013. Before suggesting specific interventions or curricula, we conducted ethnographic research to observe how students' learning trajectories naturally evolved. This paper describes interviews to determine what is personally meaningful to the students in the club. While we initially intended capture students' understanding of programming related to *Kodu*, the interviews evolved to capture a broader landscape of environments, goals, aspirations relating to learning game design and programming.

Interviews with Cyberlearners

Originally attending the club meetings to introduce students with new resources, we quickly discovered that the structure and interactions within the club were already—at least to some extent—supporting advanced practices and the development of a unique culture. Rather than disrupting the group with interventions, we took the opportunity to understand the interests and needs of the kids who attend the club, seeking to identify features within the space that support exploratory and advanced practices among the participants. To gain a deeper understanding of the individual students in the club, we conducted semi-structured interviews with students who regularly attend the Cyberlearning Club. Through these interviews we attempt to capture the students' conceptual understanding and personal landscape relating to the club, programming, and game design activities. Questions in the interview protocol encourage the students to talk about the games they have designed and to describe their experiences with and opinions of programming tools and resources. We also asked about how they enlist friends and family as resources, what their personal goals are, and how/whether they think of technology and programming as valuable workplace and career skills.



Figure 1: Five boys collaborating on an *Alice* game at the Cyberlearning Club.

Currently, we have conducted interviews with eight of the club's most dedicated students, all boys. The interviews ranged from 10 to 45 minutes depending on the depth of the boys' responses. After completion of the interviews, we first developed an emergent coding scheme and used those codes to identify patterns and themes in the students' responses in order to identify emerging learning trajectories or practices. From there we decided to focus on four different cases for this paper—twins with a strong interest in game design and intermediate programming experience, and two other boys with very different profiles. These four cases demonstrate the diversity of attitudes, experiences, and skill levels among the students in the Cyberlearning Club, hinting at the different types of learning trajectories that the students are engaged in. Below, we discuss each of the boys and make recommendations about what learning supports and resources they would benefit from based on their current programming abilities and interests.

Cyberlearner Profiles

Adam (Age 11): Choosing the power of dragons over the power of Python.

Programming in *Scratch*: "I don't know what 15 degrees is, so it's kind of hard to program with it."

Tending to shy away from overly intimidating challenges, Adam seems happiest when engaged in activities that he finds to be both fun and easy. He is more content to stick with *Kodu* than many of the other guys, not expressing interest in reading books on web programming and advanced languages or venturing into learning text-based languages. While many of the boys seem to find *Kodu* and *Scratch* to be comparably easy to learn, Adam does not fully understand the programming concepts in *Scratch*, such as rotating objects a certain number of degrees to guide a character on the screen. He notes, "It don't know what 15 degrees is so it's kind of hard to program with it [Scratch]." However, Adam is quite proficient with *Kodu*, describing that he felt comfortable making games within a day and now adds increasingly more *Kodus* [moveable objects] and code into his games. This same tendency shows up when Adam talks about school. He claims that spelling is his favorite subject in school "because it's easy and fun"—the same terms he uses to describe how he feels about *Kodu*. Adam's hesitancy to try out new tools or learn new programming languages seems at least in part because he does not see programming as essential to his future career plans. Hoping to be an artist or geneticist, he expresses that programming probably wouldn't help much with these professional paths. As a geneticist, "I could bring back a dragon and then take over the world," he says. For Adam, proficiency in Python seems less essential than the power of a fire-breathing dragon in a world takeover.

Mac (Age 11): Programming is just for game design. And building a time machine.

What do programmers do? "Fix bugs, program new things, get stressed out mostly." Having discovered *Scratch* at the age of seven with his twin brother, Mac shows a high level of engagement with game making and programming. He is a self-motivated learner and frequently takes the initiative to expand his skillset. He describes having

made roughly 50 games in *Scratch* over the years. While he occasionally makes a game in *Kodu* the tool is a bit simple for his tastes and typically only takes him “about five minutes.” He juxtaposes programs like *Kodu* with real programming, which “has if-statements and functions and stuff.” Mac has recently begun learning Python and JavaScript with his brother. He says he personally prefers books like *Python for Kids* and *Invent Your Own Computer Games with Python* to online tools like Code Academy, though he notes that different people have different learning styles. Mac and his brother both aspire to be independent game developers. After having just watched *Indie Game the Movie*, he says he got the impression that programming a game professionally is a stressful job, but that he is not deterred. Games are the primary motivator for Mac to learn programming. He has little interest in making websites because that is “not as fun as making games” and says he can’t imagine using programming for anything but game development except maybe “building a time machine.” He adds, “Possibly. If it’s possible.”

Mitch (Age 11): Preferring *actual* programming to *Kodu* and *Scratch*.

“I like doing the *actual* programming more than like where they do *Kodu* or *Scratch*.”

Mitch is very articulate about the differences between the various game design and programming tools. While he recognizes that *Kodu* provides new learners with a structure, users of *Scratch* learn more of what he calls programming “fundamentals.” Mitch and his brother Mac have thrived under early exposure to game design and programming tools. The boys have been making games for four years and they both seem to be in a critical learning period now where they are branching out to learn more complex programming languages like Python and JavaScript. Unlike his brother who never plans to make a website, Mitch admits he may consider making one, but “only to put some games on it.” It seems like they are on the threshold of a new level of expertise with programming, starting to be able to compare and critique languages and tools they encounter. The boys enjoy a number of benefits from their home lives. While their parents are not programmers, they both have jobs in science fields and seem to promote a tech-savvy lifestyle. The twins and their sister share a desktop computer at home and each member of the family has their own laptop. In addition to spending about an hour-and-a-half each day collaboratively studying programming, the boys enjoy the added benefits of support from the Cyberlearning Club. Here they learn about new tools like Code Academy and gain access to some of the books on programming that they use. Furthermore, the club adds a more playful-minded, social facet to their current interaction with programming. At this stage in their programming trajectory, it seems that the twins would really benefit from some more advanced mentoring and more formal education on programming. It is unfortunate that there are no formal computer science education courses for them to take at their school.

Zeek (Age 13): You fail and people laugh, but you just have to deal with it as a programmer.

“Because, just, programming is fun. It’s me, you know? It’s not something I can go, “okay, I’ve learned this to my full extent. I can’t go past this point.” I like to break through, keep going. ...I want to become a programmer. I want to do things like that my whole life.”

Zeek is very passionate and thoughtful in his understanding of programming. He describes being around technology his whole life, listing off the many game systems he has had over the years, and explaining that he has been interested in coding for quite some time. He notes that watching the movie *The Matrix* was his first exposure to the idea of programming and it stuck with him. Zeek seems to be especially well informed about what programmers and game developers do: he talks a lot about how programmers incorporate feedback and criticism, showing that he understands programming as an iterative process that requires constant debugging and testing. However, he is a relatively new programmer, only having about six months of experience starting from when he joined the Cyberlearning Club. He primarily uses *Kodu*, and mostly during his time within the club, though he admits to trying and disliking *Scratch*. Zeek seems especially sensitive to the feedback and criticism inherent in design. He describes that his dream of designing games will be hard because “you always have someone who goes, ‘this is wrong, this is wrong, this is wrong – change it.’” At another point he says, “When you try, you fail and people laugh at you, which is the thing you have to live through as a programmer.” Zeek admits to dealing with failure and negative feedback in his life, describing a tendency to poor grades and struggles with being teased. However, he recognizes that these experiences have primed him to be more successful as a programmer, dealing with feedback.

What Zeek would most benefit from is someone to encourage him to be persistent and follow through with things. Seeming to equate tasks that take a long time with being difficult, he seems to lose interest in projects very easily— he describes abandoned games, unfinished writing projects, giving up on figuring out how to make things work on his computer. When asked about his knowledge of programming languages he suggests that he knows JavaScript, but when probed on it he reveals that he only spent about “ten minutes” on Code Academy, but that he is “planning on learning more.” He knows a good amount *about* JavaScript, describing it as the base for many other programming languages, but he lacks experience in learning how to program *with* the language. It seems as

though Zeek has a great grasp on his end goals but may not have the support or motivation to reach those goals. Coming from a working class family and having a dad who he describes as not being good with computers, Zeek would benefit immensely from a class on programming at the high school level.

	Adam	Mac	Mitch	Zeek
Enjoys Kodu	Yes	Too easy	Too easy	Yes
Enjoys Scratch	No, too challenging	Yes	Yes, but prefers Python	Not interested
Learning other prog. languages	No, not interested	Python, JavaScript	Python, JavaScript	A bit of JavaScript
Prefers to be challenged	No	Yes	Yes	Depends on context
Likes school	Yes, especially easy classes	Yes, when it's not too easy	Yes, when it's not too easy	No, struggles with his grades
Wants to be a game developer	No	Yes	Yes	Yes
Wants to be a programmer	No	Yes	Yes	Yes
Resources needed for next future steps	Gentle guidance on increasing his code complexity	Mentoring & access to more advanced peers	Mentoring & access to more advanced peers	A formal intro to CS class, encouragement on persistence

Table 1: Overview of the Cyberlearners' likes, dislikes, and future plans.

Analysis

As we completed the first round of interviews with the students in the Cyberlearning Club, we were excited and impressed by the creativity, enthusiasm, and drive evident in these self-directed, engaged students. They *love* games and they *love* designing them. We cannot help but feel inspired listening to these young students talk about how are learning complex programming languages like Python on their own and sharing their ambitious plans about being indie game designers and making only the best games which no one will criticize because they included only the best design elements. Of course, we also anticipate road blocks that the students are likely to encounter along their way, and want to see support structures in place to help them get past upcoming barriers.

Cyberlearning benefits

Though the boys we interviewed were ranging in their interests and experience with programming, it was evident that the structure and culture within the club was significant in facilitating interest in programming for these students. The club coordinator provides an open, creative space and myriad resources to tempt students into programming. Though not a programmer herself, she's designed a self-supporting culture, in which students gain expertise and support each other as they interact with the new resources she supplies. For each boy we interviewed, the club provided a different, meaningful experience for their interactions with programming and game design. For Adam, the club provides him with motivated, experienced programmers who he partners with to design games in *Kodu*. While he continues to gain experience and skills with programming, he primarily wants to design games rather than program them. For the twins, the club offers a space in which to interact with more dedicated programmers. Their time within the club is generally spent working with one or two other comparably experienced club members making games. It is a space for them to tackle challenging problems in a social, fun way. Finally, for Zeek, the club gives him exposure to the ways in which other students are working towards their programming goals in addition to the many resources to get their. Zeek seems to gain the most from the tangible and social resources offered within the club, mentioning that he was exposed to *Kodu* and *CodeAcademy* through the club and only started working with *Scratch* when it was reintroduced within that space.

Cyberlearning needs

Many of the students in the Cyberlearning Club are at critical learning points, ready to leverage their enthusiasm and curiosity toward more substantive knowledge about computer programming and game design. These students are lucky to have a club coordinator who devotes her time to the club and seeks out resources like researchers at the University of Wisconsin-Madison who can help support her by recommending resources and curricula, or with writing grants to acquire better technology for the school library. However, the Cyberlearning Club coordinator is only one person and has a limited knowledge of game design and programming herself, and as we got to know the students in the club better, we realize that some of these students have needs that go beyond the current scope of the club. Many of them could benefit from classes in the formal school curricula, expert peers and mentors, or more focused scaffolding and encouragement.

Adam is content with things as they are, liking the tools he already uses and not wanting to branch out to learn more complex programming languages. Perhaps that's enough, as this is an interest-driven after-school club, but we wonder what he might do with a mentor to gently push him to challenge himself and expand his abilities. Mac and Mitch have tools like Code Academy and a few books, but their knowledge seems to be quickly exceeding the current club activities. We believe they could benefit from access to a more advanced group of peers, people who have made more complex programs and games who can offer more personalized instruction than a book or an on-rails web resource. The twins seem almost ready for a high school or college level introductory course on programming. Zeek has the same ambitious drive toward game design and passion as Mac and Mitch, but like Adam, he gets deterred when he encounters a really tough challenge. Many of his projects are left unfinished and he seems to lack persistence in his efforts to learn more complex programming skills. A structured class in his middle school, with specific objectives and assignment due dates might help him keep on track with his learning trajectory. Fortunately for Zeek, the club coordinator is helping other teachers to incorporate programming activities to better engage him, as he is dangerously close to disengaging from his core classes. Unfortunately, the school district that these students live in does not have computer science or programming classes at any level, inhibiting the progress they will be able to make until they reach the next steps in their education.

Diversifying Cyberlearning

One of the reasons that the Cyberlearning Club facilitator reached out to researchers at UW-Madison was that she was concerned that the club was not attracting female students. Girls occasionally come to the club meetings, but they tend not to attend regularly or engage as deeply in the club's activities as the majority of the boys. In late 2013, the researchers conducted focus group testing with middle and high school girls in the school district in order to ascertain how the club might foster a culture more interesting to the girls. As a result, the Cyberlearning Club facilitator and UW-Madison researchers will be piloting a summer course in wearable computing, connecting fabric and crafts design with electronics and computational literacies. Additionally, the facilitator has been working to specifically invite and encourage female students with an interest in game design and programming, a tactic that has been shown to be effective in recruiting girls to programming classes (Goode, 2008).

Conclusion

Our interactions with the Cyberlearning Club illuminate several meaningful factors in understanding programming education for youth. While formal learning environments provide a structured base of fundamentals, informal spaces, especially those that offer a wealth of resources and environments in which to explore programming, may prove more engaging and effective for a wider audience of learners. For the students in the Cyberlearning Club, the variety of tools and resources offered is key to keeping them interested, confident, and creating. Furthermore, the social environment within the club supports students gaining expertise in a variety of areas, with students focusing on design, game programming, website development, and even art. This culture is extremely important for supporting a creative environment but also in introducing students to new practices. Consequently, the learning goals and practices for each boy we interview may become more meaningful as we continue to conduct our interviews and study of the Cyberlearning Club. We summarized the each boy's programming landscape, and patterns throughout these may develop as we interview a larger number of club participants. As we continue to work with the Cyberlearning Club in the upcoming year, we plan to continue to introduce new tools and programs to the students as a way to support continued growth and learning for the kids in the club. While we hope that the district offers a programming course in the formal curricula, until that happens, the informal programming environment is providing a space to support students' engaged learning practices.

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Learning Analytics for Educational Game Design: Mapping Methods to Development

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Introduction

Big data in education (c.f. U.S. Department of Education, 2012) has fostered emergent fields like educational data mining (Baker & Yacef, 2009; Romero & Ventura, 2010) and learning analytics (Siemens & Long, 2011). Simulations and educational videogames are obvious candidates for the application of these analytic methods (Gee, 2003; Steinkuehler, Barab, & Squire, 2012), affording big data situated in meaningful learning contexts (Mislevy, 2011; Shute, 2011; Clark et al., 2012). In the design of these game environments, experts assert that players rarely interact with the game in exactly the way the designers envision, and thus heavily emphasize early, repeated user testing (Schell, 2008; Salen & Zimmerman, 2004). With the added element of content-specific learning goals, or concrete growth over time in a domain-specific skill, attending and adjusting to organic play patterns becomes even more vital (c.f. Shute, 2011; Norton, 2008; Institute of Play, 2013). Thus, just as design-based research in the learning sciences involves data-driven, iterative refinement of measurement tools and experimental design (Barab & Squire, 2004), educational game design needs to incorporate learning-specific assessment mechanisms and leverage sophisticated techniques to understand nuanced learner patterns in play – informing development from the earliest stages of design.

This paper presents a framework of educational data mining methods for optimizing design of games for learning from the earliest development stages. Specifically, it aligns telemetry-based assessment structures and applied learning analytics to inform three stages of development: initial core design, alpha and early beta user testing, and final design overlay of learner-adaptive gameplay. To establish a baseline of analytics for reference throughout the design process, we begin with a literature review of data mining in digital learning environments. Then, applications of these analytics (visualization, association mining, and prediction) to specific design processes will be discussed in the context of each development stage, supported with examples from GLS game research and current work in the field.

Theoretical Framework: Data Mining in Digital Learning Worlds

Many commercial videogame developers are implementing analytics in games for usability testing (e.g. Drachen et al., 2013) and marketing (e.g. Ross, 2013). However, many of these methods are not learning-specific, nor tailored to measuring growth in educational knowledge or skill over time (c.f. U.S. Department of Education, 2012). Representing a host of education-specific machine learning tools, Educational Data Mining (EDM) can provide excellent groundwork for defining data mining methods readily applicable to these large data sets (Baker & Yacef, 2009; Romero & Ventura, 2010). This section will review current literature in EDM, and articulate visualization, relationship mining, and predictive modeling as base methods categories for our discussion of game-based learning analytics.

Educational Data Mining

EDM “is concerned with developing methods for exploring” large educational data streams (Baker & Yacef, 2009, p. 324). EDM is an emergent, multi-disciplinary field in constant evolution (c.f. Romero & Ventura, 2010). As a result, EDM experts survey the field from a variety of different perspectives (Baker & Yacef, 2009; Romero & Ventura, 2010; U.S. Department of Education, 2012). Baker & Yacef (2009) as and the U.S. Department of Education (2012) focus on data modeling goals and methods, while Romero & Ventura (2010) organize around the human subjects of study and educational context (classrooms, e-learning spaces, etc.). However, a common EDM schema can be derived by extracting two mutual methodological components: 1) broad analysis goals, and 2) specific analysis methods.

The main common components of EDM are broad analytic goals and specific methods. Broad analysis goals (or “metagoals”) common to the expert EDM synopses are visualization, relationship mining, and prediction (c.f. Baker & Yacef, 2009; Romero & Ventura, 2010; DoE, 2012). Visualization involves graphic representations of data to elucidate patterns; relationship mining looks specifically at associative patterns in the data; and prediction can project outcomes via algorithms of sequence, probability, and regression. The last core EDM component, specific method types, are subunits of these metagoals. These method types include: descriptive visualization, social networks, clustering, association, classification/regression, and pattern mining (Figure 1). A loose mapping of these specific

methods to the broad metagoals of EDM is visualized in Figure1.

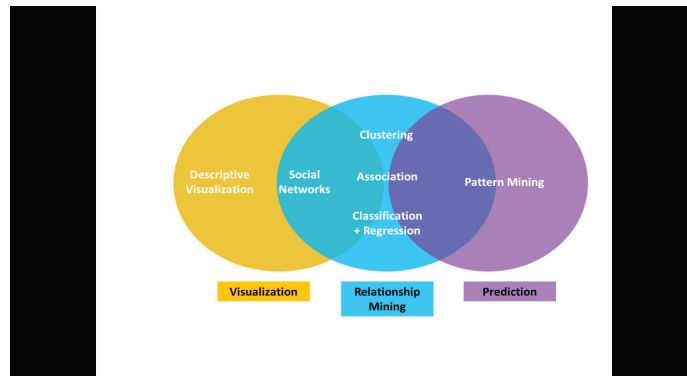


Figure 1: EDM analytics – specific methods loosely mapped to three base metagoals

These specific methods, applied in various EDM contexts, have powered recent work in the field. Descriptive visualization has been used in virtual learning environments to chart the most popular student resources, time on site, and item-specific performance measures (e.g. Feng & Heffernan, 2006). Social network analysis and related techniques have been used to track blog-based citations (e.g. Simmons et al., 2011), make teacher tools to visualize learner trajectories for optimized student grouping (Berland et al., 2013) and convey hierarchical changes in social structures over time (Carley, 2003). In related relationship visualization examples, clustering has been used to identify learner groups and explore user patterns of navigation (e.g. Kerr & Chung, 2013).

Relationship mining through association has been used in EDM to provide indicators for curricular improvement of e-learning and online educational environments (e.g. Retalis et al., 2006). Classification and regression, building on association, belong to the predictive modeling metagoal. They have been leveraged to provide insight on e-learning profiles and learning style (e.g. Yu et al., 2008), projected student performance (e.g. Ibrahim & Rusli, 2007), and create teacher-friendly collaborative learning tools (Anaya & Boticario, 2011). The last category, pattern mining, are methods that capture and analyze sequential events. These can include Natural Language Processing for student text interpretation (e.g. Song et al., 2007), Markov chain modeling for showing learner trajectories (e.g. Fok et al., 2005), and Bayesian networks for probability-based student modeling (e.g. Millán et al., 2010).

Phase I (Early Core Design): Articulating a Learning Data Framework

As evidenced by EDM, one challenge for data mining in educational systems is identifying, capturing, and outputting salient learning data for analysis. Clickstream events are, in their natural state, massive and inchoate; data for collection must be specifically identified, tagged, and collected (c.f. Baker & Yacef). These captured data then directly affect the kind of analyses possible. In educational games, identifying salient learning features (these data for collection) can be a challenge. Indeed, identifying valid information “about what the student knows, believes, and can do without disrupting the flow of the game” is a “main challenge” of educators in using games to support learning (Shute, 2011, p. 508). Yet, identifying this data in early development stages is vital, because it affects our ability to understand player experience during and after the design process.

Games & Learning Data: A Brief Review

Squire asserts that games as designed experiences (2006) provide endogenous engagement (Costikyan, 2002) for the player through “roles, goals, and agency” (Squire, 2011, p. 29; Norton, 2008). Thus by definition, in *learning* games, there can exist two kinds of designed mechanics: one related to progression through the gameworld as an engaging context (Schell, 2008; Gee, 2005; Salen & Zimmerman, 2004); another a more direct measure of the content the game is trying to teach (e.g. Clarke-Midura et al., 2012). Ideally, these two overlap; good educational games meld learning mechanisms with the core mechanics of the game, where gameplay itself is the only necessary assessment (Gee, 2012; Shute, 2011). With a multitude of mechanics, some related to content measurement and others to play progression, how can critical features be identified?

Some theoretical models help answer this question, striving to identify learning-salient data in virtual learning worlds. Among the most prominent of these is ECD, an assessment data framework that revolves around aligning educational content with learning evidence from tasks in the educational space (e.g. a task model). ECD, however, has been tailored specifically to use in simulations, and does not deal with specific click-stream implementation

details (Mislevy, 2011). One game-tailored framework used at GLS incorporates the idea of a task model while identifying information on basic play progression, capturing gameplay as more than a series of academic tasks (Halverson & Owen, in press). This framework, also an implementable API, is called ADAGE (Assessment Data Aggregator For Game Environments). In short, ADAGE records information on task model moments in the game – called Critical Achievements (CAs), designed to directly measure learning gains – but it also captures context-rich play progression through the narrative space.

Data Frameworks: Informing Early Design

In the early design process, using a learning game data framework can not only help pinpoint existing data features for usertesting insight and later analysis – it can inspire the creation of helpful learning measures in-game (like critical achievements). ADAGE is just one example, and is used below to show how a strong learning data framework can empower early design efforts.

At GLS, ADAGE and CAs have become a core part of a larger design process. Unlike simulations, educational games are not driven completely by a task model, and the immersive designed experience of the game has been held at a premium (Squire, 2006). Thus, CAs are a harmonious element (rather than a driving force) in core game design. Moments considered important for measuring learning can be built into the design process, crafted with the goal of informative yet seamless feature of gameplay. In game design literature, these critical achievements can be seen as part of game mechanics, which is only one element of core design – balanced with the vital elements of narrative, dynamics, and aesthetics (c.f. Schell, 2008; Salen & Zimmerman, 2004).

These kinds of key assessment mechanics have been built into existing GLS games as part of collaboration with scientists in the UW community. GLS design partners match subject matter content to video game genres, translating procedural academic knowledge into narrative-based verbs of play. In the context of these games, the ADAGE framework has been critical for the design team to determine the relation between the game flow and the content model.

One strong example of the Critical Achievement data structure supporting early design is in *Fair Play*. The player is put in the shoes of the main character, Jamal, who experiences implicit bias as a first year graduate student. In this context, Jamal has conversations with several students and faculty, during the course of which he must identify a recently experienced implicit bias in order to progress. Seamlessly built into the game design in early development stages, this CA mechanic helps measure player understanding without breaking narrative (Owen & Ramirez, in submission).

Crystals of Kaydor, a game in the *Tenacity* collaboration with the Center for Investigating Healthy Minds, provides several examples of CA mechanics built into early game design for the purpose of measuring student skill growth. *Crystals of Kaydor* is an RPG designed to cultivate the development of pro-social behavior through collaborative social interactions. The player controls a robot who has crash-landed on an alien planet. For the first kind of CA, in order to win the aliens' trust, the player must pay close attention to non-verbal cues, tracking aliens' facial expressions and intensity through a slider interface. Secondly, the player must then correctly select the emotion of the alien, and for the last CA, choose an emotional response to the aliens' affect. Alongside CAs, ADAGE play progression data has also provided a context-rich backdrop to evaluate play progression in relationship to learning (Beall et al., 2013).

During early design phases, anticipating evidence of learning and play progress is vital, because it directly impacts the kind of analyses – and insights about player behavior – that become possible. ADAGE serves as just one example of a framework that can help do this. For instance, building in CAs in initial phases of game design (rather than clunky late-game additions or identified post-hoc by desperate researchers) has several advantages. First, it helps beautifully integrate play progression and learning measurement mechanics for a seamless player experience. Second, these designer-specified mechanics directly inform data structures and early-phase analytics, making usertesting results even more relevant to developers. Thirdly, these key learning mechanics provide anchoring measurement points for educational researchers, who can then provide insight into growth patterns that inform final in-game scaffolding design (see late-beta section below).

Phase II (Alpha and Early Beta Development): Analytics for Usability Testing

Strong data structures enable telemetry analysis for data-driven design in the alpha and early beta phases. Visualizations and descriptive analytics (Figure 1) can be particularly helpful in refining UI design, as well as identifying bugs and player attrition points. All of these analytics, based in click-stream data, can greatly complement qualitative usertesting methods like interviews, surveys, and think-alouds.

In refining UI design, visualization and descriptive statistics of player usage can be key tools in the alpha and early beta design process. For example, during work on the *Tenacity* project, GLS conducted focus-testing groups for UI functionality and design. Player navigation through levels was analyzed and visualized through a network diagram, showing most frequented levels of the game – and it was discovered only one available level of the game was getting little to no use at all. Upon revisiting the UI map selection menu, designers realized most players catch that is it was a scrolling menu (with the last level out of sight). Immediately, the UI was redesigned with all levels showing (in a matrix format), and the problem disappeared. Additionally, in one slider mechanism for *Tenacity*, the player-entered value could range between 0-1 (with the default being 0.5). A simple distribution graph of these slider scores showed most responses at *exactly* 0.5. Upon further review of the UI, it was realized that most people were simply skipping the self-report, thus reporting the default value. This, also, was remedied immediately, and movement on the slider was then required to unlock progress (Beall et al., 2013).

Visualization of telemetry data can also be a powerful tool in identifying bugs and player attrition points. Using statistical visualizations of event frequencies, including game-restart flags and duplicate events, can highlight points of systemic dysfunction. Spatial visualizations of common attrition points can also indicate dysfunctional level design. For example, early phase *Tenacity* analytics included histograms of the “restart game event” and duplicate quest-starting events in order to catch large-scale game crashing. Integrated with corroborating interview data, these data isolated areas of game malfunction (Beall et al., 2013). Similarly, visualizations using state changes and ADAGE virtual context were used to heat map player progression in the GLS *Anatomy Browser*, showing exactly where learners were getting stuck and consequently quitting (1). A similar example exists for early design and testing of *Fair Play*, where positional data was recorded to create a heatmap of player activity. One map level (aerial view) in the game was programmed to show color-coded areas of frequent player travel (Owen & Ramirez, in press). This helped inform placement of in-game assets critical to content exposure and game advancement.

Phase III (Final Stages of Design): Scaffolding for Learner-Adaptive Play

In final stages of game development, after extensive data collection with late-beta builds, learning analytics can be used to predict in-game actions and performance most characteristic of learning. This knowledge of ideal player behavior can then inform the final design phase: user-adaptive, fully scaffolded play for optimized in-game learning. To this end, optimal player actions, sequential pathways, and assessment growth trajectories can each be explored through learning analytics (including visualization, prediction, and pattern mining methods).

Player actions and events most characteristic of learning, whether related to play progression or Critical Achievements, can be effectively modeled with various prediction and association mining methods (Figure 1). These studies include use of correlation, classification trees, and probability nets to better understand which player moves predict learning. For example, ADAGE game study has explored learning in *Progenitor X* through correlation of in-game success and failure with pre-post learning outcomes (e.g. Halverson & Owen, in press). Predictive modeling with classification and regression trees (CART) has explored in-game performance and learning (e.g. DiCerbo & Kidwai, 2013; Owen et al., 2014). Bayesian networks have also been used with this data theme, probabilistically connecting chunked performance data to creative problem solving in games (e.g. Shute, 2011). If gameplay models show certain actions at certain points to be more predictive of learning, then player-triggered scaffolding (e.g. help resources) can be implemented in-game to help keep players on track at these crucial points.

Sequential learner pathways can also be modeled using machine learning methods. Specifically, visualization and predictive modeling (including clustering and pattern mining) have been used with success in learning games research to capture learner trajectories. For example, SimCityEDU researchers are building player profiles by identifying groups of using hierarchical cluster analysis, then contrasting these groups according to level of in-game success (Institute of Play, 2013). In another visualization example, ADAGE-based heatmaps can visualize learners’ critical pathways though the game (e.g. Owen & Ramirez, in press). A heatmap of top learner actions can highlighting a high-performer, learner-centric path through the game. Markov modeling, a pattern mining method, has been used to illustrate the probability of play sequences among different learner groups (e.g. Clark et al., 2012). With text data, natural language processing is another pattern mining method that can be used to discern algorithmic differences in game-based discourse patterns over time (e.g. Mechtley & Berland, in submission). With any of these sequential learner trends identified, adaptive scaffolding could then be placed in-game to support students’ progress along paths connected with learning gains.

Lastly, growth in player performance between specific points of assessment (e.g. Critical Achievements or isomorphic game tasks) can be tracked especially well using data mining methods of prediction. These prediction methods can include pattern-mining methods and Bayesian reasoning, used to forecast which growth patterns indicate learning. For example, Bayesian Knowledge Tracing (BKT) is an algorithm that can predict learning moment-by-moment based on multiple performances on a chosen task (e.g. Baker, Corbett, & Aleven, 2008). BKT

has also been used in tandem with detectors, which are automated models that can predict student behavior from log file data (e.g. Baker et al., 2004). Recently, the application of detectors has extended to goal-driven learner behavior in games (e.g. DiCerbo & Kidwai, 2013). In application to games, these powerful algorithms can help designers anticipate and support in-game performance indicative of learning.

Conclusion

In core design, alpha usertesting, and final-stage adaptive play design, telemetry-based analytics in educational game development play a key role in optimizing learner experience. This paper maps a clear framework of learning analytics methods to learning game development phases – from core data structures, to bug killing, to customized, automatic scaffolding design. Leveraging these powerful analytic tools of visualization, association mining, and predictive modeling throughout the design process is key to supporting players in a user-adaptive, engaging play experience optimized for learning.

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Endnotes

(1) <https://itunes.apple.com/us/app/anatomy-browser/id523208752?mt=8>

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Game Design and Player Metrics for Player Modeling in Adaptive Educational Games

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Introduction

As data-driven information technology becomes more prevalent, its potential use on game-centered learning systems becomes increasingly evident. By monitoring learners' progress based on a series of observable metrics, adaptive learning environments can make inferences about individual learner's needs and preferences and adjust accordingly to support the learner. Online educational organizations such as Kahn Academy, Code.org, and Codecademy have shown promising results of mixing traditional education with online learning environments, but also run the risk of trading educational merit for entertainment (Kumar, 2014).

Recent educational games have started to incorporate adaptive technologies to facilitate learning. For example, *Plant RPG* (Hwang, et al., 2013), a game to teach natural science in elementary schools, experimented with adapting its presentation of learning missions in accordance to a player's alignment with the sequential/global component of Felder-Silverman's learning style model (Felder & Spurlin, 2005). Depending on how students scored on a pre-test survey measuring their sequential/global inclination, the game presents its missions either as a sequence of unlockable, linear quests or an overview of multiple quests available at any given time. Another example is the Crystal Island project (Mcquiggan et al., 2008), an educational game that explores how to modify story sequence of the based on how the learner progresses in solving the game's biological puzzles.

Adaptive educational games are still in an early stage of development when monitoring "fine-grained student needs and interests" (Magerko, Heeter, & Medler, 2010). Much about how to design and develop adaptive learning games is largely not well-understood. In this paper, we present our approach for designing *game mechanics* and *player metrics* toward player modeling, necessary steps toward adaptive educational games. Through our on-going Avian project, we demonstrate how we design gameplay activities to support learners of different player types and design player metrics to capture their behavior patterns for player modeling. We believe that the approach behind our game design can be applied in other adaptive educational games that uses player modeling. We also discuss our future plans to player modeling and the evaluation of our approach.

Theoretical Framework

Player type and play style have been two main means of representing players and their in-game behaviors in the game-centered learning community. Play style is the "actual play behavior enacted while playing a specific game" (Magerko, Heeter, & Medler, 2010). As play style is directly tied to players' observable in-game behaviors, it is relatively straightforward to measure (Magerko, Heeter, & Medler, 2010; Heeter, et. al, 2009; Foster, 2009). However, a player may adopt different play styles in the same game, for instance, based on how confident he or she is about achieving her goals at a given moment. Beyond player choices, the design of games themselves limits available options to players: control and expression in games are confined by their genre -- their underlying design patterns -- and thus can only support a certain set of actions and strategies. Such limitations by game design decisions therefore constrain the possible play styles a player may engage in. The variability of play style of a single learner makes it challenging to construct and maintain a stable player model.

By contrast, player types are traits or underlying characteristics of a player (Magerko, Heeter, & Medler, 2010; Foster, 2009). Research has shown how player types influence the way players interact with and learn from video games (Foster, 2011; Magerko, Heeter, & Medler, 2010). Although player types cannot be observed directly, it has been suggested that one way to construct a player type is through the combination of observable player behavior and the motivations that drive them (Bartle, 2004; Foster, 2011; Heeter, et al., 2011).

In our project, we aim to model player types based on a player's in-game activities and their motivation. In particular we use Foster's framework of player type (2012), which combines research on achievement goal theory (Ames, 1992; Elliot & McGregor, 2001) with player styles (Foster, 2009). This work builds on the research of Heeter, et. al. (2009), seeking to clarify play styles and learning in educational games. Built on the Achievement Goal Theory (AGT) framework, Foster (2009; 2011) divides player types into two general categories of *Explorers* and *Goal-Seekers*. Explorers investigate and analyze the inner-workings of game features while Goal-Seekers

are primarily focused on achieving the goals of the game. When applied to educational games, this means that explorers are inclined to experience a wider range of in-game content while goal-seekers will tend to focus on content necessary for winning. Based on how much players value game objectives, knowledge attainment, and social interaction, there are two subtypes within each division that reflect valences seen in AGT. Explorers can be Localized – becoming an expert in a single subject with a willingness to help others – or Comprehensive – experts of a broad range of game material who are less willing to socialize. Goal-Seekers can be Competitors – players who focus on winning the game and enjoy socializing to the point of sabotage – or Achievers – players who are interested in completing the game as fast as possible without the desire for socializing.

Avian: Research and Design

Avian is an educational game that aims to teach basic ornithology through virtual bird watching activities, e.g., photography and bird identification on two virtual islands. Players are asked to catalog bird specimens, fill in their personal field guides (Figure 1 Left) and report their findings to kiosks (Figure 1 Right). To win the game, a player has to correctly submit photographs of the requested bird species to all four kiosks.

In addition to promoting an engaging learning experience on ornithology, a main goal of Avian is to provide an environment to collect data for modeling the player types defined by Foster (2011). It is our assumption that the more learners of the four different player types behave differently in Avian, the more likely we can build an accurate player model of player type. Therefore Avian needs to support learners of different player types by providing different game activities that attract each of the four player types.

Gameplay Design for Player Types

Gameplay activities in Avian can be broadly grouped into four categories: island navigation, photography, field guide usage, and kiosk usage. As shown in (Figure 2), elements of each category are designed to appeal to specific groups of learners based on their player type.



Figure 1: In-Game Screenshots (Left: Field Guide Bird Catalogue, Right: Kiosk and Leaderboard)

	Goal-Seeker		Explorer			Goal-Seeker		Explorer	
	Competitors	Achievers	Localized	Comprehensive		Competitors	Achievers	Localized	Comprehensive
Island Navigation					Field Guide Usage				
Find New Kiosks	✓	✓	□	□	General Info	✓	✓	✓	✓
Find New Areas	□	□	✓	✓	Local Validation	□	□	✓	✓
Photography					Complete Guide				
Kiosk & Guide	✓	✓	✓	✓	Complete Guide	□	✓	✓	✓
Upload to Gallery	□	□	✓	✓	Kiosk Usage				
					Online Scoring	✓	□	□	□
					Complete Kiosks	✓	✓	□	✓
					Local Scoring	✓	✓	□	□

Figure 2: In-Game Activities for Player Types

Island Navigation. Basic mechanics of Avian involve the navigation and exploration of the virtual islands in the first-person perspective. In order to differentiate the two main player types, we include clear indications of the goal. For example, since winning the game requires the player to find all four kiosks, trail paths are marked on the ground which lead players from one kiosk to the next. The locations of all kiosks are clearly marked in a map. For explorers, since we know that they are less driven by winning the game, Avian allows players to wander off the trail paths and discover new areas with other payoffs such as scenery and rare birds. To potentially further differentiate the behavior of the two player types, we include a second island that does not have any kiosk and hence is unnecessary to win the game.

Photography. Players are able to take pictures of birds and scenery as they navigate the islands. These photos can be uploaded to an unranked online gallery for sharing, or submitted to a kiosk and/or the field guide (details below). Photography in Avian is purposely unrestricted. Although a green indicator shows when the camera is pointing at a bird, players can take a picture at any time about any subject. These pictures, birds or otherwise, can then be uploaded to the online gallery should the player choose to do so. The online gallery displays photo submissions of all the users. Each photo shows the player who took it, but doesn't present any information about score or evaluation. Since there is no formal competition between the photos, the gallery is designed to share experiences, birds, and scenery that players find interesting. These qualities are representative of explorer inclinations.

Field Guide Usage. The field guide consists of a bird catalog, index, and help section. The bird catalog (Figure 1 Left) includes a series of birds, each of which contains the name of the bird species, descriptions, and a picture slot where the player can submit a photo of that species (only correct photos will be accepted.) In addition, the index section displays user information and the help section contains explanation about how to play the game. These elements provide general information to all players.

Uploading the correct photos to the bird catalog does not affect player's scores or allow them to win the game. Instead, it provides feedback for the quality of the photo based on the bird's species, its facing angle, distance from the player, and its captured action (e.g., perching). As a form of local (i.e., single-player) validation, the bird catalog is designed for explorers as an uncompetitive alternative to kiosks (discussed below). Finally, the ability to complete the guide is designed to attract explorers and the achiever type under goal-seekers.

Kiosk Usage. Each kiosk contains the task of finding a particular species of bird, which the game places near the kiosk. The player can submit the photo to the kiosk and get scored on the quality of their photo. The score is computed based on the same criteria as the feedback from the bird catalog except the kiosks provide a numeric overall value.

The scoreboard provides a list of the highest scoring players for the goal bird at any given kiosk. The online scoring feature of the kiosk is designed for competitors, who are motivated to compete with other players of the game. It is our hypothesis that competitors will make multiple submissions per kiosk to maximize their score, while achievers will make as few submissions as possible to win the game quickly. As discussed above, winning the game requires completing the tasks at all four kiosks. It is designed for all player types except localized explorers.

Player Metrics Collection

Our game records data to generate a series of metrics that capture how each player interacts with the game and eventually to build a model of play style patterns. While modeling player types is premature, our research draws relationships between play styles and achievement goal motivation through aggregated player metrics. More specifically, we currently collect the following groups of data. 1) Time spent on different types of activities, such as menu usage (help pages, bird catalog), navigation, photography, and total time spent in Avian. 2) Trail variance, such as percentage of time spent on the trail paths, how often the player deviate from them, how far from the starting position does the player go in average, and whether the players ventures to a second island via the use of a bridge. 3) Photo content, such as what percentage of photos taken contain birds, and among them, how much variance is present among the birds. 4) Gallery uploads, that is, how many and what kind of photos players upload to the gallery. 5) High scores, that is, how often players submit photos to kiosks along with the score, timestamp and what species of bird was submitted.

In order to identify trends and patterns in our data and to evaluate our current player metrics, we developed tools to visualize user activities. Fig. 3 is an example displaying of multiple players' navigation traces and the locations where they used their camera to take photos (see Figure 3). Heatmap is another visualization technique we implemented as it shows where players focus attention (and where they ignore). They show aggregate player behaviors and may prove useful not only in seeing possible patterns relevant to research, but also to potential flaws in game design that can be improved upon in future iterations.

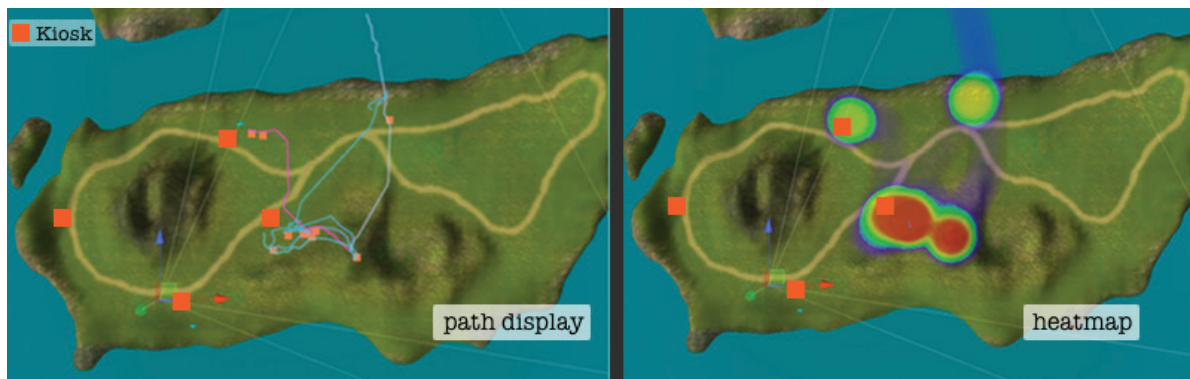


Figure 3: Visualizing Player Paths in Avian (Left: Path Visualization, Right: Heatmap)

Future Direction

As part of our future work, we plan to conduct a study to collect data on how different players interact with the game. We will use this data to analyze player behavior. Specifically, we are interested both in performing two types of analysis. First, we will use machine learning clustering methods such as k-means (MacQueen, et. al, 1967) to investigate whether meaningful clusters of players emerge and whether they are correlated with any aspect of interest to our study. Second, we are interested on using this data to validate our game design hypothesis regarding the different activities (Fig. 2) in our game.

To validate our player modeling results, we have designed an instrument based on the Achievement Goal Questionnaire (Elliot & McGregor, 2001) – a 12-item achievement goal orientation instrument ($r=.800$) – to measure players' self-reported goal orientation. Results of the automated player modeling techniques will be compared with the results of the AGQ.

Conclusion

In conclusion, we presented our approach to game design and player modeling in adaptive educational games. Through an on-going educational game called Avian, we have shown how we designed Avian's game mechanics in order to allow learners of different player types to engage in different gameplay activities. We also present

the player metrics Avian collects. We believe that the approach behind our game design can be applied in other adaptive educational games that uses player modeling. Our next step is to collect player data through a study and evaluate the effectiveness of our player metrics for player modeling.

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Construction and Community: Investigating Interaction in a *Minecraft* Affinity Space

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Introduction

Game-based learning provides opportunities for players to build literacies and develop skills in environments that are both engaging and social (Gee, 2013). Increasingly gameplay is happening not only in the game itself, but also in the external body of sites dedicated to sharing information about digital gaming, called the meta-game. An especially strong meta-game is the one found around *Minecraft* (Mojang, 2013). Fan production in the game has generated a massive network of player-created media ranging from: tutorials about procedural elements of the game, fiction told within the *Minecraft* engine, and a sprawling wiki and official forum which guide both new and veteran players (Macallum-Stewart, 2013). A theoretical framework which is commonly used to conceptualize interactions in the meta-game is that of the affinity space.

Affinity space theory describes how learners connect through online networks to pursue shared interests, without the need to develop persistent, stable communities rooted in ideas of belonging and membership (Gee, 2003). The framework has been applied to study learning behavior associated with the acquisition of a number of vital skills and competencies (Durga, 2012; Gee, 2013; Curwood, Magnifico & Lammers, 2013). However, as the field of affinity space research matures, researchers have begun to problematize some of the pre-suppositions of the framework. Although the idea of belongingness found in communities of practice is often absent in the fluid and unbounded digital spaces of modern game-based learning (DeVane, 2012), continuing work with affinity spaces has begun to suggest that certain spaces are welcoming and nurturing while others are exclusive and elitist (Gee & Hayes, 2012), leading us to ask where this distinction originates. Affinity spaces can be powerful sites of informal learning, but these spaces can also be contested and limited to those who already fall within established identities frequently associated with so-called gamer culture (Duncan, 2013).

In the following paper, we examine a particular affinity space, a forum dedicated to the game *Minecraft*. We first analyze the network structure of interactions that occur within the space. Then, we compliment this structural analysis with qualitative analysis of the forum posts occurring across the social graph to better understand the way that participants discuss their gameplay, and the meaning applied to the conversation taking place. Through this combined methodology, we find that this particular forum thread is a prime example of a nurturing affinity space as described by Gee (2004; Gee & Hayes, 2012). However, by examining the unstated assumptions found within the discourse of the space we find that participants often bring with them an assumed culture and community which exists outside of immediate boundaries of the space. We use these preliminary findings to frame future research which may better understand how ideas of community and belonging influence use of an affinity space, and conclude by discussing the implications of our work for creating affinity spaces which are more open and accepting of diverse types of players.

Theoretical Framework

Prior work on informal learning in online games has found that players tend to reflect apprenticeship practices in their online interactions; passing along not only instrumental help to new players, but also the cultural values of the game (Steinkuhler & Oh, 2012; Steinkuehler & Duncan, 2008). Exchanges within game spaces can have a great deal of complexity, and are largely mediated by the design of the game (Duchenaud & Moore, 2004). One way to situate such informal group learning is as a *Community of Practice* (CoP).

A CoP is a group that defines membership around interest and activity in a shared domain. In communities of practice, members are trained (frequently through apprenticeship) in the cultural and practical behaviors of the community by first being given tasks that allow them to understand some piece of the community (called legitimate peripheral participation) while being slowly integrated to core tasks of the community (Lave & Wenger, 1991). In communities of practice, the focus of study is on how the community interacts and learns together to enhance an individual's identity as a member of that community, and to hone their ability to practice the skill set the community is dedicated to propagate (Lave & Wenger, 1991).

Another framework that is salient to this study is that of an affinity space. This theoretical construct was developed to counter what was seen as a general overuse of the communities of practice framework. The research angle provided by the theoretical construct of the affinity space focuses more on what interactions between participants the space can afford, rather than describing the characteristics of a community within that space (Gee, 2004; Gee, 2012). This shift in focus is especially helpful since the idea of membership in these environments is often murky (DeVane, 2012). With the increasing participation of many different types of people in both games and online social interaction there are blurred lines between what constitutes a CoP versus an affinity space. For example, an affinity space may afford local, learning interactions with a group of members that do not form a community, but each of these members may bring an assumed conception of a community with which they frame their actions. These different processes – participation in an affinity space, but working towards an assumed CoP – may interact to explain what happens in various game-based learning sites. For example, the fan production of artifacts related to digital games may be less a representation of the passion of a niche group, and more of a question of mainstream cultural participation (Macallum-Stewart, 2013). Also, the learning benefits provided by participation in affinity spaces (Curwood, Magnifico & Lammers, 2013) are not uniformly available across all spaces. Instead many spaces are gated by elitist attitudes that privilege certain modes of participation over others (Gee & Hayes, 2012). Although power relations in nurturing affinity spaces are optimally non-hierarchical and dispersed, this social structure isn't always the case. As in any human endeavor, affinity spaces can be contested among their participants.

Duncan (2013) raises this question in the following way, “Is World of Warcraft ‘well-played’ in different ways to the different participants in the space? Are we left with deciding whose perspective on the game is more worthwhile?” (p. 49). These issues motivate the central question of this paper: how does the conception of community and belonging influence the interactions among participants in an affinity space? Specifically, we aim to better understand how a meta-game forum, associated with *Minecraft*, functions as both an affinity space and where participants nevertheless may bring assumed, backgrounded concepts of community to their interactions.

Methods

Setting

To examine a meta-game affinity space, we chose to analyze a thread titled “What have you accomplished recently” from the official *Minecraft* forums. This forum thread was chosen because it represents a wide cross-section of activity commonly associated with both gameplay and participation in the affinity space meta-game. In the wide variety of activity represented, the forum acts as a portal to information sharing and socialization relating to the game. This thread fits with Kozinets’ (2010) criteria for a rich online site of study, as being: relevant to the topic, regularly active, interactive between participants, containing substantial communication, containing a number of heterogeneous participants, and presenting data that is both rich and multi-modal.

We focused on *Minecraft* forums because the game ecosystem (as a type of sandbox game) relies on players to share a large corpus of tutorial and informative material maintained out of the game-world to facilitate play. These resources are so vital that they become a core part of the game, despite being external to the game program (Banks & Potts, 2010). In addition to informational resources, one will often find images and videos of players showing off work that they’re proud of to other players (Duncan, 2012; Lastowka, 2012). *Minecraft*’s position as a complex system requiring the sharing of information, and as a creative platform for self-expression, result in two main genres of social information shared in *Minecraft* spaces: (1) help seeking and information provision, and (2) expressions of accomplishment and social support. The combination of both genres forms an ecosystem of social learning built around *Minecraft* (Banks & Potts, 2010), and this ecosystem exists primarily in social information sharing platforms such as Youtube, discussion forums, and Wiki software (Lastowka, 2012).

Data Collection

Data was collected by starting at the first post in the thread and coding each post for both the structural, social network analysis, and the qualitative elements of the post. Structural and qualitative data were collected side by side in a chronological fashion to understand the conversation in the thread as it occurred between participants. Participants in the forum are anonymized and are referred to by generic names, such as Participant 1 (P1), Participant 2 (P2) and so forth. Our data collection encompasses seven weeks of activity in the thread, with 372 posts made by 182 unique posters.

Data Analysis

We were interested in examining the structure of social interactions that occurred in this forum thread. Thus, we utilized social network analysis techniques to visualize and make sense of the social structure. In the social network graphs, each individual poster is a node in the network. Lines between nodes represent an interaction (e.g.

response) between posters in the thread. We constructed two sets of network graphs to reflect the different social interactions that can occur in a learning group. Using Garton et al.'s (2006) framework of social relations that can exist in online communities, we coded interactions that were (1) social in nature, such as the sharing of accomplishments and social support for game activity, and (2) instrumental in nature such as when players provided details and information relating to how to play the game.

In addition to understanding the structure of social interactions in this meta-game space, we also wanted to understand the ways in which players conceived of the space themselves. To this end qualitative analysis was conducted on the posts themselves, informed by Gee's methodology of discourse analysis (1991). Understanding the posts through discourse analysis allowed for a description of the socially figured world of the participants within the space.

In our analysis we examined blocks of discourse between participants, breaking the thread up by individual posts and continuing exchanges between participants. Qualitative analysis went through iterative coding which was informed by Gee's (2011) seven building tasks of language: significance (how is this piece of discourse relevant to the actions of the participants?), practices (what is being enacted by the participants' discourse within the focal thread?), identities (how does the poster figure their own position in the discourse, and the positions of others?), relationships (what ties are being formed between participants in the thread?), politics (what are the power relations within the thread?), connections (how does this piece of the thread relate to larger ideas within the discourse?) and sign systems and knowledge (what larger systems and signs is this part of the thread relating to?). By combining a structural analysis of the space alongside qualitative analysis of the discourse occurring within that space, we aimed to understand both how the space was used and the larger meanings attached to it by its users.

Findings

A Nurturing Affinity Space

The results of the social network analysis revealed that, as one would expect in an affinity space, there was a dedicated core group of participants in the center of the graph who shared information and supported one another. The central participants - P1 and P2, represented by the solid black node and the striped black node, respectively – shared common space with the less experienced participants (Figures 1 and 2). Many of the other nodes in the graph are connected to P1 and P2 who are central overall to the structure of the graph. However, singletons are still able to contribute to the thread even if they aren't central to the flow of the discussion. P1 and P2 offered a sort of informal leadership, directing conversation, enforcing the minor rules of the thread, and encouraging others. Other active participants, such as Participant 3 (represented by the dotted, gray node in figure 1) made use of the space to show off projects from their initial stages to completion and getting feedback along the way. Members provided support to one another and many different ways of participating were acknowledged by other participants. P1 often played the role of encouraging conversation and complimenting displayed work, but other participants throughout the thread also took up a guiding role. However, a large majority of participants in the social network contributed a post, without directly referencing another participant. Participation skewed towards a core group, as is visible in the figures below, and is an expected pattern in affinity spaces (and most online social information sites) where a small minority often account for a majority of the participation. In all of these ways, this space conforms to traditional conceptions of a nurturing affinity space (Gee & Hayes, 2012). However upon closer examination of the posts themselves we observed hints of a broader, underlying community identity among players that interacted with the affinity space.

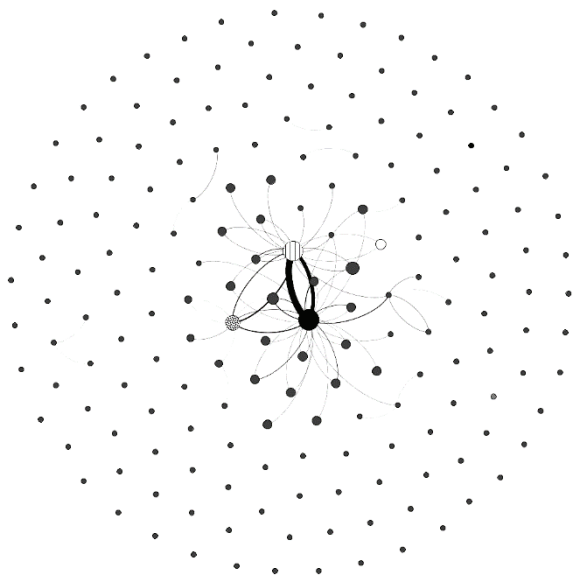


Figure 1: A graph showing the social interactions in the thread. The central group of major participants is visible in the center, with many single participants making up the periphery of the graph.

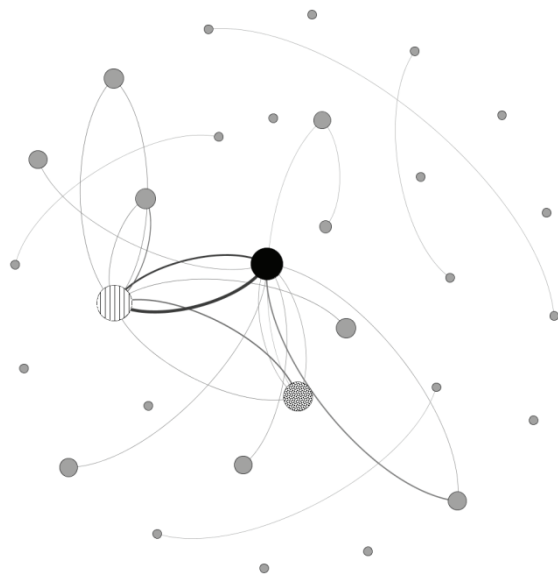


Figure 2: A graph showing the instrumental interactions in the thread. Although the structure of this graph is more tightly bound than the social graph, there is still a similar pattern of core participation. Many of the same central participants in figure 1 also comprise the center of this graph.

The Background Moves to the Fore

One key characteristic of an affinity space is that issues of demographics and identity politics tend to be backgrounded in favor of a focus on the task at hand. However, midway through the thread, an issue arose among the participants that momentarily derailed the conversation, starting with a post from P5 who questioned why P2 displayed a swastika on his or her forum profile: “Hmm well I feel that this needs to be brought up. P2 why do you happen to have a certain Nazi related emblem in your profile picture.”

The above post prompted another user to defend P2, stating “Cant really speak for the person but : The swastika is also a Chinese character used in East Asia representing eternity and Buddhism. The symbol long came before Hitler defaced it. Its is a symbol as tainted as the christian cross thanks to ignorant people.” Another participant clarified, “That’s not Nazi related at all. Nazis aren’t the only ones to use swastikas. Here is what that symbol is for: http://en.wikipedia.org/wiki/Lotta_Sv%C3%A4rd”. Finally P2 replied:

“Just because many people avoid to use similar symbols. And swastikas are not always bad, as you see. The same situation is with pentagrams. Here is a picture of a christian church: [image of a church with a pentagram] You can search in wikipedia fore more info about pentagrams in christianity. The upside-down version of the sign is considered as evil since mid 19th century.”

This exchange highlights the strength of this particular affinity space, and gives an example of the strength of the framework as a whole. Despite a brief misunderstanding about the iconography of a user’s avatar, the participants were able to clarify the issues and continue with the conversation relating to *Minecraft*. However, in defending P2 one of the participants of the thread hinted that other symbols such as the cross in Christianity were also used in negative ways. The issue explicated above was never addressed again, but raises the question if a devout Christian participant reading this exchange might feel intimidated or unwelcome. Although the above episode was an uncommon incident of tension between participants, further analysis of the discourse in the thread revealed other assumed identities that come to bear on affinity space interactions.

Survival vs. Creative: Hints at the Cultural Value of Play

A common theme throughout the thread was the need of posters to foreground the fact that a particular achievement or project that they are posting about was completed legitimately. In *Minecraft* there are two different game modes: survival (where all blocks must be mined or farmed by the player) and creative (where every block is available instantly to the player through a menu). As this thread was posted in the 'survival' sub-forum of the larger affinity space, players repeatedly clarified that their play was legitimate, with illegitimate play being defined by using creative mode to accomplish a task or make resource collection easier. Multiple participants in the thread comment on this distinction, for example:

P2: "2nd pic: the new stones were made with a block transmuter. It can be considered as cheating, but i think adding a new block only to creative mode is unfair."

P3: "[captioned images of a large project] all legit I just flew to get a better view for the screenshot [flying is a capability only enabled in creative mode]."

P4: "I have built my base, and defeated the ender dragon! 100% Legitimate!"

The continued negotiation of play exemplifies an unspoken cultural value that survival play is legitimate, while creative play is a lesser form of gameplay.

Finding Inspiration and Modeling from Others

There was also evidence of apprenticeship within the space. Specifically, players often referred to and modeled their play on well-known celebrity designers. The practice of modeling on celebrity players hints at a broader, assumed community of practice for different players who sense a legitimate way to play or seek to model their practices on who they view as core members of a *Minecraft* community. One of the main leaders of the thread, P2, provided an example of a participant modeling their behavior on a more famous member of the larger community that exists outside of this particular space:

"After a time I collected lots of resources. And I use them to make my world look better and better. Keeping them in chests is pointless. I have inspiration from Etho's videos and I give more attention to details now."

Etho was a famous designer whose major contributions were narrated play-throughs hosted on *YouTube*. P2 showed that he was inspired by the work of a more famous player, Etho, and placed a similar level of care in the aesthetics of his own work. P2 further emulated Etho by providing tutorials to other players. P2 not only has learned a skill, but also adopted the value of teaching others through tutorials. The relationship shown between P2 and Etho is similar to Steinkuehler and Oh's (2012) findings, where apprenticeship relationships developed that incorporated not only instrumental apprenticeship between junior and senior players, but also the transmission of cultural norms about the game.

Other players frequently recognized P2's consistent level of contribution. For example P5 said to P2 in the forum: "the stuff you post is amazing! Id like to see more of your creations please 😊 Maybe a world download or more screenshots?" This social support prompted a reply from P2:

"My stuff is amazing? Thanks! Since a time I decided to build things bigger than I really need. It gives me more space for designing. And some things that I do not need but think it is cool to have them in my world. And I avoid using cobble. Even some holes in my mines I fill with dirt, stone or gravel."

P2 also went on to create his own personal site to showcase his work, much like the well-known designer Etho had his own Youtube channel. These observations represent how some players explicitly model their behaviors on more famous players within the larger community of *Minecraft* fandom at large.

Discussion

In many ways the focal thread we examined fits very well within the theoretical outlines of an affinity space. As shown in the structure of our social network analysis, the forum is a space that allows a porous and heterogeneous group of users to interact with one another to share a wide variety of information (both social and instrumental) relating to a common interest.

However, in addition to the immediately visible contours of the affinity space, there also exists a broader community of people who identify as *Minecraft* players, with some further identifying with the elite level of producer found within the larger *Minecraft* meta-game (Maccallum-Stewart, 2013).

The analysis presented in the findings points toward a problem in the larger discourse surrounding digital gaming, which is the way that a perceived gamer culture often results in unwelcoming attitudes towards those who fall outside of that culture. Our focal thread, which is otherwise welcoming, supportive and non-hierarchical, still exhibits elitist attitudes where players privilege some types of play over others.

Although the question of community and demographics have been backgrounded in previous affinity space research, recent attention to these issues in the popular gaming press make it more vital to consider these issues in future affinity space research. One possible question that we are interested to pursue in future work is, how do disparities in a participant's background culture (e.g., race, gender or sexuality) conflict with the assumed culture of a given affinity space? Perhaps the answer is that affinity spaces afford interactions that can overcome inequalities, but this potential can only be realized through the actions of human participants who may bring elements of cultural and social inequality with them to the space. Future research is needed to understand how the affordances of an affinity space and broader culture interact in gameplay and learning. Overall this fits with Duncan & Hayes' (2012) call to expand our conception of affinity spaces for the way that modern youth are learning and playing online. A fuller understanding of how community identities interact with affinity spaces will allow both game designers and educational designers to create experiences that reach a broader array of players and learners, not just those who fit with the dominant assumed culture of a given space.

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Tech Trajec-Stories: Values That Shape the Lives of Women in Technology

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The underrepresentation of women working as programmers and computer scientists in the technology industry is an issue of great concern for stakeholders in both industry and education. Recent computer science enrollment statistics suggest that the gender gap is actually increasing (Goode, 2008). In 2012 Game Developer Magazine reported that just four percent of programmers in the games industry are women (Miller, 2013) and in 2013, there were three US states in which not one single female student took the AP Computer Science exam, though many of those states had very few students of either gender take the course (Ericson, 2013). Research on this topic reveals myriad reasons for these disparities—from technology placement and habits of use in homes to differences in how boys and girls tend to play and tinker with technologies to the ways in which parents and teachers talk with children and teens about technology and media (Margolis & Fisher, 2002; Goode, 2008). Even when women do “make it” and obtain computer science related jobs in technology fields, surveys and research suggest that many women find these jobs conflicting their values and family lives, leading many women to seek other career directions (International Game Developers Association, 2004; Consalvo, 2008). This trend suggests a need for additional empirical research on the experiences and trajectories of women at varying stages of their careers in technology and computer science.

Exploring the role of technology in learning, work, and play

Our lives are mediated by lifelong processes of play and learning, beginning from very young ages and continuing through life in the workforce and beyond. As researchers, we wonder, how are we looking at technologies as a tool for learning, entertainment, productivity, citizenship, and health across the human lifespan? Recognizing the evolving roles of digital media in women’s lives from when they are really young and through their trajectories in the workforce, we are interested in discovering recurring themes in the lives of women in computer science. As a result of this ongoing work we hope to better strategize ways to proactively support women throughout their education and careers. Better understanding women’s trajectories promises to help educators and industry leaders to level the technology playing field where women continue to be underrepresented.

This work shares many features of research on technology identities (Goode, 2010), exploring individuals’ belief systems as they relate to four core areas: beliefs about one’s technology skills, beliefs about opportunities and constraints to use technology, beliefs about the importance of technology, and beliefs about one’s own motivation to learn more about technology. Goode’s research on technology identities and the research presented in this paper on how people rank their values relating to technology serve to further problematize the digital divide conversation. As initially conceptualized, the digital divide focuses almost exclusively on *access* to technology and fails to fully account for the myriad sociocultural influences relating to how people actually *use* technology. Just as we need deeper research on the experiences and trajectories of women and minorities in technology careers, we also need research that more deeply explores how people use technologies and what kinds of impacts those uses have on learners’ long-term learning trajectories.

Existing research on the experiences of women who work in technology fields such as games suggests that women have a particularly complicated relationship with the work (International Game Developers Association, 2004), leading many to leave careers in the field over time. Consalvo (2008) notes that it is frustrating for women to perpetually try to “fit in” to a predominantly masculine culture or to feel like they are being treated differently on the basis of their gender. Her research suggests that the game industry’s pervasive practice of “crunch time,” periods of increased mandatory work hours in the weeks or months before a game ships, are especially problematic for women, who often find it difficult, if not impossible, to balance these unreasonable work demands with their commitments to their families. This work poses considerations about industry cultural norms that have critical implications for the growth and diversification of industries like the games industry and broader technology fields. However, there *are* women currently in technology fields who identify as computer scientists, and who find fulfillment and success in their roles. This research describes the outcomes from a series of interviews with six successful women at various phases in their computer science careers and professional focuses. These women shared their life narratives with an interviewer who guided the discussion around their development towards involvement in computer science and used a value and activity ranking system to focus conversation.

The research questions that guided the process were:

1. How do successful women in computer science fields describe their life story in terms of play and learning experiences?
2. Given a list of ten values, how do successful women in computer science fields rank values across selected seasons from youth to adulthood?

Games to engage girls?

While not all of the women who served as research participants for this study work specifically in game development, we give special attention to the role of games in these women's tech trajectories, a decision backed both by the interview content and games research. Half of the women interviewed currently work in game production or development, and most of the women noted the role of games in their trajectories throughout their interviews. In the past games have been cited primarily as a means to interest young men in computer science courses, but there is increasing evidence that games may also be an effective avenue for engaging women's interest. A recent Pew Internet & American Life surveys show that 97 percent of American youth play video games (Lenhart, et. al, 2008). Additionally, women over the age of 18 represent a much greater portion of the game-playing population than boys under the age of 18 (Entertainment Software Association, 2013). As a result of these trends, several researchers have begun to argue for the potential advantages of using game play and game design to encourage girls in IT pursuits (e.g. Fullerton et. al, 2008; Hayes, 2008).

Methods

For the interviews reported on in this paper, six women in computer science and technology jobs shared their experiences of play, schooling, and their social communities across key periods in their lives. The guided interviews took place one on one with an interviewer and the participant. The interview protocol was made up of open-ended questions about youth activities, learning experiences, play/free-time activities, and opinions about the role of women in STEM and computer science fields.

The interview also included value-ranking activities and think-alouds. Participants were asked to consider the list of values listed below and rank them according to importance at four phases of their life: later elementary school (8-11 years old), middle or intermediate school (11-13 years old), high school (14-18 years old), and adulthood (18+ years old). The values activity was inspired by the work of Flanagan, Howe, and Nissenbaum (2005), who did values-based evaluations of their design team processes. The values they used were adapted to work with this style protocol, align to specific research questions, and evoke specific kinds of conversation as the women shared their stories about the different time periods in their lives. Once the women had finished ranking the values for the given time period (including putting some values on the side if they felt the values were irrelevant for the time period), they were asked to tell the interviewer a story about themselves at that age that exemplified something about the way they ranked the values. It is noted that some of these time periods may have included multiple shifts in values and behaviors. Participants were also asked to select the time that they felt the most significant shift took place considering their previous rankings. The following is a list of the values the participants ranked:

1. Access – to have resources or knowledge available for use or attainment
2. Autonomy – independence, the freedom to make one's own decisions
3. Collaboration – working together with one or more others, cooperating on a task
4. Community – a relational group of people sharing common interests, ideas, or beliefs
5. Creativity – using original thought, creating meaningful new ideas, products, methods, or interpretations
6. Diversity – the state of having many differences and a variety of characteristics
7. Equality – having the same value, rank, or ability
8. Group Success – achievement/high position or performance, attained by collective team
9. Individual Achievement – personal accomplishment of an objective, especially by hard work or ability
10. Subversion – intentionally going against norms, working to undermine the foundations or assumptions of something

Findings

The sample size of this study was low, so it is not prudent to make declarative statements about women in general, or even women in computer science fields from this study. However, emerging trends may lend insights into the complexities of the developmental experiences of girls who take a path into computer science fields, and possibly push back against assumptions currently made about youth experiences and their connections to technology as a tool for work and play.

The narratives given by the women demonstrate the importance of the role of culture; for example, two participants had childhoods in Russia, with one of them moving to the United States in elementary school. Participants were raised in the south, the Midwest, and on the east coast and have a variety of cultural heritages, which have varying levels of influence in their day-to-day life. Regardless of cultural backgrounds, the role of peer influences was high, especially in middle and high school. How this influence played out varied from participant to participant. Family background and socio-economic status also influence the kinds of learning and tools children are exposed to, and opportunities that may emerge from such exposure. In short, these are six very different women with different life stories, backgrounds, and experiences. However, by examining trends that emerge from this group of women, patterns seem to begin to counter some assumptions that researchers and developers make about how girls interact with technology.

Childhood and Youth Experiences

All six participants had early experiences with technology and success with academics. Even Mary, who had challenges with reading in elementary school, was able to overcome her difficulties, and continued to work hard academically, as school was highly valued in her family. Most of the women identified with games or gaming at some point in their lives, giving credit to the questions Hayes (2008) asks of game spaces for IT career trajectories, “To what extent do such games—and the communities and practices associated with them—offer affordances for developing domains of IT expertise? This expertise includes not only mastery of technical skills but also modes of problem-solving, specialist language, design knowledge, and the appropriation of ‘tech-savvy’ identities.”

Three of the six women interviewed came from families in which math or engineering were one of the parent’s careers. All six also had examples of interest-driven learning that emerged strongly during elementary school or middle school, and contributed to what the women considered among their more powerful learning moments. The interests range from musical instruments to theatre to computer games. Interests in computers and identifying as one who used technology as a tool to carry out interests emerged between middle school and high school for all six women, though not all women made connections between their technology interests and computer science immediately. A few of the women did not make that connection until their undergraduate years. For example, Katia didn’t know what to major in, and decided to take computer science classes because that’s what her boyfriend was doing. She already used technology as a tool, however, because she identified as a gamer. In her words, “it was my junior year in high school when I built my first computer... ..so clearly I *had* some interest, but I never *thought* of it that way. It was like a weird hobby thing.”

Another theme that emerged clearly was the role of social groups. This aligns with ranking differences seen (discussed below) between group success and community. Community remained important for all women across their life trajectories. From an early age, Evelyn found that community was important to help her transition to living in a new country. Katia found that her drive for individual achievement and academic success hurt her peer relationships in high school, so she purposefully held herself back in her academic achievement to gain greater community acceptance. And Ally’s peer group served as her entry into gaming and deeper investigations into hacker communities. For all participants, it was either peer support (friend or boyfriend) or mentoring within a programmatic opportunity (Academy of Information Technology, Research Experience for Undergraduates, Robotics Club) that helped each woman make transitions into connecting with an identity of being a computer scientist.

Value Ranking

In going through the process of the value-ranking activity, participants were given the option to put items on the side if they were not of any importance at that time. These non-ranked items give insight into patterns and trends regarding when certain values seem to become especially significant in the lives of the participants. Unranked values are listed in Table 1 below.

	Frequency of Unranked Value			
	Elementary School (8-11yo)	Middle School (11-13yo)	High School (14-18yo)	Adult (18yo+)
Access	1	1	2	0
Autonomy	2	1	1	1
Collaboration	4	2	2	0
Community	1	2	0	0
Creativity	0	0	0	0
Diversity	3	2	1	2
Equality	1	2	1	2
Group Success	4	4	1	0
Individual Achievement	0	0	1	0
Subversion	6	2	0	1

Table 1: Frequency of unranked values.

A caveat in thinking of the way the participants identified with certain values must be made regarding the role of institutional schooling in shaping the values. For some women, their language indicates that when they identified strongly with an institution, such as school, the institution’s values became their personal values as well. “This was important in elementary school” became “this was important to me” for some women. Molly describes upper elementary school, “I felt like a lot of the work that we did, especially in elementary school was very, like, individual based. I don’t feel like there was a lot of group activity...” This does not suggest that we should discount the values that are hinted at being more institutionally based. In these cases, the participant’s identification with the institutional activities and practices leads to a personalization of those values. It is just important to recognize that environmentally or institutionally based values can shape the way people personalize their own experiences, whether through practices of identifying with the values as given, or rejecting them in acts of independence and/or subversion.

Some trends emerge that merit further exploration with subsequent studies. Subversion, which was defined as intentionally going against norms or working to undermine the foundations or assumptions of something, was unranked in elementary school, was ranked by everyone in high school, and remained ranked by all but one woman in adulthood. Creativity was ranked across all groups, indicating that it remained a value for all six women across their life trajectory, and individual achievement was almost always ranked as well. Perhaps one of the more intriguing findings from what is unranked is in contrast to the strength of individual achievement. Group Success did not become commonly ranked until high school, and then adulthood when all women interviewed ranked it. This differs from the rankings for community and indicates that while a social group may have been important for these women during their younger years, they tended to value working and achieving alone. Participant Evelyn describes the difference in childhood. “...it’s not like ‘let’s create a project together,’ but like, ‘let’s just play together’... That’s also important.” The lack of evidence for valuing Group Success in early school years may be another case of the participants taking up the institutional values of school as their own. Though schools in Western nations have begun to incorporate more group work into their curricula, assessment still tends to reward individual contributions.

When assigning numerical weight to the values that participants gave in their responses, values were assigned a number for their rank, with low values being assigned to those valued most highly. Ranks were then averaged by the number of participants who ranked the value. Because the survey group is so small, and because averages aren’t all based on all six participants, rather, are only based on the number of women who ranked the value, patterns shouldn’t be assumed from looking at the averages alone, but in consideration of the range of responses and individual trends as well. See Table 2 below for averages of ranks.

	Average Rank			
	Elementary School (8-11yo)	Middle School (11-13yo)	High School (14-18yo)	Adult (18yo+)
Access	4.4	6.4	5	6.33
Autonomy	3.75	4	3.6	6.6
Collaboration	5.5	3.75	5	4
Community	3.6	3.5	4.33	4.5
Creativity	2.33	3	3.33	3.17
Diversity	4	4.25	6.4	2.75
Equality	2.6	5.5	6.2	8.25
Group Success	5.5	3	3.6	4.67
Individual Achievement	2.33	2.33	3.2	2.17
Subversion	99	4.5	4	6

Table 2: Averages of value ranks.

Results from the rankings of show that autonomy drops in average rank from a consistent neighborhood of 4 to a rank of 6.6 in adulthood. Of the six women, one ranked it as a 1, the rest ranked it 7 and above, with one not ranking it at all. By young adulthood, diversity became a more prominent value (2.75) while equality dropped (8.25). However, if you consider the range of responses (see Table 3 below for ranges), diversity had a high range of response (differences between 5, 6, and 7) *until* adulthood, when responses were within a range of one. The average ranks for community, creativity, and individual achievement remain fairly consistent over time while also maintaining a high frequency of being rated by most or all women.

	Range			
	Elementary School (8-11yo)	Middle School (11-13yo)	High School (14-18yo)	Adult (18yo+)
Access	4	4	8	5
Autonomy	5	7	9	8
Collaboration	3	4	7	5
Community	3	4	5	3
Creativity	4	5	8	6
Diversity	6	7	5	1
Equality	1	8	6	3
Group Success	3	4	5	5
Individual Achievement	3	5	7	4
Subversion	0	6	4	9
Avg Range	3.2	5.4	6.4	4.9

Table 3: Range of rank values.

The same caveats for considering averages also apply to consideration of ranges. Since this is such a small number of participants, and because this initial pass looks at descriptive statistics rather than comparative and non-parametric analysis, the findings must be considered in light of the other descriptors as well. For the most part, responses tended to vary the most in middle school and high school, indicating highly personalized experiences. Equality had a low range for elementary school (1, ranked by 5, avg of 2.6). Diversity had a low range for adulthood (1, ranked by 4, average of 2.75).

When women stand on the soapbox

The last question of the interview offered the participant their very own soapbox from which to share their feelings about the current status of women in STEM or computer science fields. Some women offered advice and reflection based on their own learning experience, some pushed back against cultural norms and expectations, and some challenged the way we prepare children for futures in computer science. Below are highlights of the women's responses:

- "...once you stop seeing people as labels, like oh, he's a guy and he's white [laughs], then you know, you're just people trying to solve something." (Evelyn)
- "...for me, really, it was like a big theme of the story was really finding confidence... reaching that point is not really finding who you are, but finding... not shying away from who you are." (Evelyn)
- "I think exposure is definitely something that the tech industry has to work on. Getting more girls more exposed to technology, and getting them to realize the impact they can make." (Mary)
- "My biggest pet peeve is that, where the blame is being placed [for not having enough women in CS], where the attention is being placed is just *wrong*. The attention needs to be in Pre-K, not in the workforce. Like, we can't get new women into the workforce *from* the workforce." (Katia)
- "There's this culture [that women] have to have some secret knowledge or whatever...there seems to be increasingly like, the idea that you have to justify yourself as being geeky... this idea that if they don't *pass* some 'test of geekyness' then they're just there to find a man." (Ally)
- "... I think I'm typical in that when I want to build something... I'm building it for a *reason*...I think a product, or a goal, is a lot. Sometimes when they're trying to introduce computer science especially, boys or girls, they introduce it from a very mathematical programmatic standpoint, and not so much like I want to see what it *does*." (Ally)
- As a woman, you have to be strong enough. The myths are that you are not good because you're a girl, and that if you are a girl that you have to be the brightest. (Anela, paraphrased)
- Being a homosexual was an advantage. I already had broken a norm. I had set a precedent. One you have experienced defiance, STEM just becomes another one. It's not just about learning to be different. It's about being capable of being different. (Ellen, paraphrased)

Conclusions

This research presents findings from a series of interviews with successful women who are at various stages of study and work in the field of computer science. The life stories of these women shed light on the roles of technology and social dynamics for females who find power and purpose in the field of CS. The findings from this study do not mean that they are true for all women, or even all women in computer science. In fact, part of the theoretical framework for the study includes "acknowledging diversity among girls' and women's identities, preferences, and experiences (Hayes 2008)." The hope is that these sorts of findings can be folded back in to design, and that we can then create technologies and game spaces that are more equitable to girls, and that perhaps this will result in more young women who are passionate about STEM mindsets (wonder, discovery, invention and creation, systems thinking and modeling), and also increase the numbers of girls in technology related fields.

This interview protocol can serve as a pilot for deeper questioning and analysis, including finding ways to more tightly align values with STEM mindsets and disciplines (for example, adding curiosity as a value). The data set can and should be expanded to include more women. The applications of this line of research imply that both education and media industries have a responsibility to design products and environments with an eye towards equitable activity and practice in order to find solutions that address the underrepresentation of women in computer science fields. This includes asking important questions, like how do activities and practices empower participants to make larger connections for impact beyond a particular product or experience? How can the environments we create for activities and practices serve as a catalyst for girls to experience deeper engagement and creative expression? This means that increasing the numbers of females in computer sciences is not simply about evangelism and persuasion. It's about leveling a playing field of experiences.

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Crossing the Bridge: Connecting Game-Based Implicit Science Learning to the Classroom

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Overview

This paper explores implicit science learning through the game, *Impulse*, and how that learning might be leveraged to improve classroom learning. The assumption inherent in the design of *Impulse* is that by building foundational learning through games, students may be better prepared to study related science in class. We are testing that conjecture through an implementation study with hundreds of high school students.

In this paper, we present the results of pre-post assessments of Newton's laws of motion from three groups of high school students. The Game group (209 students in 21 classes) was encouraged by their teachers to play *Impulse* outside of class and some played in class. The "Bridge" group (179 students in 18 classes) was encouraged to play the game outside of class, some played the game in class, and their teachers used examples from the game in their classroom instruction on Newtonian mechanics. One hundred eight (108) students in 11 classes in the Control group neither played the game nor had game examples in class.

Researchers gathered pre and post assessment results as well as daily logs of teacher activities. HLM analyses look at the relationship between study group—Bridge, Game, Control—and students' post-assessment scores. Results show higher post-assessment scores for students in the bridge classes, as compared to the control classes after accounting for the students' pre-assessment scores, student characteristics, teacher characteristics, and school demographics. Whether or not the class was a Honors/AP class, however, moderated the study group effect. This confirms our conjecture that *Impulse* can help prepare some students for improved science learning in class.

Making the Bridge from Games to Classroom

Implicit learning may be foundational to all knowledge (Polanyi, 1966) but is particularly challenging to measure because it is, by definition, largely unexpressed by the learner. Polanyi described implicit knowledge as foundational for explicit knowledge building (1966). McCloskey (1983) and diSessa (1993) studied learners' misconceptions in science in terms of their implicit understandings of the physical world around them, pointing out that many learners have inaccurate fundamental implicit models of forces and motion because of our daily experiences with friction and other complicating factors.

Games offer a unique opportunity to promote and study implicit learning. They are a highly engaging environment that can be designed to use mechanics that mirror authentic science and are rich research environments because of the digital log data they generate (Asbell-Clarke et al., 2012; 2013; NRC,2011). The *data exhaust* from games (Halverson et al., 2012) can be used along with education data mining methods (EDM) to detect patterns of play that learners use and how those patterns change as players advance towards more successful and sophisticated activities (Baker & Yacef, 2009; Martin et al., 2013).

Games that are made for educative purpose, however, often lack the polish desired by typical game players (Isbister, 2010). There are many games on the market that are widely popular and have game mechanics that immerse players in an environment where they need to grapple with accurate physical phenomena to succeed (e.g. *Badlands*, *Where's my Water?*, and even *Angry Birds* for the most part). If a player can successfully navigate game spaces like these, however, and cannot understand and explain how objects move in the real world, it is not of much value in an educative sense. Educational game designers must walk the balance between fun and purpose.

Our group has addressed this challenge by creating games that will be played voluntarily by a wide variety of players in a popular venue, and that are also driven by challenging authentic scientific game mechanics. Through an NSF-funded research grant that looks ahead to how learning environments may be designed later this decade, we are working with professional game developers, teachers, students, scientists, and gamers in the general public to design and study a series of games played in free-choice time that are based on core high-school science content.

Our research attempts to capture the strategies players develop during gameplay that may reveal implicit knowledge and can be leveraged for high school classroom learning and assessment.

Even a good educational game is likely only one part of a complete learning experience. Post-game debriefing and discussions connecting gameplay with classroom learning are critical in helping students apply and transfer learning that takes place in games (Lederman & Fumitoshi, 1995; Ash, 2011; Ke, 2009). To exploit learning that happens in games, teachers may build on the games' "aha" moments and help their students make connections between their actions in games and the content being covered in the classroom.

Description of Research

This paper reports preliminary results from an implementation study of 40 classes and 23 teachers divided into three groups, Bridge, Game, and Control. In Fall 2013, teachers in the Game and Bridge classes were asked to recruit students to play the game *Impulse* in their free time. In Bridge classes, teachers used video clips from the game that were suggested by the research team when teaching about Newton's Laws of Motion. In the Control class, students did not play the game and teachers did not use the game examples. All classes covered their typical content on Newton's Laws of Motion during the implementation period.

The implementation study is being conducted, in part, to examine the conjecture that implicit learning in game play can help prepare students for classroom learning. To test this conjecture, changes in assessment scores before and after classroom instruction were compared for the Game, Bridge, and Control groups using a series of hierarchical linear models using the SPSS MIXED linear models procedure. HLM was chosen to account for the clustering of students within classrooms and the clustering of classrooms by teachers.

Our conjecture would lead us to anticipate that the Bridge group would show the greatest gains in the pre/post assessments. Whether or not the Game group would show gains over the Control group is an open question. Our conjecture is that the game will help prepare them for learning and we hypothesize that having the teacher use examples from the game when teaching the related content will help forge the connections to leverage the implicit learning from the game. While we believe that there may be implicit learning even among the students in the Game group, our framing did not predict whether or not that implicit learning would be apparent without an explicit bridge made by the teacher.

Description of the Intervention: *Impulse*

Impulse immerses players in a particle simulator in which they must predict the Newtonian motion of the particles to successfully avoid collisions and reach the goal (see Figure 1). The motion of all particles obey Newton's laws of motion and gravitation. Players use an impulse (triggered by their click or touch) to apply a force to particles. If the player's particle collides with any ambient particle, the level is over and they must start again. Each level of the game gets more complex, requiring players to grapple with the increasing gravitational forces of an increasing number of particles and also particles of different mass (and thus inertia). *Impulse* has been played by over 10,000 players online and through iOS and Android app stores.

Data Collection

One hundred thirty-five (135) teachers applied to be part of the study. Based on information in their applications and responses to emails, 42 teachers were assigned to the Bridge, Games, or Control group. Teachers were assigned to groups to ensure balance between the groups in terms of: the percentage of students at the school receiving free/reduced price lunch, the percentage of minority students, and the extent to which students had access to the technology needed to participate in and out of school. To a lesser degree, we also sought balance between private vs. public schools, years of science teaching experience, region of the country, and their prior experience using educational games.



Figure 1: A screenshot from *Impulse*. The player is the green particle.

All students were required to return signed parental consent and student assent forms to participate in the study. All Bridge and Game student data were collected through the game portal BrainPlay.com. Each class was given a unique ID that students entered as part of registering in *BrainPlay*. Upon registering, students were immediately taken to the online pre-assessment. Once they completed the pre-assessment, the game was unlocked in *BrainPlay* and all game play activity was logged. When the teacher finished instruction, s/he asked students to complete the online post-assessment. Teachers in the Control group were given URLs outside of *BrainPlay* for the pre- and post-assessments and were asked to assign students unique IDs.

Sample

This paper reports results from the 23 teachers who taught 40 classes to finish participating in the study in the 2013-14 academic year. Eight teachers were in the Bridge group, ten teachers were in the Game group and five teachers were in the Control group. Up to three sections of the same course were included in the study. The schools these 23 teachers work at are mostly public schools (18 or 78%) with 15 (65%) teachers reporting their schools had more than a quarter of their students receiving free/reduced price lunches and 4 (17%) teachers reporting that the majority of their students were from non-white groups. Their schools are located in 16 different states. All except six teachers had more than 5 years of science teaching experience and 18 (78%) reported some prior use of educational games or game-like simulations in their instruction.

Class sizes ranged from 8 to 28. Of the 40 classes in the study, 19 were Honors/AP classes (6 of the 18 Bridge classes, 5 of the 21 Game classes, and 8 of the 11 Control classes). The percentage of students in each class with complete data ranged from 21 percent to 100 percent. 'Complete' data means the students returned the parental consent forms, answered all items on the pre and post assessments, and, in the Bridge and Game groups, played to at least Level 2 of the game (Level 1 is a tutorial mode). Most students were not included in the study because they did not return parental consent forms.

A sample of 556 students had complete enough data to be included in these analyses. Thirty-nine (39) students who answered all pre-assessment items correctly were excluded to avoid a ceiling effect. Eleven students were excluded because they did not provide their gender. Of the remaining 496 students included in these analyses, 270 (54 percent) were females, 108 (22 percent) were in the Control group, 209 (42 percent) were in the Games group, and 179 (36 percent) were in the Bridge group. Students were concentrated at higher grade levels: 15% were 14 years old, 14% were 15 years old, 29% were 16 years old, 35% were 17 years old, and 7% were 18 years old. Almost half (211 or 42%) of the 507 students were in an AP/Honors course—38 percent of those in the Bridge group, 23 percent of those in the Game group, and 85 percent of those in the Control group.

Measures: Pre-Post Assessments

Consenting students took a pre- and post- online assessment on relevant content. As part of the assessment development process, think-aloud interviews were conducted with 10 high school students to confirm the items

assessed the intended physics concepts. Each assessment included six items, three dealing with Newton's First Law and three dealing with Newton's Second Law. For each topic there was one question that resembled an animated version of a question from the Force Concept Inventory (Hestenes, Wells & Swackhamer, 1992; Thornton, Sokoloff, 1998), one question using an example from *Impulse*, and one using an excerpt from a NASA astronaut video. All items were written to be answerable with an intuitive understanding of the physics concepts. The post-assessment had the same format with slightly modified questions. Both assessments had a maximum of 10 points possible. To ease interpretation of the HLM results, the pre- and post-assessments were standardized as Z-scores (subtract mean and divide by standard deviation) to have a mean of 0 and a standard deviation of 1. Thus, all coefficients are reported in effect sizes. For the pre-assessment, the mean was 7.44 with a standard deviation of 1.530. The post-assessment had a mean of 8.25 and a standard deviation of 1.586.

Measures: Teacher & Classroom Level Characteristics

All teachers were assigned to one of three groups—Bridge, Game, and Control. In the HLM analyses, the coefficients for Bridge and Game groups are comparisons to the Control group—how many standard deviations higher or lower did students in the gaming groups score on the post-assessment relative to the students in the control groups. In their applications, teachers were asked to classify their schools in terms of the percentage of students receiving free/reduced price lunches and minority status by picking one of these categories: 0-25%, 26-50%, 51-75%, 76-100%.

Classroom level characteristics included the number of students enrolled in the class, whether the class was a Honors/AP course or not, and what percentage of the enrolled students had complete data. Classes were divided into two groups: those with the two-thirds of their students completing the study vs. those with less than two-thirds completing the study. The percentage of students completing the study was included to provide a sense of how representative the data was of the entire classroom.

Measures: Student Level Characteristics

All student level characteristics were collected as part of the registration process into the game-based data collection system called *BrainPlay*. *BrainPlay* was developed by our team with our game development partners to organize and export pertinent data from each game along with player data from surveys. To register in *BrainPlay*, students were asked to provide their gender and birthdate. From this, their age at the time of registration was calculated.

Data Analyses

Using the SPSS MIXED linear models procedure, HLM analyses began with an unconditional 3-level model with students, classrooms, and teachers using Restricted Maximum Likelihood (REML) and unstructured covariances. In that model, 14 percent of the variance in the post-assessment was attributable to teacher level variation while 9 percent of the variance was attributable to the classroom level. Neither of those variance components was statistically significant at the 0.05 level. Because group membership was assigned at the teacher level, subsequent HLM analyses were two-level models with students nested within teachers. In an unconditional 2-level model, a statistically significant 20 percent of the variance in the post-assessment was attributable to the teacher level.

Sets of covariates were added to the unconditional HLM model in this order:

Set 1. Pre-assessment score (standardized)

Set 2. Study Group (Bridge vs. Control; Game vs. Control)

Set 3. Student Level Characteristics: Student gender & age; whether or not they were enrolled in class where more than half of the students completed the study; whether or not they were enrolled in an AP/Honors science class

Set 4. Teacher Level Characteristics: Teacher gender; whether or not more than 25% of students in their school receive free or reduced price lunch; and whether or not more than 50% of the students in their school are minority

Only statistically significant covariates were retained in the HLM model presented in this paper. Interactions between Study Group and each of the remaining covariates were examined. Only one interaction was retained in the final model. The model with the interaction was a slightly better fit than the model without interactions ($X^2(2 \text{ df}, N=496), 4.64, p<0.10$).

Findings

Our original submission from the first 14 teachers to complete the study showed a significant positive effect of the Bridge group compared to the Control group on student's post-assessment scores after accounting for pre-assessment scores. This Group effect, however, was significantly moderated by whether more than half of the students enrolled in the class completed the study (strong vs. weak cohort). For the strong cohort classes, those with high participation rates, the bridge intervention did not have a significant effect, however for weak cohort classes it had a strong effect.

Post-submission, however, we completed data collection, and the best-fitting HLM model, which accounts for 75 percent of the variation at the teacher level, is presented in Table 1. The intercept coefficient represents the estimated outcome for male students who scored at the mean level of the pre-assessment, were in the Control group, were not in a Honors/AP class, and were in classrooms where less than two-thirds of the students completed the study. These students would score 1.24 standard deviations below the mean post-assessment score. The Pre-Score coefficient reflects the change in number of standard deviations of the post-assessment for every increase of 1 standard deviation on the pre-assessment. For every standard deviation increase on the pre-assessment, students would be expected to score 0.31 standard deviations higher on the post-assessment. Even after accounting for study group and pre-assessment scores, female students scored 0.17 standard deviations lower than male students on the post-assessment. Students in classes where two-thirds or more the students participated in the study scored 0.22 standard deviations higher on the post-assessment than students in classes where a smaller proportion of students participated.

Covariate	Coefficient Estimate	Std. Error	df	t	Sig.
Intercept	-1.239835	0.23524	11.898	-5.271	0.000
Pre-Score (Standardized)	0.306283	0.041667	483.389	7.351	0.000
Bridge (vs. Control)	0.677532	0.279544	41.038	2.424	0.020
Games (vs. Control)	0.608235	0.267469	47.321	2.274	0.028
Female	-0.165283	0.079182	493.804	-2.087	0.037
2/3 Students Enrolled Completed Study	0.223509	0.095319	111.527	2.345	0.021
Honors/AP class	0.616081	0.260715	175.479	2.363	0.019
Bridge * Honors	-0.362800	0.32063	77.794	-1.132	0.261
Game * Honors	-0.858206	0.347803	29.1	-2.468	0.020

Table 1. Estimated Fixed Effects on Standardized Post-Assessment Scores

Figure 2 shows the estimated marginal means. Marginal means are calculated by using the mean levels of all covariates to arrive at a predicted post-assessment score. A univariate F test suggests the overall effect of Study Group is statistically significant ($F(2, 13.11)=3.9, p=0.047$), but pairwise comparisons show the Bridge group to be significantly higher than the Control group (Mean difference=0.527, $p=0.016$) but not significantly different from the Game group (Mean difference=0.275, $p=0.10$).

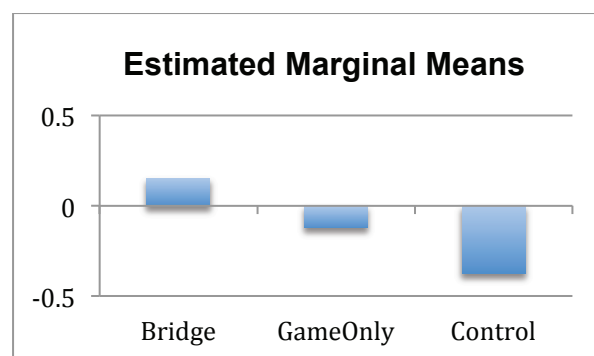


Figure 2: Estimated marginal mean post-assessment scores by study group

Figure 3 shows the predicted post-assessment scores (measured in effect sizes) for students scoring at the mean level of the pre-assessment.

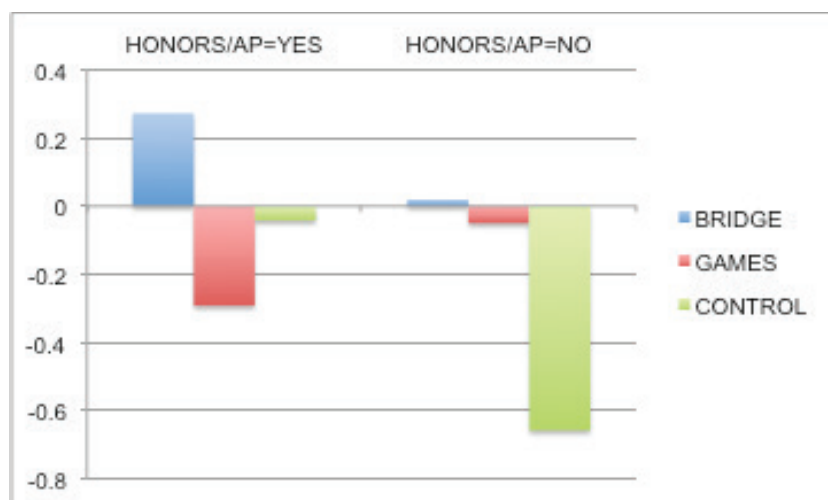


Figure 3: Predicted post-assessment scores across study conditions in Honors/AP classes versus non-Honors/AP classes

Students in Honors/AP classes in the Bridge study group would expect to receive mean level scores on the post-assessment 0.56 SD higher than students in Game classes and 0.31 SD higher than students in Control classes. Among students not in a Honors/AP class, students in Bridge and Game groups had similar mean post-assessments (a difference of 0.07 SD). Both were significantly higher than the mean post-assessment among students in the Control group (0.68 SD higher for Bridge classes, 0.61 SD higher for Games classes).

Discussion

This research was intended overall to study if playing a game designed to foster implicit science learning will better prepare students for classroom learning of related content. To study this question, we recruited high school students to play the game in their free time and gave their teachers game examples that demonstrate the phenomena of interest. We compared the learning gains from those 'bridge' classes to those of classes who only played the game ('game' classes), and 'control' classes who did their typical related curriculum. When looking at the data in aggregate, we find that overall the bridge condition students had results that were significantly different from the control condition, but not better than the game classes.

The difference between Honors/AP students and non-Honors/AP students might be explained if we assume that students in the Honors/AP classes are more academic and are served well by traditional curriculum, and that their counterparts may, on the whole, be more receptive to alternative curricula. This is consistent with our findings in a previous survey of 1500 youth about gaming preferences. Those youth who identified strongly with science preferred games that connected to science in the real world (Sylvan et al., 2013). The game, in this case, serves as an alternative form of scaffolding for the less academic students, but may be a disruption to academic students causing them to falter when given the game without sufficient bridging to the class material.

These results may indicate that an intervention such as Impulse is particularly important in less cohesive classes. Our next research steps include a comparison of the student demographics and instructional practices reported via teacher logs between the Honors/AP and regular classes, to understand the difference in impact that the *Impulse* intervention made in these different audiences.

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Designing Beyond the Game: Leveraging Games to Teach Designers about Interaction, Immersion, and Ethical Perspective

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Connecting the Dots: Skyrim, Interactive Narrative, and Ethics in Context

In 2012, RIT offered a course that used a popular, recently released role playing game to engage students in discussions about game design. In addition to common topics one might associate with role play, design of open world interaction and writing highly interactive narrative, students were challenged to explore the game with an eye toward ethical perspective inherent in play, to read and discuss ethical theory, placing it in conversation with their experiences in game play, and ultimately to modify the game to enhance the representation of ethical perspective within it. The course was an experiment in cross-disciplinary synergy within the context of a single course, using the students pre-existing excitement and engagement with the game to expand their understanding of well-aligned course content, and to use their increased understanding of out of game ethics to improve the game itself, and their own ability as designers.

The goal of the course was ambitious: to connect *Skyrim*, a single-player computer role playing game with the broader affordances of immersive, interactive narrative to enhance player understanding of ethics, proven and made concrete by bringing that understanding back to the design of the game. Though ambitious in scope, the design is based on a belief that there exists a line of connection from role play to potentially enhanced understanding of ethics, though the line that connects these concepts may require a bit of explanation.

The study of narrative-intensive games is still early in its formation, and the best practices underlying instruction of courses on highly interactive literature is very much still in formation. Some excellent works on interactive design from industry professionals and from academia have been released in recent years (Murray, 1998; Salen & Zimmerman, 2004; Fullerton, 2008; Schell, 2008; McDevitt, 2010; Sheldon, 2013). The discussion of best practices and models is lively within the field, but there are some general understandings across the field. Among these include a sense that interactive play should be centered on the actions of the player, not centrally focused on the world or on actions of characters outside of the player's control. There is also a pervasive sense that being a story is importantly different from telling a story. Particularly in role play, there is a distinction made between the strength of good role play to engaging in effective storytelling, and the strength of most other narrative media to create compelling story as a final product (Hindmarch, 2007; Simkins, 2011). In other words, the goal of role play should be seen as creating good opportunities for storytelling, not creating a good story.

The focus on interactive play, on development of emergent narrative, is building an understanding that games can tackle serious issues, but that it may do so in a somewhat different way from more traditional narrative. The main difference turns on what it means to experience another's story, as in most traditional narrative, versus experiencing a story as one's own, as one does in most games. Some good traditional media invites the reader to be a character of the story (Calvino, 1982), but the relationship of reader to character is always strained. During immersive play, the character is aligned with the player from the outset - what the player does in play is reflected in the character. The character becomes separate from the player only, becomes an "other", only when something in the play draws a separation between the player's intent and action and the character's. Of course, artifacts in a game can serve to draw a distinction between the player and the character. A cut scene is one example. Essentially mini-movies using traditional media techniques to convey story, cut scenes allow for the infusion of authorial style and intent into the narrative. The designer, not the player, is in control of the character and the scene. The player's lack of control may or may not be met with frustration, but regardless of how welcome it is, the experience is normally one of at least momentary alienation of player from character. The character is portrayed as having her own experience of the world separate from, though still connected to, the player, perhaps as an agent in her own right, or perhaps as an object merely responding to forces in the world.

Despite what one might assume initially, the intentional distinction of player from character can be a useful device. It lets the player see the character as someone with her own desires, drives, and context rather than simply applying the player's own background to the game's world (Simkins, 2010). However, it is not the only way to take advantage of this easy empathic connection between character and player in game play to create opportunities for role play, where takes on the character's role. In the first moments of *Skyrim*, the game uses cut scenes to force action on the character, but even within these initial moments the lack of control is justified by the player's imprisonment (Simkins, Dikker & Owen, 2012). The release from custody in the game's first moments marks a point of transition as the player gains full agency over the character's actions.

To play *Skyrim* is to role play. What the character does in the game is under the player's control, and those actions have consequences that can change and shape the world. This play is always treated as if it is the character taking action. The player's freedom in an open world, within limits set by and consistent with the physical and social context of the world, allows the player's role play to be a form of identity exploration. This identity exploration is not in a vacuum, however, for the player's actions affect the game world, and those changes to the game reflect back on the developing identity of the immersed player's character (Gee, 2005). Through this interchange, the player's own identity is also at play (Turkle, 1997; Bowman, 2010), and the player can play with contextualized, situated ethics (Kierkegaard, 1985; Wong, 1984) from the perspective of a character. It is this perspective on situated ethics that was chosen as the central theme for the *Skyrim* course, and much of the course's readings and discussion were focused on the theoretical underpinning of situated ethics, the cultural frameworks around the game that inform the game's social and ethical context, and how a game designer might afford a player legitimate exploration of their ethical identity.

Skyrim Course Design: Methods and Approach

Despite its potentially high brow aspirations, the course had concrete goals and was focused not only on the understanding of contextual ethics within role play, but also on modding the game to enhance and take advantage of ethical context. The proof of understanding is, therefore, in the products as teams of students design experiences that enhance ethical play within *Skyrim*'s world.

There were thirty undergraduate students and six graduate students participating in the class. Few of the students had any experience with ethical philosophy and none had experience with medieval nordic history and culture, which forms the basis for the fictional culture of the *Skyrim* game world. All of the students game design and development majors and had extensive experience playing and developing games.

The course design was structured to introduce ethical concepts briefly in the first two weeks of the ten week course (Simkins, 2010). The third week focused on *Skyrim*'s cultural context, using readings from modern warrior culture (Venkatesh, 2008), medieval nordic society (Roesdahl, 1999), and *Beowulf*, an example of Anglo-Saxon literature (Heaney, 2001).

The middle five weeks of the quarter were dedicated to readings on game design and theories of play that focused on play in context, including Hocking's discussion of *Ludonarrative dissonance in Bioshock* (2009), Elrod's *Accomplishments of Ultima Underworld* (2009), Wallis's *Making games that make stories* (2007), Sivak's *Half-life 2: Being Gordon Freedman* (2009), Costikyan's *Games, storytelling, and breaking the string* (2007), Fortunato's *On a measure for marriage* (2007), Malaby's *Play as a disposition* (2008), Steinkuehler's *Mangle of play* (2006), and Simkins's *Negotiation, simulation, and shared fantasy* (2011).

The last weeks involved a survey of ethical systems, focusing on sections from central works of philosophical ethics, including utilitarianism and consequentialism (Mill, 2007), Kantianism (Kant, 2002), situationalism and deontology (Kierkegaard, 1985), and post-structuralist ethics (Foucault, 1984).

In addition to readings, students produced weekly journals of game play for six weeks (weeks 2 through 7) in which they were to respond to the following questions: What did I do in the game this week? How did the non-player characters and the world of *Skyrim* respond to my character's actions? Assuming, to the best of your ability, that the non-player characters and world responded sensibly, why do you think the non-player characters and world responded to your character actions as they did? What worked or did not work for you in the way the NPCs and world responded to your actions? How might the reactions have been improved? Students were invited to respond to the first question, about what they did in game, from the perspective of their character. At the end of week 7, students were to deliver a short paper to summarize the experience throughout the six weeks of journaling. This assignment was called an analysis of ethical context.

The final assignment was completed in groups of 3 to five. Students developed a "mod" for *Skyrim* - an expansion to the game that changed the game's play. They were to use the Creation Kit, which was released as the quarter was beginning. The creation kit allowed players to modify the game in a variety of ways, and was derived from tools used by the game's designers to create content. Students were tasked with developing mods that enhanced the immersive nature of the game and were encouraged to use their experience from journaling to determine what they would develop. Groups proposed mods, and mod ideas were evaluated for scope and effectiveness in enhancing immersion. The final products were shared with and presented to the class at the end of the course.

Character Creation, Journals, and Summary

Students were to play through the short tutorial and introduction, and to use that experience to create a personality and background for their character, similar to the work an actor might do to prepare for a role. (Moore, 1984) Furthermore, they were asked to role play their Skyrim play. That is, to make decisions and take actions in the game in-character, not just for the benefit they might receive. The intent was to create a disjunction right away between character and actor, allowing the player to immerse into the game through their character, rather than just experiencing the game as themselves.

Example Character 1: V the Vengeful

The student who created V. was already familiar with Skyrim, having played through dozens of hours of the game before starting the course. She incorporates that prior knowledge as she describes her character, writing,

V grew up in the city of Markarth hearing tales of the Forsworn and harbors resentment towards them for their actions. Her father, H, fought for Ulfric Stormcloak's militia during the Markarth Incident. He was killed in battle, leaving V in the care of her mother who fell into a depression and slowly wasted away. V considers her father to be a hero for his sacrifice and despises her mother for her weakness of spirit.

She began her explanation of V with specific reference to one of Skyrim's large cities, Markarth, and to the central tension that creates guides conflict and many of the quest's plot throughout the region around the city, the tension between the ruling nords and the rebellious, indigenous group called the foresworn. Not only does she position herself within the context of Skyrim's conflicts, she creates a background for the character, a father who participated in one of the two large scale plots offered by the game, the civil war between Jarl Ulfric's Stormcloaks and the Empire that has ruled Skyrim for millennia. By placing her father firmly on the side of the Skyrim nationalist Stormcloaks, and creating a tragedy around the death of her father that leads to the death of her mother, she offers motivation for her character to take a clear side in this overarching plot.

Out of character observations by the student show the strengths and weaknesses of this approach to integrated character design. The student repeatedly notes how NPCs fail to react sensibly to many PC behaviors and to context. As one example, the student writes of her chance encounter with a friendly NPC bard on the road:

Why was he standing next to a random dead bandit? From a world building perspective it was confusing. The bard did not acknowledge the body, and yet it must have gotten there somehow.... Most reasonable people and consequently characters do not choose to stand near bodies. This was very perplexing for my character that a reason was never given. From a designer perspective, it's probably a coincidence where the bandit got killed by a bear, and the bard just happened to stop along his route there. As a player though, it brought up a lot of questions that were unanswered. Possibly, this sort of interaction could have been remedied by changing the NPC's awareness and response of his surroundings.

This theme of NPC obliviousness to the player's character and to the NPC's surroundings was a common theme. One character envisioned his character as having a particularly horrific appearance, but Skyrim's characters were not scripted to respond to the player character's appearance. In fact, generally, non-player characters reactions to the player's character were not particularly dynamic, and when there was mirroring it was either straightforward, such as fight or flight responses to a character's acts of violence or was highly scripted based on the plotline the NPC was starting or continuing with little or no regard for who the player was, what they looked like, or what their former reputation might be.

Perhaps more significantly, students found that *Skyrim* assumes that the player will be a hero. One of the students challenged this by creating a character who felt no internal call to action. He writes of his character, who we will call T, "My character is not a hero. He is a blacksmith wanting to do his job and make things. He initially has little knowledge of how to use a weapon or wear armor, though he knows how to make them." Later, he writes, "It is frustrating that everyone is constantly treating me as if I am a hero who wants to solve their problems for them. They act as if I am a wanderer wanting to find adventure, and really I'm just a blacksmith. It is confusing."

He wanted to experiment with denying the implicit assumption of heroism in the game by creating a character that fits into the society. He chose to create a local nord, a blacksmith, who merely wished to ply his trade. He hoped that the events of the game would provide him with a call to action, a reason and need to respond to the events of the world around him. Instead, while the game provided many opportunities for adventure, it provided few reasons to seek it out - at least not reasons that would apply to a humble character not seeking an adventurous life. This is not surprising given that, as an open world RPG, the game is focused on providing opportunities and intentionally not on requiring any particular path for game play.

We might forgive *Skyrim* for merely following the genre traditions of heroic fantasy RP. In fact some of T's difficulty comes from the course assignment that requires students to create a backstory and personality for their character prior to play. Players who simply leap into the game do not tend to notice any disjunction between what their character wants to do and what their character is initially offered as long as they are familiar with and abide by the genre conventions. Within the stories of player action, they are provided in the first ten minutes reasons to care about dragons, the civil war, and direction toward one of the cities (Simkins, Dikkers & Owen, 2012). They can choose to ignore this direction, but without a prior existing character background, that is more a player choice to ignore what is in front of them than a choice by the character. Still, from the standpoint of the course on RP design, it was extremely helpful to have players create characters, bringing these tensions to the fore that might otherwise be ignored.

Another interesting outcome of playing within a perspective was the role of leadership in the world and the general lack of responsibilities tied to roles in *Skyrim* society. Many of the students noticed that even when they were not trying to rise to the leadership of organizations they joined, the stories built around those organizations led those who follow them to a point of decision where leadership is offered. Interestingly, once leadership is achieved, rather than becoming the beginning of stories where the player's character must support, defend, enhance, or otherwise promote the organization's goals and interests, the player is given a reward and that quest line is considered complete.

Students also noted with aggravation the thin interpersonal and especially romantic relationships offered within the game. Romantic relationships in the game are established through a succession of relatively mechanical steps. The player character must win a potential partner's trust by performing a single favor for the NPC. They must then go through a relatively simple rite to show their interest in marriage. If both PC and NPC agree to marry, there is a brief scene where some of the other connections the player character has made show up to the ceremony and the player's character and NPC are wed, the NPC offers to move into one of the player's houses, if they have one. From that point on, the married NPC loses almost all unique personality, at least with regard to the interactions about the relationship. There is no real sense of ongoing romance, the struggle to maintain a connection, or even joy in being together. Though some of the students were thrilled at the freedom to choose a partner, to marry within game, and to have a wedding ceremony that involved other notable NPCs from the character's story so far, all groundbreaking for sandbox RPGs, the students were generally frustrated that romantic relationships are reduced to brief trust-building interactions. Marriage is reduced to gaining an NPC resident in the player's house who cooks, cleans, and opens a shop to sell goods and make money for the player's character.

Modding *Skyrim*

In the final weeks of the course, the students were given the opportunity to take the lessons learned from their journals and summaries, building a mod using *Skyrim's Creation Kit*, provided by Bethesda Softworks, to enhance role play immersion in gameplay.

There were five group projects. Three of them were focused in enhancing immersive role play by creating or enhancing particular game characters (NPCs) that would have ongoing and evolving interactions with the player's character. Of these, one created an Inn to serve as a hub for quests, and ongoing interpersonal interactions. Another created a new NPC companion who could travel with the character and provide additional dialogue, quests and more personalized interactions. The third did the same, not by adding a new NPC, but by enhancing an NPC that was already available in game.

The third was an attempt to mirror one of the mechanisms the game uses to give consequence to player character's engaging in illegal activity. The game assigns a bounty to a player when they commit a crime witnessed by an NPC, but there is no in-game representation of the bounty, other than the reaction of guards to the player. The students created a mod that placed wanted posters around cities where the player had a bounty. The player's face was to be placed as an image on the poster and NPCs in the vicinity were scripted to respond by approaching the poster and looking at it, then reacting to the player's character with distrust or fear, depending on the severity of the crimes.

The remaining group completed a mod that removed fast travel from the game - an out of character feature that allows a player character to jump to a visited location without traveling overland. To avoid an onerous burden on the player, they added sites with a magic portal that allowed in game teleportation between standing stones, important magical features already present in *Skyrim*.

In each case, the students used mods to enhance aspects already existing in game. Given limited time to work on the mod and limitations in the *Creation Kit*, some of the features of each mod could not be implemented, but even the process of designing the mod revealed some of the potential, and many of the challenges, in trying to create interactive narrative in an open world RPG. By actually working to implement improvements, students were reminded of just how difficult it is to account for all possible circumstances effecting a game with *Skyrim's* scope, and how impressive the game was in achieving as much mirroring and consequence as it had, and the benefit of providing the player population tools to tailor and enhance their own game play.

A Schema for Game Courses

The *Skyrim* course was generally successful, with excellent attendance, an active and involved student population, and with students completing more and higher quality assignments than I generally feel I can expect from even quality students. The excitement about the subject matter certainly helped the students to focus and excel in the course, and it also kept the discussions of games and ethics, of game design, and game development centered on a game the entire class had played together. *Skyrim* was by no means the only game we used as an example during the course, but it provided shared experience that formed a touchstone for discussion.

As a course structure, the model could be expanded to a wide variety of games. The core model presented here involves three key components - a primary subject matter that overlaps well with the themes and affordances of the central game, a game that is of sufficiently high quality and that has enough variety and play to provide a good touchstone for use throughout the course, and a thematic and game genre focus that allows for students to engage in "modding".

In this case the primary subject matter, contextualized ethics and critical ethical reasoning (Simkins & Steinkuehler, 2008), *Elder Scrolls Skyrim*, and the availability of the *Creation Kit* provided an effective synergy. However, a course could easily be structured to focus on philosophies of history, *Civilization V*, and the *Civilization* development tools included in the game. Even games that are not conducive to direct modding can use the same framework, with students creating small games in GameMaker, Unity, or other game design tools, or even creating non-digital games or creating design but not completing development on additions to the game. Of course, more courses developed in this framework will help us to determine how to best generalize it, but we hope this framework helps to inform efforts to more effectively teach effective game design, as well as teaching broader topics made concrete and practical by tying the topics to game design.

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Project TECHNOLOGIA: **A Game-Based Approach to Understanding Situated Intentionality**

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The study described herein is designed to explore the influence of a game-based instructional tool, *Project TECHNOLOGIA*, on student interactions (i.e., occasions where students use Blackboard Learning Management System to post to one another) and how these interactions contribute to a broader understanding of what it is to be a school district technology specialist. By better understanding the way game mechanics influence student learning and interaction, the educational community may begin to isolate the useful elements of game-based coursework that move beyond so-called ‘content gamification’ that has become a staple of educational gaming (Young et al., 2012). In sum, the project aims to provide: information about the development and evolution of student intentions for learning with the introduction of a dual alternate reality-roleplaying narrative (i.e., *Project TECHNOLOGIA*); an analysis of student discourse with respect to educational technology content set within a dual alternate reality-roleplaying narrative (i.e., *Project TECHNOLOGIA*); correlates of success in traditional versus game-based instructional settings; and implications for the on-going development of educational games writ large.

Based on information drawn from pilot data analysis, the authors hope to expand the current field of game-based learning, both in terms of student achievement and how situated, game-based experiences influence the learning of particular students with particular learning goals playing a particular game in a particular course/program of study. The project is divided into two parts: a qualitative analysis of student interactions (Phase I) and a quantitative follow-up of correlations between student game performance and overall educational technology Master’s program performance (Phase II). This mixed methods approach is intended to guide the identification of:

- How a game-based program can be used to examine individual intentions for learning
- How a game-based program can influence the application of domain knowledge

These objectives are embedded in the following research question:

- *What is the interaction between player intentionality, the instructionally-relevant game, and student outcomes?*

Framework for Design

Direct instruction and other traditional educational models perpetuate a separation between learning and the situations to which it is and can be transferred (Everson, 2011). Conversely, problem-based learning (PBL) environments provide an opportunity for educators, learning theorists, and psychometricians to revise commonly accepted means of instruction and assessment to supplement the distal and proximal measurement offered by direct instruction and high stakes testing (Hickey & Pellegrino, 2005). Well-designed games—falling under the broader umbrella of problem-based learning environments—inherently support rich, continuous, embedded formative assessment systems that allow users to reflect on their learning in a situated context. This principle has a long history in electronic portfolio (i.e., e-portfolio) literature (e.g., Camp, 1993; Crutchfield, 2004; Piper, 1999) and makes games an appealing option for the development and implementation of new forms of instruction since they can measure student learning, contextual knowledge, and long-term skill development across time and with great depth.

Regrettably, no studies have addressed the nature of gaming for program-level assessment—that is, a game or games bookending the full course and assignment-load associated with a K12, undergraduate, and/or graduate program. Similarly, no publications discuss the implications of having an overarching narrative structure bound to a months-long problem-based learning environment at the K12, undergraduate, and/or graduate levels (Young, Slota, Travis, & Lai, 2014). This dearth of literature has opened an opportunity for educational psychologists to pursue situated data that identifies how game/program mechanics and narrative, specifically, interact and prompt positive net learning as compared to those that do not. Before researchers can isolate the way(s) student learning in game-based environments actually occurs, however, additional study must be devoted to the exploration of hyperlink pathways, log files, and other process-oriented environmental interactions as defined by qualitative grounded theory analyses of student-student, student-instructor, and student-environment dialogue (Young et al., 2012).

The Game

To begin tackling the identification and cataloguing of valuable game mechanics, narrative elements, and other factors that may be viable areas of exploration in the topics described above, the authors have designed, piloted, and begun formal implementation of a semester-length instructional game built to contextualize district technology specialist responsibilities and behaviors (i.e., educational technology). *Project TECHNOLOGIA*, as it's called, allows for the analysis of key components associated with successful student participation in a game-based learning environment. The program's narrative structure pairs its embedded game objectives with learning objectives at a 1:1 ratio, shifting the traditionally teacher-centered learning environment to a student-centered learning environment where participating students work in research groups, co-construct solutions to complex social problems, and directly participate in tasks typically assigned to practicing educational technologists (i.e., a form of anchored problem-based learning). Through a blend of alternate reality game (ARG) and roleplaying game (RPG) mechanics, *Project TECHNOLOGIA* enables cooperative effort toward resolving contextually rich problems, thus promoting the application of skills necessary to further a broad understanding of what it is to be a K12 school district educational technology specialist.

The overarching story follows the administrators of a fictional space vessel, the Remmlar Array, headed by Duncan Matthau and his assistants, Rheegan Hamilton and Biff Wallace. Over the course of six primary episodes (i.e., content units), students envision, design, and stabilize a new educational system by providing guidance to the space station leaders. This makes the end task—balancing the needs and desires of a K12 school district—the same from both narrative and scholastic perspectives. While it is not a video game, per se, *Project TECHNOLOGIA* exists within the framework of an online text adventure, the ARG framing the students' activities in the program and the RPG framing their online interactions with the characters and narrative content. This choice was made for two reasons: 1) based on existing literature (e.g., Young, Slota, Travis, & Choi, 2014), a fully virtual world can be too confining to adequately fit the needs of a teacher/student and/or inhibit instructor/player creativity and agency; 2) overly complex game mechanics and/or a high technological barrier to entry might discourage all but the most video game-savvy from positively participating.

Initial game development began with the objectives/standards and used them as a guide for developing the narrative rather than the other way around, a design scheme reflective of the top-down approach often associated with strong curriculum development (Bergmann & Sams, 2012). This placed emphasis on the game's ruleset (i.e., how play happens) in order to bring students closer to doing the things real world educational technologists do: problem solve, critically think, examine existing literature, generate new questions, and, most importantly, collaborate toward realistic shared goals (e.g., "develop a comprehensive technology plan that represents a unified vision for the district"). Additionally, because the narrative follows the same trajectory as state and national standards (i.e., NETS/ISTE), the story missions transparently align with the information students need to successfully complete their program coursework and degree requirements. This means that the story is able to carry much of the weight that is usually attributed to direct instruction, allowing the game administrator to use the exploratory prompts as an introduction to content application (i.e., scaffolding both successes and 'productive failures' in problem solving, critical thinking, etc.).

The richness of the *Project TECHNOLOGIA* experience is drawn from the social interactions that take place as a result of student participation in game character teams. On a biweekly basis, each team enters the RPG through a web browser-based heads-up display (HUD) called the Texto-Spatio-Temporal Transmitter (i.e., TSTT; hosted via the teacher-student Blackboard Learning Management System) (Figure 1). The TSTT features a series of immersion sessions that play like media-enhanced text-adventures combined with a fictitious—but deeply content-rich—story arc. The operatives, educational technology Master's program students, are encouraged to use external research, various scientific journals, and information taken from their coursework to synthesize the information they engage with across their Master's program. Specific to the 2013-2014 cohort, teams consisted of two groups of five and one of four, each participant controlling a separate avatar/character in the story. These groups have been and will continue to be guided by a program instructional leader.

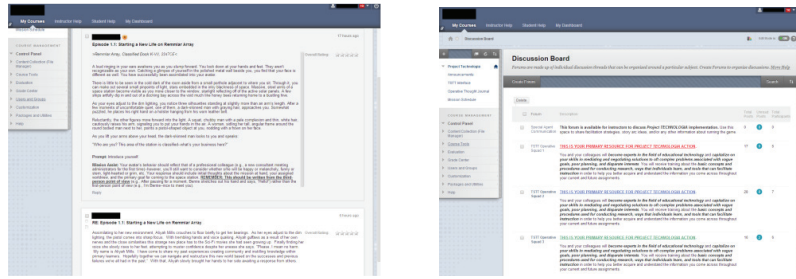


Figure 1: Project TECHNOLOGIA Texto-Spatio Temporal Transmitter (TSTT) Display

The “Project TECHNOLOGIA Prompt Trajectory” (Figure 2) highlights how the program objectives are represented by a series of narrative episodes, all of which have a “minus,” “neutral,” and “plus” modification. These team designations lead to very slightly modified versions of the narrative depending on the players’ in-game actions (e.g., helping vs. attacking a non-player character). While groups can shift from one track to the next, they cannot shift across two tracks in one session. Importantly, the differences between the “minus,” “neutral,” and “plus” versions of the narrative are relatively minor (e.g., characters responding with different facial features, slightly different phrasing of ideas) and provide the scaffolding necessary to push the student operatives closer to the primary program objectives (i.e., “Visioning” as defined by the NETS/ISTE standards).



Figure 2: Project TECHNOLOGIA Prompt Trajectory

The continuous embedded formative assessment associated with Project TECHNOLOGIA is rooted in the player-controlled characters. After viewing an objective-based prompt posted in the TSTT by the instructor, the students collaborate with their teams to decide what actions they will take in the RPG. This allows the instructor to evaluate the learners’ thinking and collaboration such that emphasis is placed on the complex skills associated with being a successful educational technology specialist rather than just the character’s response product or the types of basic rote information assessed by high stakes tests, final exams, etc.

In transitioning between the ARG and RPG layers, a typical student dialogue might resemble the following (excerpts taken from a pilot instantiation of Project TECHNOLOGIA):

Student 1: Sam takes a few moments to gather her thoughts before responding...She feels especially slighted since she tried so hard to placate Rheegan when everyone else seemed to be on the attack...She decides to lick her wounds quietly and immerse herself in constructing educational technology for this new society. Sam decides to address the group as a whole and try to organize some of this chaos. She feels that if she can tap into each person’s strengths, they should be able to build a pretty advanced educational system...“Ahem, AHM—can I please have all your attention for a few moments? Everyone is doing a lot of talking but I don’t think many of us are doing a lot of listening. I have been trying to determine how all of us (the non-travelers) can have a voice in setting up this new society.”

Student 2: “I believe that if we move forward with Bill’s Social Learning theory & Gwen’s vision of organizing and implementing lessons that reinforce their learning, we can use technology to foster a cohesive and cooperative educational experience for our citizens. We can promote the use of the internet and the devices that the population already uses to create unique and rich learning experiences for students of all ages. Back home we used a platform called Edmodo that allowed for distance learning and access to content on a multitude of devices. It also had a great badge system for reinforcing learning and desirable student behaviors.” She continued, “You know, that makes me think of one of my favorite apps for the iPad and iPhone: Class Dojo. Students earn points for positive behaviors and can also have points taken away for negative behaviors. I know that my behavior up to this point has not been stellar, but I really think this system would benefit our educational programs. Maybe this is something we can implement together as a team.”

Student 3: After hearing Sam speak, Brandon stands and collects his thoughts. Many of the things that Sam mentioned made perfect sense...They needed to be good models for the citizens and that needed to start now. “Sam... I like the way you think. We absolutely need to work as a team and use our skills to give this community a model educational system. I think it can be done, but there are definitely some questions that need to be answered before we can create something wonderful. Duncan, you mentioned technology. Along with Sam, I would also like to know what we have available to us and to the citizens and what technology, if any, the citizens of Remmlar Array are already familiar with. Is there anything that they know how to use that we can use in conjunction with the technology you are making available to us?”

Student-student interactions via the TSTT HUD afford the instructional opportunity to facilitate the correction of misconceptions in real-time rather than providing direct instruction and waiting for summative assessments to dictate end of unit or whole course achievement. Feedback often includes veiled critiquing through a character in the game’s plot or direct intervention as the course instructor. For example:

Instructor: “I’ve been an administrator for a long time, and I’ve never come into a new and changing situation and found the group ready and waiting with a shared vision and a set of prioritized objectives they wish to pursue together. That’s crazy talk. Getting the folks on this station, our new home, talking together so that they can co-construct a shared vision—” A wave of yelling momentarily breaks his train of thought. “*THAT’S EXACTLY WHAT WE NEED YOUR HELP IN DOING.*”

“...You have to understand that many of these folks are set in their ways...Your ADDIE model and needs assessment may be helpful eventually, but right now they need a chance to interact, to become vested in the process, and to feel like they have been heard. They need a chance to understand the possibilities, and together set those priorities... your so-called behavioral objectives.”

Dialogic interactions like those sampled above emphasize the way *Project TECHNOLOGIA* focuses on knowledge gains by placing learners in complex, problem-rich contexts that require application, creativity, and self-evaluation of learning. This permits the teacher to emphasize and evaluate action on all tiers of Bloom’s Taxonomy rather than focusing on one or two at a time. Altogether, the assessment process exemplifies the constructivist nature of the program by allowing students to piece together on-going portfolios that establish longitudinal, experiential knowledge growth over the breadth of the Master’s program, exhibiting the cumulative spiral effect described in Bruner’s four governing principles of constructivist instruction (Slota, 2014; Young et al., 2012).

Research Methodologies

Qualitative (Phase I)

Game environments are situated much in the same way as other learning contexts and, by definition, rely on social interaction. Consequently, the study hinges on student-student and instructor-student dialogue throughout gameplay (i.e., occasions where individuals post to one another in the RPG). It follows to utilize grounded theory analysis set within an interpretation theory framework to extract meaning from player/student interactions over the course of *Project TECHNOLOGIA*’s implementation (Author, 2012; Potter & Wetherell, 1987; Rennie, 2007; Thomas, 2003). Like other qualitative methods, grounded theory analysis is inductive in nature, though *Project TECHNOLOGIA* places specific emphasis on open, interpersonal dialogic loops between participants in lieu of participant responses taken in isolation of one another (Cheek, 2004). For this reason, all qualitative information collected across the study is set to be divided into dialogical units of analysis (i.e., interactions between individual players and the game with respect to individual goals/intentions) so that the authors might capitalize on the inter-

pretive affordances of dialogic loops (e.g., ‘ways to improve future performance’, ‘instances of real or perceived failure’, ‘points of critical thinking’—any units that can be extrapolated into broader macrocategories of discussion) (Bakhtin, 1981; Foster & Ohta, 2005). Participant thought journals/logs (i.e., participant-maintained journals used for jotting down out-of-game thoughts, ideas, etc.) will expand upon participant goals and intentions at the time of making in-game posts—this will permit the capture “internal” snapshots that may lead to a much richer assessment of individual differences among participants.

There is no singularly correct way to administer this approach. However, several steps tend to be consistent across the studies in which it has been applied (e.g., Shaw & Bailey, 2009). These steps allow the researcher to make inferences about social interaction based on primary statements/questions and the responses they yield (Thompson, 1988). Because meaning, symbols, knowledge, and other abstract concepts are socially constructed, this is especially helpful in establishing how complex social behaviors such as group learning manifest in real-world (i.e., in vivo) contexts (Berger & Luckman, 1967; Lave & Wenger, 1991; Vygotsky, 1978).

To that end, the authors have used pilot data to establish several assumptions prior to the analysis of data involving this iteration of the game, specifically: 1) the interactive process (or processes) is favored over outcomes and products; 2) data collection and analysis come exclusively from the researcher, meaning that all data necessarily filters through an individual rather than a machine or piece of software; 3) subjects must be studied in context, implying the need for fieldwork (in this case, understanding student situations and the context for communication); 4) data analysis centers on interpretation and the emergence of meaning; 5) there is inherent orientation toward constructing hypotheses, concepts, and theories from details rather than using details to confirm or deny existing hypotheses, concepts, or theories; 6) all interactions are formed as the result of dialogue and meaning will come from the formation of dialogical units (Bakhtin, 1981; Creswell, 1994; Hathaway, 1995; Merriam, 1988). The accepted structures and methodologies associated with quantitative study prevent quantitative researchers from capitalizing on the aforementioned assumptions, thus inhibiting the explanation of how and why learning occurs. As a result, grounded theory analysis serves as a more advantageous selection for establishing how and why participating students develop particular individual intentions, co-construct particular types of solutions, and adopt particular strategies in *Project TECHNOLOGIA*.

Quantitative (Phase II)

The combination of a limited sample size (n=14) and lack of standardized benchmark exams make it extraordinarily difficult to take a predominantly quantitative approach with *Project TECHNOLOGIA*—the number of participants needed to create experimental/comparison groups and achieve appropriate statistical power is roughly 200-300. Achievement measured by way of final program artifact grades/evaluations will instead be used as a rough guide for the researchers to correlate student performance and play choices in the game with student performance in the overarching Master’s program. This means that there are no variables to manipulate, per se, but the quantitative portfolio elements will act as descriptive tools that aid in establishing player/student intentionality, personal goal-setting/achievement, and engagement with the program as a whole.

Preliminary Findings

The iterative instructional design process underpinning *Project TECHNOLOGIA*’s development has yielded valuable information about how the game affects student learning, engagement, and the ability to apply skills associated with a K12 educational technologist. Additionally, findings from the pilot have shaped the authors’ expectations for the current implementation by offering insight into possible and/or probable outcomes pending the end of the current implementation cycle (i.e., May/June 2014).

First, student-student and instructor-student interactions observed throughout the *Project TECHNOLOGIA* pilot indicated that the timeline for content release and quality of online interactions were critical in shaping the overall experience for both instructors and students. This issue is well-established in the context of drug abuse prevention programs and is defined by five major measures of fidelity: Dosage, Adherence, Program Differentiation, Participant Responsiveness, and Quality of Program Delivery (Dusenbury et al., 2003). In particular, Dosage (i.e., frequency and complexity of new prompt episodes) and Quality of Program Delivery (i.e., depth of shared storytelling/interactions) served as strong determinants for student engagement and, taken together, acted as a kind of ‘canary’ for long-term implementation success. Though the authors originally anticipated that one episode per month would be sufficient for maintaining interest and success, it quickly became clear that students tended to forget major plot points, lose focus on their objective(s), and stop participating when disengaged for more than two weeks and/or receiving only general responses to specific character actions. The game has since been revised to feature bi-weekly episodes and additional material (e.g., character-specific expository dialogue) aimed at improving Dosage and Quality of Program Delivery.

Related to this issue, dialogue sampled from the pilot and current implementation suggests that the underlying narrative is rich and dynamic enough to be engaging, but it requires regular instructor-driven updates to compete with higher-prioritized Master's program coursework and assignments. As a post-pilot remedy, the authors targeted areas of the existing narrative that most appealed to pilot participants and/or generated high-quality discussion/debate (e.g., conflicts between characters, arguments, a riot initiated by non-player characters)—a means to introduce additional opportunities for student participation and fortify comparatively weak plot points. This has expanded the narrative such that the authors believe it more aptly capitalizes on the “teachable moments” that emerged during the pilot and improves the likelihood that individual intentions will be more easily identifiable after the current implementation.

Data observed in the early stages of the current implementation indicate that answering the research question “What is the interaction between player intentionality, the instructionally-relevant game, and student outcomes?” may be deeply embedded in how an instructor tailors a game's story toward student actions, perceptions, and choices. This is not to say that open-endedness and unlimited student agency are the governing factors in all game-based learning environments but rather that well-guided player action—as facilitated by a compelling narrative—may be the biggest contributor to emergent student intentions for learning and application in an ARG/RPG. If true, the implication would be that narrative is at least as important to the long-term fidelity of a game-based learning program as the game's other mechanics, thus lending support to the notion that high-end game graphics are not necessary for maintaining engagement so long as the narrative and learning objective structure generates sufficient appeal. Importantly, however, final judgments about these and other extrapolations will remain purely speculative until we near the end of the current implementation (i.e., May/June 2014).

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The Common Core State Standards, the Next Generation Science Standards, and the Potential of Digital Game-Based Learning and Assessment

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Introduction

Over the past decade, game-based learning and assessment have emerged as promising areas of innovation that could inform and enhance the provision of personalized learning at scale. Perhaps the greatest influence of game-based experiences on the next generation of learning will be not as instructional courseware per se, but as assessments *for* learning—that is, assessments that not only measure learning, but also generate actionable evidence to help personalize and improve teaching and learning.

This paper presents promising practices in the emerging field of technology-enhanced, game-based educational assessment. We examine recent developments in the field and present interviews and case studies to illuminate potential paths along which game-based assessment might evolve. We aim to increase understanding of how game-based assessment could become an integral component of assessment practices and systems, and we encourage the game industry, the assessment industry, and “games for learning” advocates to develop game-based assessment products with the potential to enhance meaningful accountability and to inform teaching and learning processes. We seek to advance games, learning, and assessment as an emerging field and to suggest that game-based assessment may hold relevance for broader conversations about next generation assessments, particularly those aligned with the Common Core State Standards (CCSS) and the Next Generation Science Standards (NGSS). Finally, we generate recommendations for designing and applying digital games to address the demands of assessment.

The recommendations are based on applied research conducted by the authors. Over nine months, beginning in early 2013, we conducted either in-depth interviews or surveys with over 125 professionals with relevant expertise, including leaders from game companies, education technology firms, publishers, research universities, school systems, non-profits, entrepreneurs, advocacy organizations, and policy researchers. We also reviewed pertinent academic and policy research and industry reports on the CCSS’ relevance for game-based courseware efficacy, design, and dissemination.

Assessment in a K-12 Context

The U.S. education system is no stranger to assessment. Increasingly, schools and teachers have been evaluated on the basis of their effectiveness at advancing student learning. No Child Left Behind (NCLB) ramped up attention to standardized testing by mandating assessment and accountability for all states. Now, the adoption of the CCSS for Mathematics and English Language Arts (ELA)/Literacy and of the NGSS has created a need for corresponding next generation assessments. By reconciling and aligning existing state standards, CCSS adoption offers an opportunity for systematic, strategic thinking about how we might redesign the assessment system in a way that is more conducive to teaching and learning. Coupled with new game-based learning technologies, CCSS adoption offers two major opportunities for assessment design:

- *Prospect 1:* Assessments that serve, inform, and enhance teaching and learning. Formative assessments have the potential to be effective instructional tools, but they have not been widely used because they are burdensome for teachers to create and implement during limited class time. However, CCSS expectations and new game-based learning technologies make formative assessments both desirable and feasible.
- *Prospect 2:* Assessments that leverage technological advances to more efficiently assess a wider range of competencies. The transition to digital assessment is underway, necessitated in part by the transition to the CCSS and NGSS. New assessments developed to align with the CCSS will be computer-based and leverage technology in a range of ways. These technology-enhanced assessments promise to allow assessment of a wider array of cognitive competencies and to increase the efficiency of assessment.

The current assessment system has been subject to frequently raised concerns, which may be relevant to designing more promising teaching- and learning-centered assessment:

- *Lack of precise, actionable information.* Traditional assessment does not provide the sort of precise, actionable information necessary to improve instruction and learning. This limited information makes current assessments inadequate as instructional tools.
- *Static snapshots.* Summative assessments were designed for comparability across schools and systems accountability purposes; they provide static snapshots of achievement at particular moments but fail to capture real-time progressions of student mastery that would allow teachers to adjust and improve instruction during the course of the year.
- *The design of reliable and valid measures.* One challenge in providing more precise, actionable, and comprehensive information is ensuring that measures of learning processes and outcomes are both reliable and valid.
- *Fairness and equity.* Beyond the issue of test bias, the use of assessments for high-stakes decisions raises broader issues of fairness: when high-stakes assessments are poorly aligned with the actual content taught to students, they are unfair proxies for student achievement. Unfair or inaccessible assessments cannot be used effectively to improve instruction because they are poor measures of actual student learning.
- *Test administration and interpretation.* Quality assessment depends on design and how tests are used and administered. Ensuring that schools and teachers administer and interpret tests properly entails careful consideration of how data should be interpreted, whether interpretations are meaningful, and what the stakes are.

The Next Generation of Assessments

The next generation of assessment should seek to move beyond the limitations of status quo assessment toward a new assessment system that exists in service of teaching and learning. The next generation of assessment needs to take seriously the separation of assessment and instruction—and the possibility of overcoming it—and look towards standards for quality, including comprehensiveness, coherence, continuity, and dynamism.

Comprehensiveness

Assessment systems should be comprehensive for educators and policymakers interpreting results, meaning that “a range of measurement approaches should be used to provide a variety of evidence to support educational decision-making” (Pellegrino, 2012, pp. 10-11). The range of measurement approaches that schools and teachers use should generate a variety of evidence and provide multiple pathways for students to demonstrate competence and mastery. A critical component of a comprehensive assessment system is formative assessment, which provides real-time feedback to inform teaching and learning.

Coherence

Assessment systems should be vertically coherent—from large-scale summative assessments to classroom-based formative assessments—and horizontally coherent with curriculum and instruction. If the underlying models of learning are consistent, assessments have the potential to complement each other rather than conflict as a student moves from the classroom through the school, district, and state. The CCSS provide a model of student learning that can create consistency across summative and formative assessments.

Continuity

An assessment system ideally provides continuous records of progress so that change over time can be observed and interpreted. Pellegrino (2012) compares continuous assessment to “a videotape record rather than to the snapshots provided by most current tests” (pp. 10-11). Continuous assessment requires “multiple sets of observations over time,” which “must be linked conceptually so that change can be observed and interpreted. Models of student progress in learning should underlie the assessment system, and tests should be designed to provide information that maps back to the progress. Thus, continuity calls for alignment along the third dimension of time” (Pellegrino, 2012, pp. 10-11). Compared to snapshot summative assessments, continuous assessment systems are better able to assess “the processes of learning and an individual’s progress through that process” (Pellegrino, Chudowsky, & Glaser, 2001, pp. 256-257).

Dynamism

Next generation assessments should be dynamic, meaning that they are able to diagnose and guide personalized learning and support interaction and complex learning tasks. Formative assessment and adaptive instruction could address “the unique and situation-specific needs of learners by concurrently providing clear information, opportunities for thoughtful practice, informative feedback, and a favorable combination of intrinsic and extrinsic motivators tailored to the individual learner” (Dieterle & Murray, 2009, p. 601). By leveraging technology, next generation assessments could enable self-assessment and engage students in learning while they complete assessment tasks.

Potential Added Value of Game-Based Assessment

Game-based assessments could offer additional sources of evidence to support educational practice and decision-making. In a coherent assessment system, game-based assessments would be grounded in the same underlying model of student learning as other assessments. Game-based assessment, like most technology-enhanced assessment, has several potential advantages. Games can accommodate complex approaches to questions and responses; embed formative assessments and offer timely feedback; provide rich insight into learning progressions; generate data to explain and improve learning outcomes; and give users control, agency, context, and motivation.

Complex approaches to questions and responses

Games can be an important part of next generation assessment systems that ask new, more complex questions with more flexible response options. Next generation assessments will “go well beyond traditional item formats” to ask students to “connect knowledge, processes, and strategies to conditions of use”; that is, next generation assessments must “make mandatory the use of more complex tasks, including simulations and other extended constructed-response formats” (Bennett, 2013, p. 127). For example, an assessment might ask students to engage in adaptive problem solving, in which they are given a situation and must “identify the problem and its constraints, represent the problem so that it can be solved, figure out alternative solution options, implement one strategy, and evaluate the adequacy of the solution or solutions” (Baker, 2012, pp. 10-11). In such a format, they cannot simply regurgitate recently learned procedures, but must “draw from previously learned patterns or schema, adapt them to the problem at hand, and perhaps invent something new in order to reach a solution” (Baker, 2012, pp. 10-11). The transition to next generation formats will be driven by “the need to measure competencies that cannot be assessed through less labor-intensive means” (Bennett, 2013, p. 127).

Embedded formative assessments and timely feedback

At present, it is impractical for many classroom teachers to administer robust daily or weekly formative assessments. Doing so requires significant time and attention, increasing demands for managing data collection, flow, analysis, and application. But game technology has the potential to ease the logistical demands and complexity of providing formative assessment feedback by making collection, interpretation, and reporting simpler and less time consuming. By embedding assessments, games could become “potent formative assessments tools” (Baker & Delacruz, 2012, p. 3). Data could be captured “through evaluation of students’ online clickstream behavior to support inferences about students’ ongoing understanding” (Baker & Delacruz, 2012, p. 3).

Rich insight into learning progressions

Recent technological advances have spawned what is now known as “big data.” Our activity on the Internet, for example, can be analyzed to make predictions about our future behavior. Next generation game-based assessments can harness big data and provide us the means for gathering on-the-fly data about student progression, mastery, and learning, which can then be used to make instructional decisions tailored to individual needs. Stealth assessments, embedded in immersive game environments, could be used to continuously monitor performance and give feedback.

Data to examine learning progressions and mastery and improve teaching

By monitoring students as they engage in the process of learning, game-based assessments can help refine learning progressions to more accurately guide instruction (Pellegrino, 2012, p. 5). Games can enrich the problems posed by assessments; they can present complex, realistic, open-ended, interactive challenges; and generate evidence about the approaches students choose. Baker (2012) calls this “one of the biggest potentials for game design—the ability of process data to help explain learning outcomes (e.g., use of productive or unproductive strategies), sense and adapt to students’ evolving understanding of the domain, misconceptions, or gaps in domain

knowledge” (p. 3). Behrens and DiCerbo (2012) embrace this capability and suggest “a reframing of assessment practices from identifying correctness of test questions to capturing a constellation of learning transactions using digital technologies to make inferences about student cognition and learning” (as cited in Gordon Commission, 2013, p. 20).

Self-assessment

Digital games can facilitate the shift toward self-assessment by making assessment personal, accessible, and immediate. Self-assessment is a significant dimension of next generation learning. It is a crucial skill for developing motivated learners who are able to take stock of where they are and what they need to improve. In other words, self-assessment can “encourage students to reflect about what they’ve learned and how well they’ve internalized and understand it; how it all comes together; how it has or can change their behavior; and what else is needed to continuously achieve their own as well as society’s goals” (Torre & Sampson, 2012, p. 6). It helps to fill the gaps between school- or teacher-led assessments and ensure that learning happens continuously.

Validity through engagement and motivation

Incorporating game-based elements into assessment may bring the added advantage of engaging students. For instance, adaptive instructional and assessment tools are already transforming basic math instruction, through tools such as DreamBox learning and Dragon Box. Engagement is not only about student experience; it also helps ensure assessment validity. Research suggests that less engaging assessment tasks tend to underestimate student abilities (Bauer et al., 2012, p. 24). Especially in literacy assessments, research finds, achievement scores may depend on “providing interesting text, providing clear conceptual goals, providing choice, and collaboration”—properties that are “uniquely suited to, or can be more readily effectively incorporated within, technology enhanced assessment formats” (Bauer et al., 2012, p. 24). By increasing assessments’ novel interactivity, and by providing immediate, task-relevant feedback, technology can increase assessment validity (Bauer et al., 2012, pp. 24-25). Because games are so engaging, they can also extend students’ time-on-task by migrating learning opportunities beyond formal educational settings. This advantage may be especially relevant for students at risk of academic failure (Baker & Delacruz, 2012, p. 1).

Opportunities for Games, Learning, and Assessment

Develop game-based interim and formative assessments

Game-based assessment should include interim (periodically administered) and formative assessments that will work together with large-scale, summative assessments in a system that is comprehensive, coherent, continuous, and dynamic. Game-based assessment would thus be one type of evidence to support educational practice and decision-making and would be grounded in the same underlying model of student learning outlined by the CCSS and NGSS. Research and development of new digital courseware and assessments are required to understand how, if, and to what extent game-based assessment systems can come together with assessment systems currently in place.

Align digital games with the CCSS and NGSS

To achieve their full potential, learning games should be designed from the ground up to be integrated with instruction and assessment. Game-based assessment should not be designed to exist in isolation, but should be aligned with the CCSS, the NGSS, and the assessment consortia. The CCSS and NGSS signal worthwhile goals for schools, educators, and students. The aspects of learning that game-based systems assess and emphasize should aim to be consistent with the evolution of classroom practice. The CCSS and NGSS call for meaningful, worthwhile work—meaning that “teaching and learning to the test” has the potential to become a good thing. From the outset, designers should “design the assessment architecture, in other words, embed the assessment in the transactions of the game and build it into a game’s underlying engine. Maximizing the potential of process data requires a tight (conceptual) coupling among the set of goals of learning, purpose of assessment, student behaviors, student responses, task design, and assessment design” (Baker & Delacruz, 2012, p. 3).

Common standards also help preserve equity: “common understandings and common standards for performance for both accountability and instructional purposes are required if equity is to be served and performance disparities reduced. If students in different schools are held to vastly different types of performance, equity issues will exponentially increase with performance assessment” (Baker, 2010, p. 8). There is a need for increased and sustained collaboration focused on both the theoretical and practical matters of game-based assessment and its relevance to the assessment consortia. This applies not only to collaboration between researchers in game design and the

measurement sciences, but also to the collaboration of these groups with game and user interface designers, learning scientists, usability researchers, teachers, curriculum specialists, and assessment developers.

Produce game-based measurement tools that are fair, equitable, valid, and reliable

Game-based assessments have the potential to enhance fairness and equity and to improve validity. In order to evaluate validity, developers must first define the desired intellectual processes or academic outcomes to be measured as well as how the assessment will be used. Well-defined, common standards help clarify assessment tasks and help teachers understand the instructional tasks that will prepare students for assessments, further strengthening validity (Baker, 2010, pp. 6-7). Game-based assessment should value the need for high-quality evidence of CCSS skills mastery, including the need to meet our nation's measurement standards, including validity, reliability, fairness, and accessibility.

Conclusion

Together, technological advances and the adoption of shared next generation standards offer an opportunity to revisit and improve the existing assessment system. An improved assessment system would serve, inform, and enhance teaching and learning and leverage technological advances to more efficiently assess a wider range of competencies. Next generation assessment can move beyond the current system of snapshot assessments by developing a comprehensive, coherent, continuous, and dynamic assessment system with a robust formative assessment component. Game-based assessments are well suited to meet many of the needs of a next generation assessment system: they can accommodate complex approaches to questions and responses, embed formative assessments with timely feedback, generate data for rich insight, and encourage self-assessment and student engagement.

Realizing these opportunities will require the collaboration of policymakers, game designers, educational practitioners, investors, and many others. Our recommendations suggest ways in which each of these groups can support the development of game-based interim and formative assessments that are aligned with the CCSS, relevant to the broader assessment context, and based on Evidence Centered Design.

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The Effects of Avatar-based Customization on Player Identification in Extended MMO Gameplay

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Introduction

Massively multiplayer online games (MMOs) have emerged to be one of the most popular gaming genres over the last decade and have been studied from various perspectives (e.g., player demographics, addiction, socialization, player motivations). This popularity is partly because of MMOs' affordances to allow players to temporarily become a game character and adopt the salient characteristics of that character (Looy, Courtois, Vocht, 2010). As the background below will outline in detail, players' identification with their avatars/characters impacts their gameplay experiences (e.g., enjoyment in Klimmt, Hefner, & Vorderer, 2009). Determining aspects of games that improve players' identification with their characters would be of interest to game designers as well as educators who choose games for their students. One potential game aspect that may influence how players identify with their characters/avatars is avatar-based customization.

Avatar customization is an understudied factor when it comes to identification. It allows making each character different in MMOs by providing different combinations of attributes, adornments/physical properties, skills, and traits (Dickey, 2007). This experience may help the player identify with the character, increasing the likelihood of affecting his/her self-identity. Avatars and characters mean different: Avatars are the embodiment of the user in virtual environments whereas characters are fictional identities within the narrative setting of a game. In this paper, "avatar" and "character" will be used interchangeably because this research study was not set up to differentiate avatar customization from character customization.

This paper expands the literature on digital identities constructed within virtual worlds, specifically MMOs, by examining novice players' identification with their characters over multiple gameplay sessions varying avatar-based customization. Therefore, the following research question is asked: How does avatar-based customization interact with the number of gameplay sessions to predict players' identification with their avatars?

Background

Looy et. al., (2010) call for more attention to the concept of identification in game studies. Playing computer games is engaging, partly because players can enter imagined worlds and perceive themselves in alternate ways. Consequently, studying player identification with avatars in a virtual environment is potentially crucial for understanding gameplay experiences. Cohen (2001) defines identification with media characters as "an imaginative experience in which a person surrenders consciousness of his or her own identity and experiences the world through someone else's point of view (p. 248)." Adapting this definition to video games, some argue that identification allows for experimentation with one's identity by temporarily mentally becoming a famous hero, sportsman or supermodel, adopting aspects of the identity of the target videogame character (Klimmt et al., 2009). However, player identification with characters is complicated because of the multiplicity of roles (e.g., subject, audience, director, user) a player takes during gameplay (Flanagan, 1999). When a player exerts agency over the avatar to interact with objects, events and participants, this is mediated both by the player character's abilities and player's abilities, and those have consequences to the avatar within the game world (Murphy, 2004). In MMOs, players also make their characters perform various social actions through emotes. An avatar's representation of the player emotions and intentions has a great impact on identification with the avatar (Hamilton, 2009) and a perceptual integration with the avatar -- player's awareness of her presence both in their body and in the screen (Dove, 2002).

Previous studies determined player behaviors, attributes of avatars and virtual worlds that facilitate identification. Among these features are avatar attractiveness (Kim, Lee, & Kang, 2012), character abilities (Newman, 2002), avatar choice (Lim, 2006), and physical resemblance of characters to their users (Maccoby & Wilson, 1957). Players' perceived similarity to characters is also called mirror hypothesis (Chandler & Griffith, 2004). The mirror hypothesis refers to the fact that viewers tend to relate favorably to on-screen characters who are either like themselves (the mirror), or ones who represent someone the viewer would like to be (the magic mirror). The magic mirror relates to another type of identification: wishful identification. In wishful identification, the observer desires to emulate the character, either in general terms as a role model for future action or identity development, or in specific terms which extend responses beyond the viewing situation or by imitating a particular behavior (Hoffner & Buchanan, 2005). Wishful identification provides a glimpse of "what if," and these glimpses are powerful predictors of future behavior (Cohen, 2001).

Players' direct control over their characters can imbue them with sense of agency and may increase their positive affect in the game (Hefner, Klimmit, & Vorderer, 2007). Ganesh et al.'s (2012) neuroimaging study revealed that

avatar related self-identification is related to the experience of agency and control over the observed body. This finding implies a relationship between player control over the avatar and self-identification with the avatars.

Despite these implications, there is a lack of empirical research that studies the extent to which control over the avatar strengthens the relationship between the avatar and the player (Shaw, 2011). The majority of the literature written on such a relationship has been through either theoretical approach (e.g., Murphy, 2004) or surveys/interviews that specifically address the questions around identification (e.g., Looy et al., 2010). This study aims to contribute to the literature by examining the effect of user control, specifically avatar-based customization, on player identification with avatars.

Customization

Self-representation is intentional within the given choice structure of a virtual world. The visual characteristics of an avatar, the name, as well as character abilities provide users with an expression of identity and an opportunity for extended identity formation (Turkle, 1995). Many games allow avatar customization to some extent on these aspects. Developments in graphics technologies allow players to create their game characters and design physical attributes within the constraints of a given game. In their study of aggression, Fischer, Kastenmuller and Greitemeyer (2010) found evidence that avatar customization may amplify the psychological effects of video games through increased identification with one's character, and, in turn, identification with a game character may increase game enjoyment (Klimmt et al., 2009). A survey study found that World of Warcraft players who strongly identify with their characters have a stronger interest in customizing the appearance of their character (Looy et al., 2010). In addition, character creation was reported to increase players' attachment to their characters (e.g., Shaw, 2011).

Duration of the Study

Previous empirical studies (e.g., Hitchens, Drachen, & Richards, 2012) relied on a short time (between 8 and 45 minutes) to draw conclusions regarding players' identification with their characters. However, MMOs are long-term games, and gameplay experience may change over time (Schultheiss, 2007). Identity and players' sense of self, and what is salient to players, can change as they spend time in a game (Turkle, 1995). Thus, a reliable study of player experiences in MMOs should take place over a significant time period. Based on data on players' average gameplay time per character per week, this study's procedure involved about 10 hours of gameplay, which was divided into four sessions of 2.5 hours per session over two weeks (see Ducheneaut, Yee, Nickell, & Moore, 2006).

Method

Participants and Design

Sixty-six participants (32 males, 34 female) completed the study. Participants were not expert MMO players, were not current MMO players, and had not played Lord of the Rings Online (*LotRO*) (Warner Bros., 2014). The average age of participants was 25.63. The experiment employed a between-subjects design with 33 participants in customization group (CG; 17 females, 16 males) and 33 participants in no customization group (NCG; 17 females, 16 males). Participants were assigned to one of the two groups by gender. A preliminary analysis showed no significant differences between groups in their age ($t = 0.72, n.s.$), or MMO experiences ($t = 1.32, n.s.$).

In the CG, participants were given various choices in the game such as the opportunity to choose their game character's specialties, skills, gender, and appearance as well as in-game rewards after they complete quests. In the NCG, the participants were assigned to well-constructed pre-designed avatars with efficient character skills and quest rewards were chosen for them that would maximize their character abilities. In the NCG, avatar gender and participant gender were matched.

Materials and Apparatus

Stimulus. Lord of the Rings Online (*LotRO*) was used for the study. *LotRO* is a fantasy type MMO based on the books by J.R.R. Tolkien. In searching for an appropriate stimulus, three factors were taken into consideration: 1) Availability of all three types of customization (Turkay & Adinolf, 2010). For example, avatar appearance, skills, and the game interface customizations; 2) Usability and playability; and 3) The match between the lab computers and technical requirements of the game.

Identification was assessed with a 22-item 5-point Likert-type scale, which was developed and tested by Looy et al. (2010). This scale includes Wishful Identification (6 items) e.g., If I could become like my character, I would), Perceived Similarity (6 items) (e.g., My character is like me in many ways), and Embodied Presence (5 items) (e.g., I feel like I am inside my character when playing). Cronbach's α for identification scale items per session were measured in the current study and found to be satisfactory (0.842 to 0.954).

Beside survey questions, semi-structured interviews were conducted after each session to allow participants to “tell” their gameplay experience without prompting them on the topic of identification. A general language was used to ask open-ended questions (e.g., Tell me about your experience this session) and determine the extent of player identification with their characters.

Procedure and the Setting

Potential participants were provided with an online survey after they showed interest in participating in the study. This survey collected demographic data (e.g., gender, age, occupation) and gaming experiences. Participants who were invited to participate in the study were provided with an informed consent document upon first entering the laboratory for the experiment. After each participant read and signed the informed consent document, they were placed in front of a gaming computer. They were briefed on the study’s procedure, and were told that they were going to finish the game tutorial in the first gameplay session, which lasts about 1.5 to 2 hours. Then, the CG participants created their *LotRO* game characters. There was no time limit for character creation. The procedure was the same for the NCG, except that they did not create their avatars but were assigned to pre-generated avatars.

Throughout the study, participants in CG were allowed to make choices to customize their character skills and equipment. They would see their choices reflected on their character by equipping the new gear. The researcher made NCG participants’ choices on such character-based customizations for them, through mirrored controls as described above. NCG participants would also not be able to see the changes reflected on their avatars when they equipped the new gear. This was accomplished by a function called “Cosmetic Outfit” in *LotRO*.

Participant’s computer was separated from the main area with screens to avoid distraction. The researcher had a table in an adjoining cubicle, where a second monitor, keyboard and mouse were placed. These were connected to and mirrored the participant’s computer, allowing the researcher to directly observe gameplay, and manipulate NCG’s choices. Participants had no direct line of sight to the researcher.

Data Analysis

Independent samples *t*-tests were conducted to test differences between CG and NCG per session. RM-MANO-VAs were used to measure the possible change in players’ identification with their characters over four sessions. Semi-structured interviews were analyzed thematically. A second set of analysis was conducted on participants’ use of first, second or third person pronouns when discussing their characters. This method was used previously by Hitchens et al. (2012)’s study of identification. They asked participants to discuss various events and actions in the games they played and analyzed the interview transcript based on their pronoun use. SPSS 19 was used for the analysis of quantitative data and Nvivo 9 is used to analyze qualitative data.

Results

Effect of Customization on Identification

Independent samples *t*-tests revealed statistically significant differences between CG and NCG (see Table 1) for all three subparts of the identification scale. After each session, participants statistically significantly differed in Perceived Similarity and Wishful Identification, in favor of CG. CG reported a significantly higher sense of Embodied Presence than NCG after the second onwards. Assuming the normality of the data, RM MANOVA was conducted to assess the difference between CG and NCG in the amount of change in their ratings on the three factors of the Identification scale.

	Levene's		Independent Samples t-test			CG		NCG	
	<i>F</i>	<i>p</i>	<i>t</i>	<i>p</i>	η^2	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Perceived Similarity 1	3.52	0.065	-3.20	.002	0.14	2.56	1.08	1.81	0.83
Perceived Similarity 2	1.46	0.231	-3.54	.001	0.17	2.53	0.98	1.76	0.77
Perceived Similarity 3	3.68	0.060	-3.39	.001	0.15	2.65	0.98	1.92	0.76
Perceived Similarity 4	10.39	0.002	-4.07	.000	0.21	2.79	1.09	1.85	0.75
Wishful Identification 1	2.57	0.114	-2.15	.035	0.07	2.34	0.93	1.89	0.79
Wishful Identification 2	1.92	0.170	-3.23	.002	0.14	2.37	0.91	1.71	0.73
Wishful Identification 3	2.65	0.109	-3.03	.004	0.13	2.52	0.98	1.85	0.81
Wishful Identification 4	2.76	0.101	-3.21	.002	0.14	2.61	1.14	1.80	0.90
Embodied Presence 1	0.02	0.892	-1.94	.056	0.06	2.51	1.06	2.02	0.98
Embodied Presence 2	0.19	0.663	-2.05	.044	0.06	2.53	1.02	2.04	0.92
Embodied Presence 3	3.01	0.088	-2.60	.011	0.10	2.84	1.07	2.21	0.89
Embodied Presence 4	0.19	0.661	-4.07	.000	0.16	3.08	1.11	2.19	1.00

Table 1. Statistics for Identification Subsections for Each Session

Since the *Box's M* value of 176.23 is associated with a $p < .001$, *Pillais' Trace* was used for the multivariate tests. A statistically significant MANOVA effect was obtained for Group, *Pillais' Trace* = 0.20, $F(3, 61) = 4.96$, $p < .01$, $\eta^2_{\text{partial}} = .20$. The multivariate effect size was estimated at 0.20, which implies that 20% of the variance in the canonically-derived dependent variable was accounted for by customization. A statistically significant MANOVA effect was also obtained for Sessions, *Pillais' Trace* = 0.26, $F(9, 55) = 2.13$, $p = .042$, $\eta^2_{\text{partial}} = .26$, but not for the interaction between Group and Sessions. *Pillais' Trace* = .123, $F(9, 55) = 0.86$, *n.s.*

Qualitative Findings on Identification

Both groups talked about their characters in the interviews when they were asked to recount their experiences. A comparison over time showed that twice as many participants mentioned their character in the last interview ($n = 39$) than the first interview ($n = 20$). Over four interviews, 90% of the CG mentioned their characters, compared to 50% of NCG players. CG participants also used the pronoun "I" (or "my character") more than NCG did while discussing their feelings about or events related to their characters (72% vs. 35% of the time) (e.g. "I fought with a group of monsters"). NCG participants mostly used "s/he" or "the character" to refer to their avatars. However, both CG and NCG alternated between referring to their character in the first and third person. This shifting maybe caused because they were still in the process of forming a relationship with their characters.

Compared to NCG, CG's conversations included more instances of perceived similarity with their characters, both about appearance and about behavioral characteristics. For example, [P59], was accepting all the quests in the game and when I asked why she did that, she replied "... My character is kind of like me. She cannot say no." This association was facilitated by character creation in the first session and built up over time, and majority of the quotes on perceived similarity came from their stories in the last two sessions. For example, [P7] reflected on her character in the last interview as "I chose this character... So whether he's the kind of people I admire or the kind of people I think I am, there is some similar things that I have...connected with me." This quote also exemplifies her choice of the character being a boundary between her ideal (other) and real self.

Wishful identification is about players' desire to be like their *LotRO* characters and was also exemplified by several participants. The most common quotes from CG in this category were about how they wanted to be represented by aesthetically pleasing avatars. Some were more interested in their characters' skills or functionality. For example, [P53]'s quote from the last interview exemplifies why he chose his character:

...I chose my guy because I wanted to be right there in the middle of the fight... I enjoyed that part I felt like I was my character...Being able to just give in and swing the axe... so that was rewarding... (P53, CG, M)

Participants talked about both functional and cosmetic character customization. Initial character creation and avatar customization were mentioned mostly as cosmetic customization. Here is a representative quote from [P64] highlighting the process of character customization, "It was fun to create my own character to put multiple characteristics on it. It was also fun, as the game goes along, to keep customizing it by adding more weapons and I liked

changing colors and all.”

In summary, a majority of the participants formed some form of a relationship between their characters, though this occurred more often for CG than NCG. For some participants, characters were a representation of themselves; for others, they were nothing but mere toys or vehicles. In all cases, the type of relation and identification with characters was dynamic and changed over time. In addition to character creation and avatar customization, socialization and realistic game world increased participants' identification with their characters. Perceived similarity was attributed to both physical appearance of the characters and characters' player assigned personality. Embodied presence was facilitated by the game design and graphics as well as the game's narrative.

Discussion

Results showed that CG players identified with their characters significantly more than NCG did. The psychological aspect of making choices might explain this result: because players chose their avatar aspects they felt more associated with the character by “taking ownership” of it. Another explanation might relate to the distance between real self and ideal self. Customization may allow players to create characters closer to their ideal self, which may increase identification with their characters.

CG players felt that their characters were similar to themselves and wished to be like their characters more than their counterparts did. Players' Perceived Similarity and Wishful Identification with their avatars as Within Subject variables did not significantly change over time. However, treatment had a moderate to large main effect on the differences in these variables. Qualitative findings showed that many CG players chose their characters to represent some aspect of themselves, such as a skill (e.g., playing an instrument) or physical characteristic (e.g., hair, eyes, built). This match and the psychological aspect of the act of choosing might have increased CG players' identification with their characters by creating a channel to relate to their characters. Character creation allowed players to create their own goals for the game. In turn, they started the game with a goal to accomplish for their characters (a goal that they determined to a certain aspect). This goal setting is motivating for people and goal achievement may decrease the gap between real and ideal self (Latham & Locke, 1979).

Players' identification with their characters increased over the four sessions as they built a profile for their avatars. This was evidenced both by qualitative and quantitative results. Although the rate of change was not significantly different for CG and NCG, customization explained the initial variance among the players' identification. These differences between CG and NCG were maintained over four sessions. Player motivation or retention depends on their emotional connection with the game and extent how meaningful that connection is to them. For CG players, having opportunities to acquire unique, visually appealing items to customize their experiences might have facilitated this emotional connection (Koehne, Bietz, & Redmiles, 2013). The fact that NCG players could not see their choices being reflected on their characters might have inhibited the construction of a relationship between the player and the character. For NCG, increased responsibility via quests in the game narrative (Schneider et al., 2004) and interaction with their avatars might have resulted in increased identification with and empathy toward their characters.

Self Determination Theory (SDT, Deci & Ryan, 1985) posits that autonomy, competence and relatedness are necessary for people's well-being. It was used previously to explain motivational aspects of MMOs (Przybylski, Rigby & Ryan, 2010). As a meta-motivation theory, SDT can also be used as a lens to understand findings of the current study. Autonomy satisfaction, mostly utilized as the feeling of having control over an activity, is crucial in encouraging people to come back to do the same activity. The choice making involved in customization implies its power to give people sense of autonomy. In MMOs, players are introduced to more choices in the form of customization as they level up, but the most concentrated choice-making happens during the character creation. Results showed that participants spent considerable amount of time making decisions on their avatar appearance and character skills. The positive relationship between CG participants' engagement with character creation in the first session and their increased identification with their characters as the sessions proceeded implies the character creation process have long-term effects on players' experience, such as identification. It is safe to put forward that CG participants' higher identification with their characters compared to NCG participants is due to the sense of agency and autonomy they felt as result of making various choices while customizing their characters in the first session. The improved sense of agency facilitated identification and empathy.

In educational settings, viewing identity as dynamic rather than static facilitate students' growth mindset (Kolb & Kolb, 2009). Virtual worlds give users imagined worlds and tools to test various identities through active process of design. Avatar is the main tool users have for the identity exploration. Strengthening the relationship between the player and the avatar can facilitate identification through which people can form their identities (Weinreich & Saunderson 2003). This study showed that avatar-based customization facilitates players' identification with their characters by increasing their sense of autonomy and agency. Considering focused decision making during character creation in the beginning resulted in CG players' higher identification with their characters, educational game

designers should consider giving chances to players periodically to re-customize their characters' appearance and skills in addition to main avatar customization in the beginning. This may allow them to re-consider their goals with their characters as well as exert agency.

This study has many limitations. Results of the current study may not be fully applicable to other types of virtual environments. Different customization tools available to users when designing avatars (Turkay, 2012) and the type of virtual environment may affect players' online identity in absolute means (Koehne et al., 2013). For example, in Vasalou and Joinson (2009)'s study, participants were asked to create 2D avatars to represent themselves in an online forum (e.g., Yahoo! Answers). In that virtual environment, users may want to be identified more closely in terms of look to their real-selves due to the possible authority of being an answer giver. Realistic avatar appearance is also not possible to assign in many fantasy MMOs since the avatars are not always humans although mostly are humanoids.

It is also reasonable to think that experts may bring dramatically different expectation to their gameplay, customization practices and how customization may impact their relationships with their avatars. Therefore, players' identification with their characters may be strengthened by all other set of characteristics, such as socialization. Therefore, the results may also not be fully applicable to all player populations with different expertise.

LotRO is not designed as an educational game. The results of this study may differ in an educational game. The goals described of the game and player expectations of educational games are different than those in entertainment games. Students may create/treat their avatars differently if the game was educational. Future studies are needed to establish the impact of avatar-based customization for player identification in educational games, and how these relate to student learning.

In summary, identification was a strong emotion that contributed to players' positive or negative game experiences. Avatar-based customization played an important role in players' identification with their characters by increasing their sense of autonomy. Future studies are needed to differentiate the effects of customizing character skills from customization avatar appearance on identification as well as to identify how differences in given customization choices constrain identification and identity exploration possibilities in virtual environments.

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No Hands Needed: Investigating the Affordances of Using a Brain Computer Interface (BCI) as a Game Controller and its Potential Effect on Learning and User Experience

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Introduction

Educational researchers have been dabbling with interactive media that allow learners and users to explore educational content through various theoretical approaches, including digital (virtual) immersion, (serious) games, simulations, situated learning, embodied cognition, multimedia learning based in cognitive theory, etc. (Annetta & Bronack, 2011; Dede, 2009; Mayer & Moreno, 1998). Particularly, in immersive digital gaming environments, the user's experience depends vastly on whether she or he believes that (s)he is fully immersed in the environment using (all or some of) her/his senses. "The more a virtual immersive experience is based on design strategies that combine actional, symbolic, and sensory factors, the greater the participant's suspension of disbelief that she or he is 'inside' a digitally enhanced setting" (Dede, 2009, p. 66). New interfaces, such as Brain Computer Interfaces (BCIs) particularly focus on the actional and sensory factors, specifically the user's neural activity that is triggered while performing a cognitively demanding task such as playing a game. Ko, Bae, Oh and Ryu (2009) and Nijholt, Bos and Reuderink (2009) suggested several ways to use BCI for game designs; generally concentrating on its use as a controlling interface and feedback mechanism based on EEG signals. The present exploratory study used the Emotiv EPOC neuroheadset to investigate the affordances of using BCI as a game controller and its potential effect on learning and positive player experiences with a view to providing implications for designing educational games.

Brain Computer Interfaces (BCIs)

BCIs are devices designed to detect neural activities, particularly the ongoing electroencephalogram (EEG) signals, of a brain in a non-invasive way that offers "an alternative communication and control channel that does not depend on the brain's normal output pathway of periphery nerves and muscles" (Millan, 2003, p. 75). BCIs can translate those neural activities into operative control signals (Leeb et al., 2007; Allison, Wolpaw & Wolpaw, 2007) that can be recognized by a computer for interpretation. BCIs have predominantly been used in the physical rehabilitation and medical fields, but are now being researched in other areas, including education. Education researchers may be interested in the possibility of BCIs in learning contexts as off-the-shelf wireless EEG headsets become more available for public consumption, and as many move away from interfaces that require touch or clicks to explore motion and sensor-controlled interfaces. In game development, input obtained from the measurement of brain activity through electroencephalography (EEG) headsets such as OCZ's Neural Impulse Actuator (NIH), NeuroSky's Mind Set and Emotiv's EPOC neuroheadset are attracting attention.

BCIs and Games

Some studies have shown that simple error detection triggers relatively fixed EEG patterns in a certain brain region. Other studies have taken such research one step further and shown that imagined movements trigger the same cortical areas in the brain as in the areas when such movements are executed in real life (Arzy, Thut, Mohr, Michel & Blanke, 2006; Astafiev, Stanley, Shulman & Corbetta, 2004). These are important findings because BCIs require that users control movement of game objects with their thoughts, not their body. In addition, regarding human-computer interaction, there is a lack of research on communication, user experience and user sense of control from a healthy person's brain to a computer in a game-based environment (Müller, Krauledat, Dornhege, Curio & Blankertz, 2004). BCIs are not a replacement for other modalities (e.g. physical movement), but can be used as one of multiple input modalities (Ko et al., 2009), although application and research is still rare in this area. While BCIs potentially afford richer game experiences, they bring challenges as well. Users are less likely to be able to control a BCI environment because it is difficult to concentrate on a consistent thought and maintain it through the course of use (Guger et al., 2009). Lack of full and seamless control may prevent users from enjoying game play

and pose bigger threats to learning in the case of educational games. However, Middendorf (2000) has shown that with practice users can become fluent in controlling their brainwave signals.

Sense of Control

Although sense of control has different constructs in the literature (see Stipek & Weisz, 1981 for a review), it generally promotes motivation (Boggiano et al., 1988) and self-efficacy (Schunk & Pajares, 2009) in academic settings. Likewise, providing sense of control over an activity is an important design consideration for intrinsically motivating instructional programs (Lepper, 1988) and is widely applied to the designs for effective Computer Assisted Instructions (CAI). In CAIs, research that examined the effect of control over the instructional programs on achievement revealed mixed results; however, research yielded consistently positive influence of the sense of control on user reactions (Hannafin & Sullivan, 1995). Needless to say, control has been identified as one of essential characteristics of games (e.g., Cordova & Lepper, 1985; Gee 2003). Therefore, this study also has relevance to questions about whether or not players' sense of control moderates the impact of a BCI on learning.

Rationale for Current Study

Incidental Learning in Games

Some studies (Filipczak 1997; Griffiths and Davies, 2002; Gee, 2003) have shown that online adventure games (i.e., MUDs) and fantasy role-playing games can provide opportunities for experiential learning, as these games are innately social and therefore support social and situated learning. These different types of learning occur either incidentally or intentionally through playing a game in different ways to become a better gamer (Dempsey et al., 1996). This is one of the reasons why educational game designers should consider incorporating an incidental learning strategy to an intentional learning task within a game (Mitchell & Savill-Smith, 2004). Prensky (2001) refers to incidental learning in games as "stealth learning" because the gamers would be learning the embedded content material "by accident" without realizing that learning is occurring (Oblinger, 2004).

Different Interfaces for Learning

Several studies reported that different interfaces in educational software lead to different learning outcomes. For instance, Han and Black (2012) showed that the use of a haptic interface was more effective than a non-haptic one in learning a physics concept from a computer simulation. Paek (2012) also reported better learning outcomes from a touch interface than from a mouse interface in mathematical learning. Most recently, education researchers have become highly interested in exploring the potential of BCI devices such as the Emotiv headset to see if they can offer a better understanding of the relationship between learning and cognitive activities (Goldberg, Sottolare, Brawner and Holden, 2011; Wehbe et al., 2013). Our particular interest in the current study is the device's potential to harness the overt thinking and concentration required to move on-screen objects and how this may promote vocabulary learning, i.e., learning abstract rune-like symbols and their association with English words.

Research Questions

The present study addresses the following overarching question: Does the use of the Emotiv BCI headset while playing a game promote incidental learning? This general question was addressed by evaluating the incidental learning of English word meanings for previously unknown, abstract symbols, and through a set of more specific questions, noted below.

1. When compared with the control group, does the use of the Emotiv BCI headset while playing a game result in better learning of English word meanings for unknown, abstract symbols?
 - (i) Within the Emotiv BCI headset group, do those who believe they are in actual control of the game learn more English word meanings for unknown abstract symbols than those who do not believe they are in actual control?
2. When compared with a control group, did the Emotiv BCI headset group report more fun?
3. When compared with a control group, did the Emotiv BCI headset group report more engagement?

We hypothesized that the use of the BCI will be positively related to learning outcomes, the users' perceptions of fun, control and engagement, and that the sense of fun, control and engagement will be an important factor predicting any learning gains.

Methods

Participants and Design

Participants were recruited through fliers on public billboards at a large-sized East Coast University. Volunteers who responded to the fliers for the first several months of the study were assigned to the Emotiv headset treatment group (TG). At the end of a cut-off period 72 people had participated in the TG. Volunteers who came to participate after this time were assigned to the control group (CG). At the end of the next cut-off period, there were 68 volunteers who had participated in the CG activity. On data analysis, it became evident that some CG data were not captured adequately, which resulted in a loss of 12 CG participants, yielding a CG of 56. Thus, 128 participants (TG $n=72$ and CG $n=56$) completed the study. In the TG, participants used the Emotiv headset to move objects in the game they were playing. In the CG, without the headset participants were asked to watch an animation of the same movement. There were two subgroups within the TG, those who reported that they believed they had full control over the gameplay and those who believed they did not.

Stimuli: The game and computer activity used in this study were designed by researchers to measure learning outcomes and user experience. The goal of the game was to have participants learn eight randomly presented, unknown symbols and their assigned English meanings.

Self-Report Questionnaires: To assess participants' gameplay and computer activity experience, quantitative data were collected during the game/activity. Three feedback questions on a five-point Likert scale were given in each of four rounds of gameplay on fun, engagement and sense of control.

Post-Interviews/Surveys: After participants completed the post-test, a semi-structured interview was conducted with the TG while the CG filled out an online post-survey of similar questions. Both groups were asked about the strategies used in the game/activity to memorize the symbols.

Data Analysis: Independent samples *t*-tests were conducted to test differences between Control and Treatment group on post-test accuracy. RM-MANOVAs were used to measure the possible change in players' game experience (i.e., perceived control, engagement and fun) over four rounds.



Figure 1: A Snapshot from the Game.

Figure 2: Feedback Screen.

Procedure

Participants were provided with an informed consent document upon arrival in the university's game lab. After each participant signed the document, the procedure was explained, and the participants from both TG and CG were asked to complete the pre-survey about their demographic information and their past experiences with computer games and game controllers.

The TG used the Emotiv headset to control the game. The headset was first calibrated to fit each participant to ensure that the EEG data were transmitted and recorded. Then, the participants were given a "Relaxation" task. They were asked to close their eyes for 90 seconds and quiet their minds and center themselves. Then they had a 7-10 minute training session on using the headset to control an onscreen activity: they practiced concentrating on a specific motion, which is moving a virtual object to the right. The next task was called "Persistence" (the participants were not told explicitly that they were being assessed for task persistence measurement). Participants were asked to look at two pictures that are similar but not identical and identify four differences (when in fact there were only three) using a computer mouse. The activity was timed for 15 seconds in each round and the participants could retry and repeat the round up to ten times. After the Persistence task, the participants proceeded to the Relaxation

task for the second time in order to quiet their minds before continuing to the “Game.” In the Game, participants were asked to move a symbol using the Emotiv headset to the right of the computer screen (see Figure 1) until the symbol overlapped with an English meaning. Participants were told to use the same consistent thought they practiced in the training to move the symbol to the right. They did this with eight symbols, presented in sets of two, with each set followed by three short Likert-scale questions. The questions asked about fun, sense of control and engagement after moving two symbols in each round of the four rounds of play (see Figure 2).

The CG participated in an on-screen computer activity and were told to use the computer mouse/pad only when they were asked to complete the survey within the computer activity. The computer activity was equivalent to the game given to the TG, only the CG group were asked to watch an animation of each of the eight random symbols moving to the right of the screen to overlap with their matching English meaning. As was the case for the TG, there were also four in-game surveys of three questions about fun and engagement after each set of two symbols were moved to the right of the screen. After the completion of all activities, both groups completed a post-test. Following the post-test, which asked participants to match each symbol with its English word meaning, the TG was engaged in a semi-structure interview and the CG completed a user experience questionnaire. Some of the interview questions included; “Tell me about your experience with the Emotiv headset”, “What were the strategies that you used to memorize the symbols?” Both groups received an online seven-day delayed post-test. If participants did not respond, a reminder was sent after another week.

Results

Accuracy

On average, the CG recalled 5.00 (SD = 2.61) symbols correctly and TG recalled 4.14 (SD = 2.62) symbols correctly. We found no statically significant difference between groups on their immediate recall test of matching symbols to English words ($t = 1.81$; $p = 0.07$; $\eta^2 = 0.026$).

Within the TG, an independent samples t-test was conducted to detect possible differences between subgroups who stated that they did, or did not, believe that they controlled the symbols’ movement in the game. Those who believed they did scored on average 3.81 points (SD = 2.66) on the immediate recall test, whereas those who did not think they moved the objects scored 5.00 points (SD = 2.36). However, this difference was not statistically significant ($t = 1.75$; $p < 0.08$).

There was also a statistically significant correlation between participants’ immediate test scores and delayed test scores ($p < 0.001$; $r = 0.67$). This means that people who did well at the immediate tests did well at the delayed test as well. However, we should keep in mind that for the delayed test there is a selection bias. It might be the case that people who believed they would do well completed the delayed test. However, as no feedback was given in terms of the immediate test result, this is unlikely.

Self-report game experience

Independent samples *t*-tests revealed statistically significant differences between CG and TG (see Table 1) for fun and engagement. Except in the final round, the TG reported significantly higher levels of Engagement than did CG. After the first round, TG reported significantly more fun than CG. Assuming the normality of the data, RM MANOVA was conducted to assess the difference between CG and TG in the amount of change in their ratings on the three items of the game experience. Prior to conducting the MANOVA, a series of Pearson correlations were performed between all the dependent variables in order to test the MANOVA assumption that dependent variables would be correlated with each other in the moderate range. This assumption was met.

	Levene’s		Independent Samples t-test			CG		TG	
	<i>F</i>	<i>p</i>	<i>t</i>	<i>p</i>	η^2	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Fun Round 1	0.44	0.510	-1.54	0.127	0.02	3.09	1.07	3.38	1.03
Fun Round 2	0.78	0.378	-2.39	0.001	0.08	2.77	1.25	3.44	1.00
Fun Round 3	0.76	0.386	-2.93	0.004	0.06	2.91	1.28	3.51	1.05
Fun Round 4	2.60	0.110	-2.06	0.042	0.03	3.09	1.38	3.53	1.03
Engagement Round 1	6.19	0.014	-3.52	0.001	0.10	3.46	1.19	4.14	0.91
Engagement Round 2	11.53	0.001	-4.54	0.000	0.15	3.20	1.34	4.14	0.89
Engagement Round 3	4.79	0.030	-4.46	0.000	0.14	3.13	1.38	4.08	1.06
Engagement Round 4	4.33	0.039	-1.72	0.080	0.02	3.54	1.39	3.93	1.14

Table 1: Statistics for Game Experience for Each Round

Since the *Box's M* value of 265.046 is associated with a $p < 0.001$, *Pillais' Trace* was used for the multivariate tests. A statistically significant MANOVA effect was obtained for the treatment, *Pillais' Trace* = 0.13, $F(2, 125) = 8.99$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.13$. The multivariate effect size was estimated at 0.13, which implies that 13% of the variance in the canonically-derived dependent variable was accounted for by treatment. A statistically significant MANOVA effect was also obtained for Rounds, *Pillais' Trace* = 0.19, $F(6, 121) = 4.71$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.19$, and for the interaction between Groups and Rounds, *Pillais' Trace* = 0.14, $F(6, 121) = 3.39$, $p < 0.005$. This means that there was a significant difference between CG and TG on player experiences over four rounds. Tests of the Between-Subjects effects table indicate that there is a significant main effect of group on Fun, Engagement and Control (see Table 2).

Source	Measure	SS	df	MS	F	p	Partial η^2
Group	Fun	31.63	1	31.63	7.46	0.007	0.06
	Engagement	69.48	1	69.48	17.77	0.000	0.13
Error	Fun	533.87	126	4.24			
	Engagement	492.77	126	3.91			

Table 2: Tests of Between-Subjects Effects of Group on Game Experience

Follow-up repeated measures ANOVAs for each dependent variable showed that main effects of round of play is statistically significant only for Fun, ($F(2.47, 311.68) = 3.01$, $p < 0.001$, $\eta^2_{\text{partial}} = 0.02$). Interaction between groups and rounds is statistically significant for Fun, ($F(2.47, 207.83) = 3.29$, $p < 0.05$, $\eta^2_{\text{partial}} = 0.03$) and Engagement, ($F(1.65, 207.83) = 4.64$, $p < 0.05$, $\eta^2_{\text{partial}} = 0.04$). This indicates that the change over rounds is associated with the intervention, but only for Fun and Engagement.

No statistically significant differences were found within TG's subgroups (believed they moved the symbols vs. not) on any of the game experience items except the sense of control in the last round. In that round those who believed they moved the symbols reported significantly higher sense of control than those who did not think they moved the symbols ($t = -2.23$; $p < 0.05$).

Relationship between Accuracy and Game Experiences

A total engagement variable was created by taking an average of engagement scores over four rounds. Similarly, a total fun rating was created. There is a statistically significant correlation between the total engagement and accuracy scores for immediate ($r=0.21$, $p<0.05$) but not for delayed post tests ($r=0.18$, n.s.). Similarly, no significant correlation was found between total fun and accuracy scores for immediate ($r=0.13$, n.s.) or for the delayed test ($r = -0.06$, n.s.).

Discussion and Conclusion

Although this research project is preliminary, findings from the study indicate significant implications for the research questions (RQ) noted earlier.

In terms of RQ1, immediate post-tests for both groups revealed that half or more of the symbols were learned from a baseline of zero, as the symbols were made-up abstract ones created by the researchers. The non-significant difference between the groups indicates that the TG did no worse than the CG. We believe the novelty of the BCI for the TG might have affected the results. Many participants reported that they felt moving the symbols were interruptive to learning, although experiencing BCI itself was enjoyable. Research suggests using movement that is conceptually congruent with the content, if the learning environment involves movement, improves learning outcomes (Black et al., 2012). Although BCI does not involve physical movements, imagined movement activates the similar region of cortex as the physical movement does (Arzy et al., 2006; Astafiev et al., 2004; Barsalou, 2008). Thus, future studies could investigate whether imagined and/or physical movement that is conceptually congruent with the knowledge affects learning outcome with gamers. In the self-report in-game/activity survey, majority of CG indicated they wished they had control over the movement of the symbols instead of passively viewing the animation. When comparing between those who believe they moved the symbols and those who did not within TG, there was no significant difference between the two groups.

In terms of RQ2, although there were no significant differences in post-tests for the two groups, the fact that the TG had more fun and was more engaged with the game is promising. Learning educational contents would normally be much longer than the time spent on the game in the present study. If learners are engaged and have fun in a learning environment, then positive learning outcomes are typically expected.

In terms of RQ3, the results show that participants in TG reported higher level of engagement overall than those in CG. However, over time (from first to last round), participants in both groups reported that their level of fun increased over the previous round of play. In addition, higher engagement resulted in higher scores in the immediate post-test. This supports the current literature on a correlation between engagement and learning.

The findings from the present study show potential for using the BCI in the game-based learning environment. The participants using a BCI headset learned new random symbols and their English-word meaning, and they did so as well as those who learned from watching an animated movement of the symbols. We feel it is impressive that such learning occurred even though the randomly presented symbols were seen only once for each symbol, for a relatively short period of time (averaging approximately 8 seconds). Given the BCI headset was a completely new interface to the participants, additional practice and experience with the interface could result in even greater learning. Moreover, the participants reported that using the headset was fun and engaging; they wanted to try it again. While our study did not find differences in sense of control between BCI players and animation watchers, this may well have been a result of the novelty and disbelief that the headset was actually being controlled by users' "thoughts." For example, we note that 20 of the 72 BCI users did not believe that they had controlled the symbols' movement. A greater sense of control could result as such interfaces become commonly used, familiar, and accepted by players. Given that BCI interfaces provide a more direct link between thought and action than interfaces to date, we encourage additional studies that address sense of control with users of such devices.

In summary, the positive responses we received regarding perception of fun and engagement, and the fact that half of the unknown symbols and English word meanings were learned in essentially one trial, imply that a BCI headset has potential for gameplay, including games that embed learning activities.

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Project NEO: A Game to Promote STEM Teaching in Middle School by Changing Attitudes and Skillsets of Preservice Teachers

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Introduction

The number of STEM majors needed to meet the expected needs of our future workforce will grow, yet fewer students are choosing to major in STEM areas, and those who do may be underprepared (Broussard, La Lopa, and Ross-Davis, 2007; Langdon, McKittrick, Beede, Khan, & Doms, 2011). This has led many to suggest that middle school students should be targeted for improving STEM competency and career interest, yet evidence suggests that their teachers are themselves underprepared (Darling-Hammond, 2000; Llewellyn, 2002). Further, middle school students can only benefit if they have the foundational STEM knowledge from their elementary school years, which is often not the case (Ball, Lubienski, and Mewborn, 2005; Wu, 1999). In part, this results from elementary teachers' weaknesses in procedural and conceptual understanding (Hawk, Coble, and Swanson, 1985). Unlike middle school and high school science teachers, who must meet credentialing requirements to ensure competency in their disciplines, elementary teachers teach all subjects and are not credentialed in any subject. During their college education, most elementary teachers are exposed to science content only through lower-division college courses that are not necessarily aligned with teaching standards (California Council on Science and Technology, 2010). Because elementary teachers typically graduate from college with a weak understanding of scientific principles, they lack confidence in and enthusiasm for teaching science (Jarrett, 1999; Stevens & Wener, 1996). Therefore, interventions planned for the middle school level must be preceded by interventions for elementary teachers (Hill, Rowan, & Ball, 2005), and they must begin during preservice teacher (PST) education, before teaching habits and philosophies are formed.

Project NEO

The goals of *Project NEO* were to see if a game built around the next generation science standards (NGSS Lead States, 2013) standards could 1) improve PSTs' attitudes toward science; 2) improve science competency for PSTs; 3) improve PSTs' attitudes toward games in the classroom, and 4) improve PSTs' attitudes toward teaching science. This phase I project, funded by the NSF, designed, developed, and tested a game based on the NGSS to help elementary PSTs learn some of the more challenging content they and their future students will face. This foundational knowledge may be critical to their ability to teach and confidently model science expertise for elementary students who may, in turn, enter middle school with more skills, confidence, and positive attitudes toward science.

The project team took an initial grouping of interrelated science concepts from the NGSS focused around Earth and space science and the life sciences and connected them to the stages of the 5E Learning Cycle model—engagement, exploration, explanation, elaboration, and evaluation (Bybee, 1989). Learners participate in activities that introduce and teach introductory concepts related to the sun, earth, and moon system (SEMS) and related patterns that impact day/night hours, seasons, plant life, etc. This content was selected in part because of persistent, generalized misconceptions about the content by teachers and the general public, and because they allow broad coverage of the NGSS.

The game was designed around the 5E model (Bybee, et al., 1989), which focuses on cycles of instruction through 5 phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Each of these phases corresponded to different parts of the game. The Engage phase led to the development of a narrative that comprises 3 videos (Figure 1). The game begins with our heroine, Talia, being recruited by a league of scientists to help protect Earth from sudden climate changes created by the villain who wants to wipe out certain kinds of plant life. The exact mechanism by which he is doing this is unknown to Talia and the agency in the beginning, so Talia is tasked with determining which plants could survive under which kinds of climates so scientists can ensure survival of the species (the Explore phase). Primary game play occurs on a map-driven board that shows the Earth's continents distributed across latitudinal and longitudinal lines (Figure 1). Students explore characteristics of various plants and must drag, drop, and reorder specific plants to create matches that allow the plants to survive in different regions of

the Earth based on the changes caused in seasons and day–night hours by the villain’s manipulations. The gaming elements (Figure 1) allow the students to practice concepts related to unit topics using a casual game interface and cut scenes that tie back to the overarching narrative. Immediate feedback is built into all gaming activities, and all performance and task data are collected via a robust backend database. After each level, the player is required to provide a scaffolded explanation of what they think is going on (Explain). In the process of conducting her tests, Talia (the player) uncovers patterns related to latitude and longitude and to day and night hours that lead to a deeper conceptual understanding of the Earth and its orbit around the sun. The Elaborate phase does not become fully developed until the latter levels as the positions, plants, and time all combine to elaborate on the central topic of Latitude, season changes, and the day/night hour ratio. This leads her to the realization that the villain is really shifting the Earth in it’s orbit around the Sun. Once they know the mechanism the villain is using, the scientists are then able track the device he is using and to ultimately disable it.

Future modules developed in Phase II will expand on this narrative and focus on concepts like angle of inclination, axial tilt, rotation, and the interrelation of these factors as they impact geology, climate, flora, and fauna on the Earth, which is when the evaluation phase comes in. These levels, when fully developed, result in a full-scale inquiry-based learning game that helps the learner solve a bigger science challenge on the interrelation of day–night, latitude–longitude, axial tilt, rotation of the Earth, and the effects on Earth’s flora and fauna and society. A mega-level narrative about a villain attempting to cause multiple catastrophes on Earth in a variety of ways, culminating in the destruction of the Earth by an asteroid (near Earth object, or NEO) is introduced at the beginning of the unit and drives all science inquiry and learning across the full game.

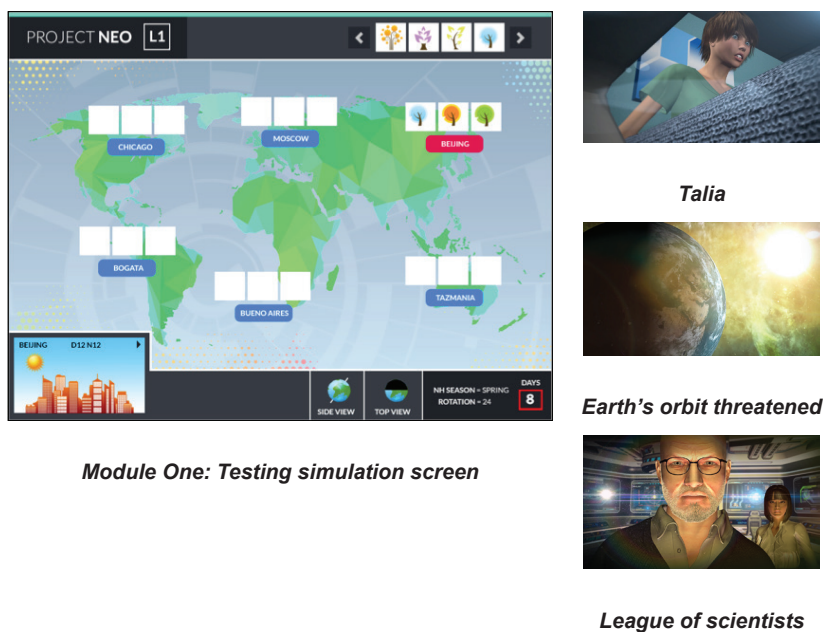


Figure 1: The primary Project NEO game screen and key frames from three narrative videos.

Methods

A mixed model within-subject pretest–posttest and repeated measurement design was used to test the impact of classroom instruction and game play on science content knowledge and attitudes toward science. The video game is intended to be used in PST science education classes as well as a stand-alone product, so knowledge and attitude measures were administered at key points throughout the project to assess the impacts of classroom instruction and the video game itself.

Sample

Twenty-two of twenty-four PST education majors in an Earth and science education course at an upper Midwest university agreed to allow their class assignments (which included playing the game) to be used for research purposes. The class covered science material related to topics of the Earth’s layers, rocks and the rock cycle, plate tectonics, weather, energy use, astronomy, planets, and the solar system. Of the 22 who signed consent forms, 14 completed all phases of the study, for a 64% completion rate.

Instruments

Attitudes Toward Teaching Science (ATTS) were measured by using selected items from the Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science, or ABNTMS (McGinnis, Watanabe, Roth McDuffie, Kramer, & Shama 1997; McGinnis & Watanabe, 1999). Subscales used included modified version of the Beliefs about Teaching Mathematics and Science (BTMS), the Attitudes Toward Learning to Teach Mathematics and Science (ALTMS), and the Attitudes Toward Teaching Mathematics and Science (ATTMS).

Attitudes Toward Science (ATS) were measured using modified versions of the Beliefs about Mathematics and Science (BAMS) and the Attitudes Towards Mathematics and Science (ATMS) from the ABNTMS discussed in the previous section, as well as the TOSRA (Fraser, 1981) "Inquiry" subscale.

Game Feedback Survey (GFS) is a paper-and-pencil two-item anonymous survey that asks PSTs to rate the extent to which the game helped them learn or better understand science content.

Science and Game Reflection (SGR) was a series of five open-ended questions about the game and the science content it covered. This was administered as a paper-and-pencil take-home assignment.

Science Test (ST) comprised science content items relating to season, axial tilt, latitude and longitude, and position of the Earth in its orbit around the sun. Items were developed by the science educator teaching the course on Earth and space science. Items 1 through 6 are multiple choice questions worth one point each. Items 7 and 8 are open-ended items that test conceptual understanding.

Teachers' Attitudes Toward Games (TATG). There are currently no validated, reliable measures of teachers' attitudes toward games in the classroom. Several studies have reported using different instruments to measure this construct, but they are not available nor have they been validated. Further, none of these instruments appears to be based on an established theoretical framework for measuring teachers' attitudes toward technology as a teaching tool. Therefore, a new survey was developed based on Fullan & Stiegelbauer's (1991) first-order and second-order barriers, later adapted by Ertmer (1999) to apply to adoption and diffusion of technology in K-12 classrooms. Sixteen existing game attitudes and use surveys and several articles that reported findings based on unpublished scales were first identified and the questions, constructs, and/or outcomes were then categorized as first- or second-order barriers. There are 83 Likert-type items on this test that use a 5-point scale.

Procedure

On October 21, 2013, the science content pretest was administered to the participants. During the following week, the students learned about material in class that was related to the content included in the *Project NEO* game. On November 18, the students completed content posttests with the same questions from the pretest in order to measure their learning from the unit in class. After completing the posttest, the students were given instructions regarding how to log in, create accounts, and play the *Project NEO* game. During this time, the students' amount of game play was tracked. On December 9, the intervention phase was closed, and participants completed the posttest surveys.

Results

H1: PSTs will demonstrate more positive attitudes toward science after playing the game. Descriptive statistics and paired T-tests were run to examine this. Attitudes did not go up, which is not surprising given the short-term duration of the intervention. Scores on science inquiry went down by .40, however, which is surprising ($t(12) = 3.128$, $p = .009$). One explanation is that the findings could simply be an artifact of regression toward the mean as a result of a ceiling effect. Pretest scores were 4.16 on the TOSRA scale, which is very high. The chances of these scores going up are significantly less than them going down. Final scores were still positive (3.75 out of 5), indicating that teachers were still positive about science inquiry as a way to teach science

Further, the entire class is focused on the implementation and value of inquiry-based learning and hands-on manipulation of materials to reinforce scientific understanding. Discussion of hands-on–minds-on learning during this course routinely results in positive comments about the value of this approach to teaching science. Analysis of the reflection papers from the elementary classroom visit these students made to deliver inquiry-based science education *during the time the game was being implemented* clearly show that students were very positive about the idea of inquiry-based learning. It may be that the drop in scores is due to the instrument design itself. The five-point Likert-type scale is anchored by Strongly Agree on the left side and Strongly Disagree on the right side. Students may not have interpreted the categories correctly, believing that values to the right of the scale indicated agree-

ment rather than disagreement. This latter possibility and the first explanation (ceiling effect) are strengthened by the students' self-reported overall experience of the game, which was positive.

H2: PSTs will demonstrate better conceptual science understanding after playing the game. Scores on Items 1–6 increased from preinstruction (3.46) to postinstruction (4.53) and postgame (4.69). Scores on Items 7–8 increased from preinstruction (2.38) to postinstruction (5.30), but decreased at postgame (4.76). Gains were generally distributed across all items. Paired t-tests showed that changes in all item scores were statistically significant from pre- to postinstruction. Scores on the same tests (totals of Items 1–6 and 7–8) after the game were also higher, although the differences were not statistically significant, with the exception of Items 2 and 7; Items 6 and 8 actually decreased.

Item 2 focuses on the conceptual understanding of the path of the sun and was directly tied to the animations of the sun in different cities within the game. Item 7 is an open-ended question focused on the relationship of day–night hours and latitude and longitude designed to assess conceptual understanding rather than factual knowledge. Both questions are directly addressed through gameplay. The increase in this score is evidence that students improved in their understanding of these concepts overall.

Item 6 focuses on how long it takes the Earth to turn on its axis, and Item 8 assesses the strength of the learner's mental model of how and why seasons occur in the first place. Because of modifications to the game during the design process, in which planned content had to be reallocated across future games in order to manage learner cognitive, neither of these concepts was directly represented or tested during gameplay. Thus, the decrease in scores on these items reflects the natural decay of knowledge after instruction (i.e., they forgot what they knew about this content from the classroom instruction phase of the study). Science content that was addressed by the game thus negated knowledge decay across the board or increased both factual and conceptual understanding. Further, in many cases, it would have been more likely to observe decreases by virtue of a regression toward the mean. Given the low power yielded by the small sample size (a 52% chance of detecting a directional increase in scores for a large (.5) effect size, and less than a 10% chance for a small (.1) effect size), *any* increases are significant.

Finally, analysis of individual test items and mastery-level scores indicated that there were more people at mastery on all but Item 6 at posttest for the game than at the beginning. Of particular note, the number of people at mastery for Item 2 increased by 24% as opposed to a 14% increase observed from pre- to postinstruction. Likewise, where no increase in the number of people at mastery was observed for Item 3 from pre- to post-instruction, there was an increase of 15% at mastery from pre- to postgame. That none of the class had a perfect score across all items is evidence that the content remains challenging for students and thus is a suitable subject for innovative methods of instruction like game-based learning. Focusing on this content over the course of one or two more games should lead to increases in learning.

H3: PSTs will demonstrate better attitudes toward games in the classroom after playing the game. Surprisingly, PSTs had a more positive attitude toward games at pretest (i.e., they saw fewer barriers) in the classroom than previous literature has suggested. Scores on measures of first-order barriers (those seen as external constraints such as access or support for technology) were in the positive range, meaning that PSTs did not say such barriers were prevalent, although PSTs tended to believe that these barriers could exist. These opinions do not reflect the actual state of affairs in K–12 schools, of course, as PSTs have not had any significant experience teaching at this point in their education. Still, it is encouraging to know that they do not enter the field with strong beliefs that first-order barriers are prevalent. Second-order barriers (those that tend to be related to internal beliefs and attitudes of teachers) at pretest were even more positive overall than first-order barriers.

Another surprise was that posttest scores tended to be lower across the board than pretest scores indicating that the game made PSTs come to believe there could be more barriers to the use of games than they had initially thought. There are two things to keep in mind when interpreting this finding. First, while the drop was *statistically* significant, it was not large (.18), which leaves the rating between “no opinion” and “agree” that such barriers do not exist. Second, because the vast majority of PSTs here are infrequent gamers (Salentiny, 2012; Van Eck et al., 2013), PSTs may have had naive expectations about the challenge and time that playing a game entails. Their initial ratings of barriers are not based on any meaningful teaching experience in the schools nor upon any meaningful experience playing games. Thus, PSTs may not realize how difficult games are and how restrictive classrooms and schools may be. After playing the game, and after teaching four science units in existing schools as part of their Earth and Science course, PSTs may have come to realize that their initial beliefs were not realistic. Games are difficult to play and even more difficult to integrate into the classroom (Van Eck, 2008), which is something PSTs may not realize until they have played games and taught in classrooms.

H4: PSTs will demonstrate better attitudes toward teaching science after playing the game. Overall, participants had positive beliefs about science and teaching science to begin with (tended to “Agree” with positive statement about science), and these did not change over short duration of this study. On average, participants scored between 3.6 and 3.9 on the modified BAMS subscale, 3.3 on the modified ATMS subscale, between 3.8 and 4.0 on the modified BATS subscale, between 3.85 and 4.15 on the ALTMS subscale, and between 3.08 and 3.23 on the ATTS subscale. Paired t-tests indicated none of these differences were statistically significant. Given the high initial scores and the short duration of the game (generally less than 2 hours), it is not surprising to see little change in attitudes. Such changes may be more likely once the full game has been developed and implemented.

Conclusion

Overall, the game appears to be effective. The product is effective in promoting science learning, can be integrated effectively into science education classes, and makes use of a model that is extensible to other science content. Gains in science content were seen for those areas directly addressed by the game, which is the first of several planned games on the topic. These gains were above and beyond what occurred as part of classroom instruction, indicating that the game can be effective as a stand-alone product. For the purposes of this evaluation, the game was kept separate from the classroom instruction in order to test the game’s additive effect on classroom instruction. If the game and the classroom instruction were deliberately integrated and used concurrently, however, there could be a synergistic effect on learning that exceeds what was found in this evaluation. Because the game does work on its own, there is promise for its use in homeschooling and self-study informal learning environments as well.

Whether the game can effect attitude change toward science and games in the classroom is yet to be determined. The small sample size of this study is not sufficient to detect such differences if they exist. Further, attitudes and beliefs often take a long period of time to change, and this intervention was approximately one-fifth of the final planned product. Participants played less than 2 hours in most cases, which is likely not long enough to effect attitude change in any regard. This is especially true given the high (positive) attitude scores of participants at the start of the study, which made changes harder to detect (the effect size would be limited by the upper bound of the instrument to measure attitude change). It remains to be seen whether this sample is atypical in this regard or not. If not, then it may be that future interventions need only focus on having teachers use games like *NEO* to improve their own learning, without having to overcome barriers toward the games’ acceptance in the first place. Likewise, future interventions using games as instructional tools in the K-12 classroom might be able to focus on teaching teachers how to use games for instructional purposes in their classes without overcoming those barriers.

It should be noted that having positive attitudes toward games and science is no guarantee that PSTs will be *successful* in using games or in teaching science. Part of the goal of this project was to address documented shortcomings in PSTs’ conceptual knowledge of science. One’s attitudes toward science are impacted by how well one actually knows the subject. If PSTs don’t have an accurate picture of their own science competence, their attitudes are of less predictive value. In other words, a PST who thinks he or she is great at science but actually is not will be overconfident. While this may lead to PSTs pursuing science lessons as a teacher without trepidation, the PSTs confidence is built on an insecure foundation and will change when he or she is confronted with gaps in knowledge. We do not want to send PSTs out to teach science with positive attitudes unless it is founded on experience and backed by competence.

Elementary PSTs don’t get a lot of exposure to science education once they are done with their general education requirements, so it may be that they have not yet learned how far they have to go. Once they do, their attitudes toward science may shift. We cannot know with certainty where our sample are on this continuum, but even with the observed gains from the class and the game, no students were at mastery level, indicating they may yet have a way to go, regardless of how confident they feel.

Likewise, positive attitudes toward games shows that teachers perceive there to be few external or internal barriers to using games. But here, too, their lack of experience may undercut the predictive value of their attitudes. They have not yet taught in the schools, so they do not know what first-order barriers do or do not exist. And because (at least these) PSTs are lower users of technology than other majors in many regards, including games, positive attitudes toward games at this time (i.e., without experience) may not be a worthy end goal. When it comes to attitudes in PSTs, we may actually need to look for an initial drop in scores as their beliefs become aligned with reality (competence and experience), followed by an increase over time as first competence and then positive attitudes increase. This argues for a multipoint observational protocol, which will be adopted in future evaluations.

Evidence continues to mount that shows the myth of the digital native is just that. Younger college students may be more exposed to technology, but their knowledge is shallow and they need both fluency and literacy training in

technology integration. It may well be that the more PSTs are exposed to gaps in their science knowledge and to games as an activity they must complete, their attitudes toward both will change; dropping first as perceptions are aligned with reality, and later becoming more positive as they become more competent with science and games. Interventions like this should include training on games and gameplay and should do so as part of a comprehensive training program that connects the game to both learning (in PST education) and teaching (in K-12 classrooms).

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A Framework for Conducting Research and Designing Games to Promote Problem Solving

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Statement of the Problem

Many have argued that games address critical thinking and problem-solving skills (e.g., Gee, 2007; Greenfield, 2010; Van Eck, 2006 & 2007). Unfortunately, what research exists on this tends toward the descriptive rather than the empirical. Descriptive analysis can illustrate how some kind of problem-solving *process* is occurring within a game (e.g., scientific method), but it cannot tell us about the *kind* of problems, how often they occur, for how long, and, most importantly, how effective a given game is at promoting problem solving skills. This distinction is critical to the advancement of claims about games and problem solving. While we may all agree that games are problems and that completing games means players are engaged in successful problem solving, we cannot say what kinds of problems players are able to solve, nor what kinds of games and game features may support (or inhibit) different kinds of problem solving. Problems vary by domain, cognitive requirements, and many other factors; if we want to design games for specific learning domains, we must understand these problem types and how they may relate to different kinds of game play. This will require rigorous, empirical testing and design of games for each kind of problem solving we are interested in.

Unfortunately, we are not prepared to conduct the kind of research that will answer these questions. Current game taxonomies are inconsistent and often contradictory, having their origins in film studies and relying on common parlance. Conducting empirical research on problem solving and games will require that we be able to manipulate and control for different types of games so that we can examine what *kinds* of games promote problem solving better than others. At the same time, we recognize that games that share the same genre can be very different experiences and that some games cross genre boundaries (e.g., action-adventure). Even were this not the case, any given game is likely to vary in terms of pace of play, amount of interactivity required, number of problems presented, and so forth. These are differences that must somehow be accounted for.

This challenge is compounded by a lack of awareness on the part of most serious games researchers regarding existing problem types and problem-solving research. We require the same level of precision in our treatment of problem solving as we do in our definition of game typologies. To design a game to promote problem solving, we must know what kind of problem we are interested in: creating a menu for guests who have different diet restrictions, troubleshooting a car that won't start, diagnosing a patient's back pain problem, or solving global warming? Each type of problem differs significantly in structuredness, requirements for prior knowledge, ability to embed other subproblems, and cognitive structure, and therefore require different means of instruction (or game design).

Fortunately, cognitive psychology and instructional design have been studying problem solving for many years, and a rich body of research exists which can help inform our studies and design of problem solving in games. In this chapter, we attempt to bridge theory and practice by examining the relationships between games, problems, their cognitive processes, and instructional design. It should be noted that this framework is only a start; we have no more empirical evidence for the problem typologies we reference and rely upon than game researchers do for the ability of games to promote those different types of problems. Yet theoretical research on problem solving exists which has been studied, evaluated, and conceptually validated through peer review. This seems a good place to begin the process of generating empirical evidence for problem solving and games.

Theoretical Framework Problem Solving

It is generally accepted in cognitive psychology that a problem has an initial state and a goal state. The initial state is the set of information and resources present at the beginning of the problem. The goal state is the information and resources that will be present when the goal has been met. The problem solver uses a representation of that goal state when considering how to proceed, which usually takes the form of doing things to reduce the disparity between the initial state and the goal state. The strategies s/he uses and the process by which s/he thinks about moving toward the goal state within the constraints of the problem and his/her prior knowledge are collectively referred to as the problem space. Most recently, Jonassen (2000, 2002) and Jonassen and Hung (2006, 2008) have proposed a typology of problems and associated prescriptions for the design of problem-based learning and

instruction to promote problem solving in general. If games themselves are examples of problem solving, they should share to the same kinds of characteristics as different problems have. A closer inspection of this literature to see if and how it can be mapped to the study and design of serious games may yield important findings.

Games and Problem Solving

Jim Gee (2007) has argued that all games are situated, complex problem solving, and others have made the same point (e.g., Kiili, 2007). The core of our argument is that problems are highly differentiated by context, purpose, and domain, that different types of gameplay have their own affordances, and that it is necessary to understand problem types and gameplay types in order to align them meaningfully in the design of games to promote problem solving, or to conduct research on the effects of gameplay on problem-solving skills. There are three dimensions upon which a problem itself may vary: structuredness, cognitive components, and domain knowledge. Space does not allow a full accounting these dimensions, and the reader is referred to our work on this elsewhere (Hung & Van Eck, 2010). Likewise, we rely on an in-depth analysis of gameplay types, which we are able only to touch upon here, and the reader is referred to the aforementioned chapter for full accounting of gameplay types and interactivity.

Problem Structuredness

Jonassen (1997) argues that structuredness describes the *reliability* of the problem space in terms of the ratio of the information about the problem known and unknown, the number of variables, the number of possible solutions, and the degree of ambiguity involved in being able to assess one's success in solving the problem. Video games (or, more precisely, the gameplay that makes up different video games) also vary on a continuum from highly structured to poorly structured, so structuredness becomes one dimension upon which we can categorize both games and problems.

Cognitive Processes in Problem Solving

Solving different problems also relies on different kinds of cognition. There are six main cognitive processes relevant to problem solving as we discuss it: Logical thinking (the mental process that infers an expected event as a result of the occurrence of its preceding event or evaluates the validity of the conditional relations of these events), analytic thinking (identifying and separating an object, essay, substance, or system into its constituent components, examining their relationships as well as understanding the nature, behaviors, and specific functions of each component), strategic thinking (an integration process of synthesizing and evaluating the analytical results of a given situation and generating the most viable plan with intuition and creativity), analogical reasoning (the mental process by which an individual "reason[s] and learn[s] about a new situation (the target analogue) by relating it to a more familiar situation (the source analogy) that can be viewed as structurally parallel" (Holyoak & Thagard, 1997), systems thinking (the cognitive reasoning processes that consider complex, dynamic, contextual, and interdependent relationships among constituent parts, and the emerging properties of a system, (Capra, 2007; Ossimitz, 2000), and metacognitive thinking (the cognitive process that an individual is consciously aware of and which he or she articulates to various aspects of his or her own thinking processes). Different problems and different kinds of gameplay will support these types of thinking in different ways. Therefore, they become important for understanding how gameplay and problem solving can be aligned.

Domain Knowledge

In addition to structuredness and cognitive composition, problems will vary by the domain knowledge they require. There are many kinds of domain knowledge that may be required for problem solving including declarative knowledge, procedural knowledge, concepts, and principles. It is not necessary to be an expert in applying this terminology so much as it is critical that each type of knowledge be explicitly examined during the problem design stage to ensure that all domain-specific prerequisite knowledge be identified, classified, and pretested. We argue only that if the designer's goal is to promote problem solving and that problem requires prerequisite knowledge, one must include prerequisite knowledge as a design goal or the problem must be reconceptualized such that it does not require that prior domain knowledge.

Classifying Gameplay Types using iGrids

The variance of problems along dimensions of structuredness and cognitive processes presents one challenge to the research and development of games for promoting problems solving. Yet games themselves vary greatly as well, as can be seen in classification systems (e.g., Apperley, 2006; Frasca, 2003). And because no one classification system is widely accepted nor completely compatible, our task is made even more difficult. Games often employ multiple gameplay strategies from different genres within the same game, leading to hybridized descriptions like action-adventure that work against meaningful classification. So how are we to distinguish among games (or types of gameplay) in a way that makes possible the empirical research and design of games to promote problem solving? While serious game researchers may not agree on different game genre classifications, most might agree that interactivity is one of the hallmarks of video games. This provides one means of classifying gameplay in a way that crosses all game types:

The smallest unit of interactivity is the choice. . . . Choices are made in time, which gives us a two-dimensional grid of interactivity that can be drawn for any game. First, in the horizontal direction, we have the number of simultaneous (parallel) options that constitute the choice that a player is confronted with at any given moment. Second, in the vertical direction, we have the number of sequential (serial) choices made by a player over time until the end of the game (Wolf, 2006).

Wolf (2006) calls this a Grid of Interactivity, and we refer to them as iGrids. Frequency of choice and number of choices make good initial measures of pace, complexity, and cognitive load, and we believe these constructs impact problem solving and problem typology differentially. Wolf points out that it is not possible to map an entire game space on a graph, nor do we mean to suggest they otherwise. Nonetheless, such plots remain a useful tool for conceptualizing the issue of interactivity and one which we can rely on as a first step to further defining the kinds of gameplay that differentially support different problem types.

Although genre-based taxonomies of games are problematic, for now we will refer to genre-based terminology for the purposes of illustration. To understand an iGrid, imagine Aristotelian archetypes of different game genres such as “action” and “simulation” (see Figure 1).

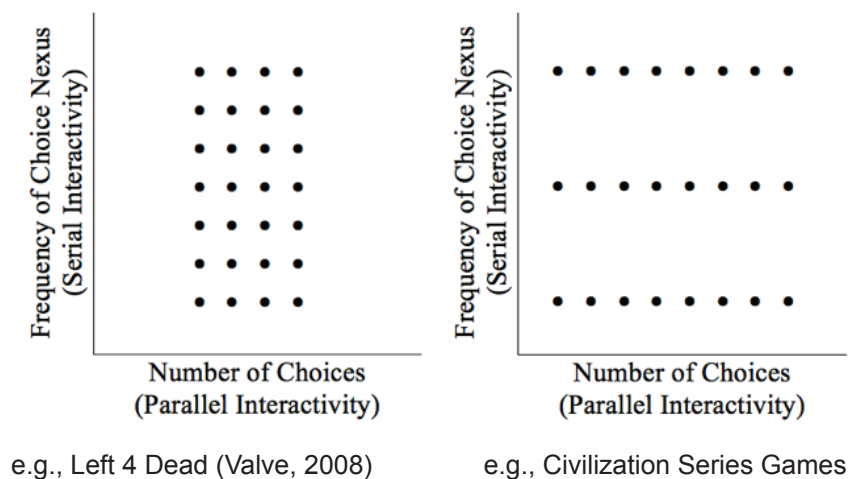


Figure 1: iGrids for two different gameplay types.

The x-axis represents parallel interactivity, which is the number of choice options a player has at a given point in time (called a choice nexus), while the y-axis represents how often the player is presented with a choice nexus. For example, the game represented by the iGrid on the left of Figure 1 forces the player to make choices frequently over the course of the game with little time *between* choices but presents *few options* to choose from at those points. In the iGrid on the right, we see a game that presents *many options* to choose from but which forces the player to make choices *fewer times* over the course of the game with long periods of time between choices. Of course, there are action games with more parallel choices (e.g., weapons, running vs. hiding, inventory, armor, etc.) and periods of gameplay with lower choice nexus frequency. Likewise, games like those in the Civilization series *allow* near-continuous serial opportunities for interaction, but they do not *require* it.

iGrids, as measures of gameplay, become useful tools for discussing the differences in games that are likely to impact learning. While not sufficient on their own to fully delineate different types of gameplay, they at least provide an additional point of reference for communicating what is meant by whatever labels we use to describe games

(e.g., action or strategy). Further, and most importantly, they allow us to describe *gameplay*, which after all can vary dramatically over the course of a single game. It will be important to be able to describe the key characteristics of gameplay in our quest to measure the ability of different types of gameplay to promote different types of problem solving.

By combining iGrids with an analysis of game/gameplay types using the same dimensions and characteristics that are used to differentiate problem types, we are able to develop a framework for describing games/gameplay that makes further study possible. In our discussion, we rely on terminology regarding gameplay which we have fully articulated elsewhere (Hung & Van Eck, 2010). Rather than generate new terminology and labels for the resulting taxonomy, we rely on existing taxonomies (e.g., Apperley, 2006) with some modifications. The resulting classifications are in some cases significantly different than common parlance, however. For example, Frasca's (2003) classification would list *SimCity* and *Flight Simulator* as simulations, whereas our analysis of gameplay suggests that *SimCity* is a strategy game (optimizing a system by strategically balancing factors) and *Flight Simulator* is a simulation game (a test of coordination of perception, cognition, and muscular control). Likewise, Apperley's classification would put FIFA Soccer and *SimCity* together as simulations, whereas we maintain that gameplay and cognitive characteristics make FIFA Soccer an action game. Space does not allow a full accounting of game play types (Action, Strategy, Simulation, Adventure, Role-Playing, and Puzzles), but Figure 2 presents the iGrids for each type.

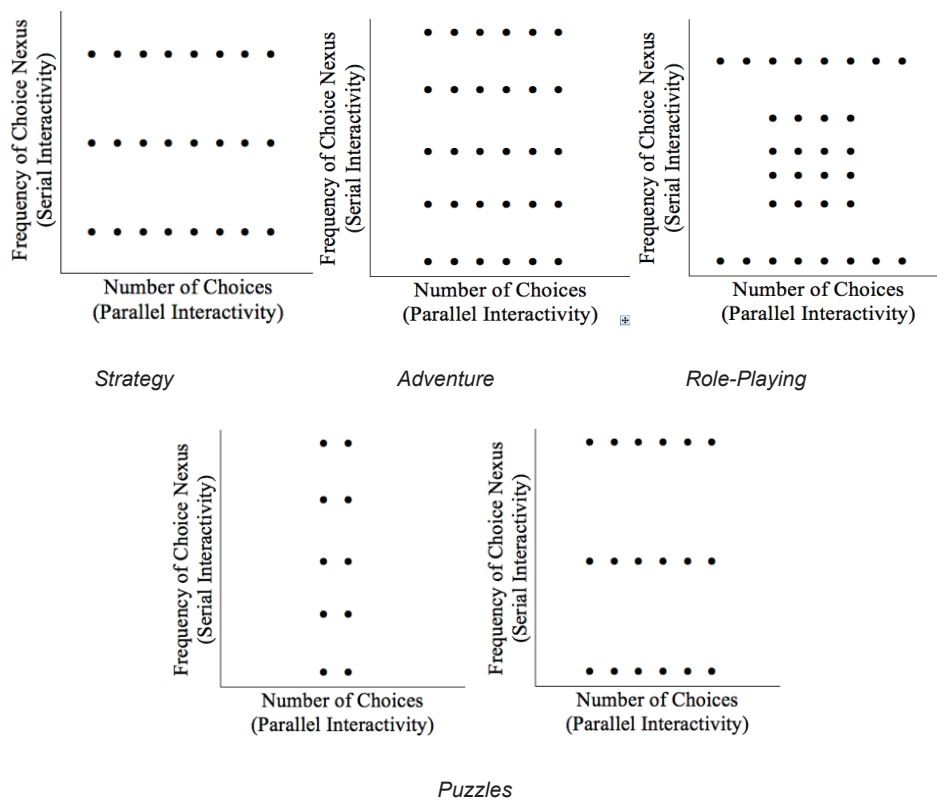


Figure 2: iGrids for five other gameplay types.

It should be noted that our categories are not intended to represent entire games as products; any given game will embed a variety of these gameplay types. But by focusing on the essential characteristics of gameplay *at any given moment*, we can make better determinations about what kinds of learning activities may or may not be best supported at a given time.

Problem Typology

Now that we have outlined our gameplay typology, we turn our attention to problems themselves. Jonassen (2000) has constructed a comprehensive typology consisting of 11 types of problems:

- Logical problem
- Algorithm problem
- Story problem

- Rule-use problem
- Decision-making problem
- Troubleshooting problem
- Diagnosis-solution problem
- Strategic performance problem
- Case analysis problem
- Design problem
- Dilemma problem

Space does not allow for a full accounting of all these problem types and examples. The reader is referred to Jonassen’s text referenced above, as well as our previous work (Hung & Van Eck, 2010). Suffice it to say that each problem type varies along key dimensions of cognitive composition (e.g., types of reasoning), structuredness, and requirements for domain-specific knowledge.

Blending these dimensions with iGrids and our analysis of gameplay types, including game-specific dimensions like psychomotor skills and the affective domain, it becomes possible to align problem-types and gameplay types along the dimensions that both share, and thus propose a framework for which kinds of gameplay types will support which kinds of problems, best (see Figure 3).

Knowledge and Cognitive Process														
Problem type ↓	Domain-specific knowledge ¹				Higher-order thinking					Psychomotor skills ²		Attitude change ²	Game type ↓	
	Declarative	Procedural	Concepts	Principles	Logical	Analytic	Analogical	Strategic	Systemic	Metacognitive	Muscular movement	Muscular-cognitive coordination		Shift of belief system
Logical					+	+								Adventure; Puzzle
Algorithmic		+	+	+	+									Adventure; Puzzle; Action
Story	+	+	+	+	+	+	+							Adventure; Puzzle
Rule-use	+	~	~	+	+	+								Action; Strategy; Roleplaying; Adventure; Puzzle
Decision-making	~	+	+	+	+		+	~	~					Action; Strategy; Roleplaying; Simulations; Adventure
Troubleshooting	+	+	~	+	+	+	+	~	~					Simulations
Diagnosis-solution	+	+	+	+	+	+	+	+	+					Simulations; Strategy
Strategic Performance	+	+	+	+	+	+	+	+	+	+	+			Action; Roleplaying; Simulations; Adventure
Case Analysis			+	+	~	+	+		~	+			~	Strategy
Design			+	+	+	+	+	+	+	+				Strategy
Dilemma				+	+	+	~	+	+	+			+	Strategy; Roleplaying

1 For Psychomotor Skills and Attitude Change: domain-specific procedural and principle knowledge and metacognitive thinking are assumed.

2 For the learning type under Domain Knowledge, application of the knowledge is also assumed in this chart.

+ signifies “always required.”

~ signifies “sometimes required.”

Figure 3: Framework for aligning problem and gameplay types.

This allows for both the design of games to promote specific kinds of problem solving and for the design of research to test the effects of varying specific kinds of gameplay on different kinds of problem solving. We can then also examine things like varying pace of play, frequency of problem solving, length of play over days, and other variables to establish heuristic design models and an empirical research base on problem solving and games. Knowing about different problem types allows us to see existing games in a new light. For example, dilemma problems can be seen in persuasive games such as *Darfur is Dying* (mtvU, 2009). But more importantly, knowing how those problem types themselves vary along the dimensions of domain-specific knowledge and required cognitive processes shows us that what superficially may appear to be similar games are in fact quite different in

terms of their ability to support problem solving. For example, many might say that *September 12* (Newsgaming.com, 2003) and *Darfur is Dying* are both dilemma games, when in fact *September 12* is too well structured and stripped of context to fully support dilemma problems.

Relying on iGrid typologies of gameplay rather than on genre classifications similarly promotes more precise analyses of games and problem solving. By focusing on archetypal gameplay styles, we can see how strategy and role-playing games seem best suited for dilemma problems, for example. Further, we are able to apply this reasoning to hybridized games that might at first glance appear to not support different kinds of problem solving. Space does not allow a full accounting of every problem type and every gameplay type (iGrid), nor how they each are aligned, but this general description and the following example may suffice to illustrate the logic behind blending them.

Extending our example of the dilemma problem, the game *Bioshock* (2K, 2007), which many might categorize as adventure-action hybrid, is in fact a hybridization of action, adventure, and strategy. The game *Bioshock* pits the player against a variety of challenges in an underwater city named "Rapture." As with *Left 4 Dead* (Valve, 2008), the player must make their way through the city without being killed by Big Daddies (giant modified humans in diving suits) and demented humans while collecting weapons and resources. Among these resources are plasmids, which grant special powers by virtue of genetic modifications, and which are injected via syringes. The key to unlocking the powers of plasmids lies in the collection of ADAM, which can only be obtained in the game from Little Sisters, who appear to be preadolescent girls. Little Sisters are always accompanied by Big Daddies, who must be killed before the player can collect ADAM. The dilemma problem in the game occurs with the decision on how to harvest the ADAM. One way results in the death of the Little Sister but results in a large amount of ADAM. The other way saves the Little Sister but results in less ADAM. While this choice seems to be pretty simple (two choices) the choices have a significant impact on the difficulty of the game and the way it proceeds. Additionally, whereas the binary choice in *September 12* (Newsgaming.com, 2003) is limited to the same instances and has the same results easily seen in a short period of time, in *Bioshock* these choices are distributed over the course of up to 50 hours of gameplay with relatively high frequency (medium serial interactivity), and the effects of these choices are not fully realized until near the end of the game. Thus, it is possible to support dilemma problem solving across the full arc of a game which itself is interspersed with other gameplay types, which in their own right may support other kinds of problem solving.

Finally, while our purpose is to outline a mechanism by which problem types with their associated cognitive requirements can be matched to different styles of gameplay, the end result also provides significant guidance for design and development of the games themselves. Because the study of problem solving within education and instructional design has been going on for decades, a rich body of research and best practices exists for supporting problem solving. Knowing, for example, that a problem is highly structured implies that less support should be provided for its solution, while ill-structured problems will require additional scaffolding and strategies to avoid cognitive overload. On the other hand, well-structured problems that occur during games with hybridized gameplay styles may indicate the need for more support than otherwise. When the problem solving itself is driving the game design, we may deliberately modify the form and frequency of a different gameplay styles in order to better support the problem (once we have conducted the empirical research to know how to promote different problem types, that is!). Knowing the kinds of cognitive processes involved also may help guide our selection of in-game tools, story structure, and objectives as well.

If we are to build games that promote problem solving, we must build on existing problem solving research. If we are to make claims about problem solving and games, we must generate new research and design heuristics based on the alignment of problem solving and different gameplay types, and test those empirically. In this paper, we have outlined a way to begin to meet both of these challenges. We used Jonassen's typology of problem types to help analyze the cognitive processes involved in different types of gameplay and, in turn, dissected gameplay that brought the essential characteristics (for problem solving, at any rate) to light. With an understanding of the cognitive, physical, and domain knowledge requirements of each type of gameplay, instructional designers and game developers will have a better idea of what types of gameplay will most appropriately afford given problem-solving learning goals and objectives.

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Build-a-Tree: Parent-Child Gaming to Learn About Evolution in Museum Settings

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Introduction

We present Build-a-Tree (BAT), an evolution puzzle game for natural history museums. BAT asks players to construct phylogenetic trees (also known as cladograms) using tokens depicting species and traits. We seek to understand how visitors learn about evolution through interactions with each other and with our game. We provide an overview and rationale for our game design and share preliminary findings from a study of parent-child dyads playing BAT in a natural history museum.

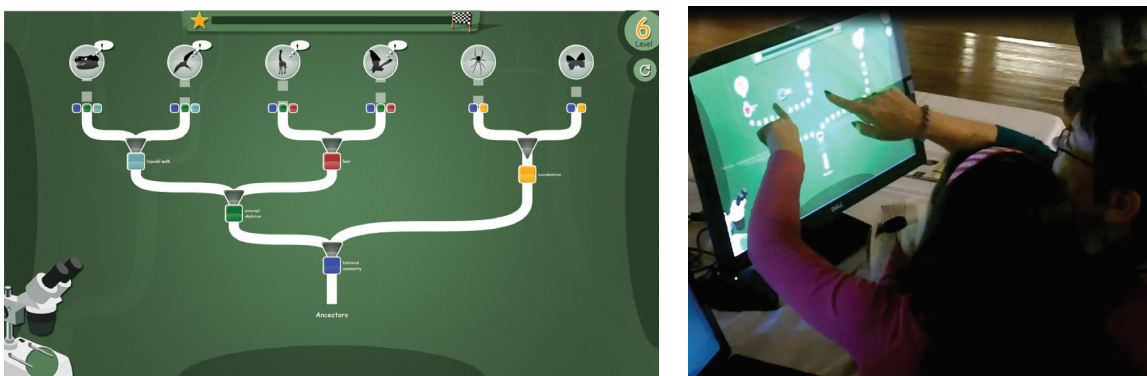


Figure 1: *Build-a-Tree* is an interactive, game-based tabletop exhibit designed to facilitate learning about evolution in natural history museums.

Evolution as a Critical Public Issue

Evolution is the central organizing theory that explains the diversity of life and explains similarities and differences among species (National Academy of Sciences, 1998). Given its importance, findings about the general public's awareness and understanding of evolution are both informative and worrying. Over the past two decades, the percentage of American adults who accept evolution has decreased from 45% to 40%; perhaps more alarming is the change in the percentage of adults who have become unsure about evolution—this has risen from 7% to 35% (Miller, Scott, & Okamoto, 2006). Additionally, surveys have shown that large segments of people, including museum visitors, have little to no understanding of evolution (Smith, 2010; Evans, 2006).

The Role of Museums

Natural history museums are uniquely positioned to help the general public learn about evolution (Diamond & Scotchmoor, 2006). These museums typically feature “life over time” exhibitions, in which visitors can view dioramas that recreate communities with paleontological specimens to reflect particular points in Earth's history (Tubutis, 2005). These exhibitions, which often feature towering reconstructions of dinosaurs and early humans, attract significant visitor attention and museums have tended to devote the greatest amount of floor space to these attractions (Tubutis, 2005). In addition to their content and collections, museums also command consistent and extraordinary trust from the general public (Semmel and Bittner, 2009). In a survey conducted by the Institute of Museums and Library Services, 77% of the 1700 adults surveyed rated museums as higher in trustworthiness than all other sources of information, including the government or commercial and private websites (Semmel and Bittner, 2009; Griffiths, King, and Pomerantz, 2008). This trust is critical when we consider the increasing lack of acceptance of evolution and recent calls to incorporate intelligent design and creationism into classrooms (Berkman and Plutzer, 2011; Beckwith, 2003). Museums can use their role as trusted sources to tackle issues of inaccuracy by fostering “a climate of healthy skepticism, in which all truth claims are weighed carefully [and] ethical commitments [are made] to identifying and reporting the truth” (Jenkins, 2006).

Interactive Surfaces

Large interactive surfaces have gained increased attention in recent years and researchers and educators alike are interested in their use for science learning. Because these devices allow multiple users to interact concurrently, they have a unique potential to support collaborative learning through engagement with digital content. Their ability to “support awareness of other’s actions and [their] ability to support concurrent input” gives agency to every engaged learner while providing incentive for individuals to interact with each other (Rick, Marshall, and Yuill, 2011). Learners around a shared display typically negotiate their actions not only to avoid interfering with each other’s intentions but also to coordinate their efforts so that they may successfully and efficiently complete tasks (Rick, Marshall, and Yuill, 2011; Dillenbourg and Evans, 2011). Others have pointed out the potential of interactive surfaces to allow learners to directly interact with representations of natural phenomenon (National Research Council, 2011) and to manipulate both virtual and physical objects (depending on the design) to solve problems (Antle, Bevans, Tanenbaum, Seaborn, and Wang, 2011).

Games for Learning

Games have, under controlled circumstances, proven to be effective instructional tools that can have a positive impact on science knowledge and attitudes (Honey and Hilton, 2010). Three key aspects of video games that make them attractive to both researchers and science educators are 1) their built-in scaffolds through their leveling-up structure, 2) their risk-free character, and 3) their encouragement of social interaction, which often leads to collaborative problem-solving (Gee, 2005). Games involving a well-designed progression of levels allow players to learn new information at each level which keeps them engaged as new tasks are added (Weppel, Bishop, and Munoz-Avila, 2012; Melero, Hernandez-Leo, Blat, 2011; Gee, 2005). By unveiling new information and tasks at each level, players feel compelled to advance through the game in order to learn more and hone their increasing expertise. Games can also encourage experimentation and productive failure without risk by promoting play (Salen and Zimmerman, 2004), making them an ideal instructional tool for science (National Research Council, 2011). The combination of experimentation and a risk-free setting allows players to learn and practice behaviors and thought processes while remaining highly engaged (Salen and Zimmerman, 2004). Lastly, games can lead to problem-solving that is collaborative in nature (Stevens, Satwicz, & McCarthy, 2007). Gaming is play across social spaces and networks, which means it includes engagement with parents, siblings, and friends (Klopfer, Osterweil, and Salen, 2009). Whether they are playing on-line with peers or engaging with stand-alone games, players often connect with other players in order to improve their chances for success (Ito, 2006; Salen, 2007). Leveraging the premise that learning is an immersive process mediated by both social interaction and technology, researchers have begun to show how the design of games often encourages collaborative problem-solving due to their highly motivating social contexts (Gee, 2004).

Design Overview

Build-a-Tree is a puzzle game that encourages players to think about the evolutionary relationships among different kinds of organisms (see Figure 1). The game begins with players being tasked to construct a phylogenetic tree with two traits and three species (level 1). By the final level (level 7), players are challenged to construct a tree with six traits and seven species.

Build-a-Tree was designed around three core learning goals: (1) all living things on Earth are related because they share ancestors in common; (2) some kinds of living things are more closely related than others; (3) evolutionary relationships can be understood through shared inherited traits. The design has five major components—species tokens, trait tokens, branching tokens, a microscope, and visual feedback—all of which work in concert to provide players with the tools to construct scientifically-valid trees (see Figure 2).

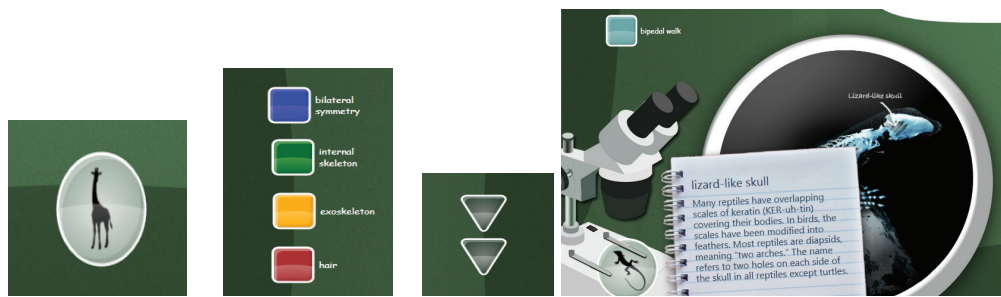


Figure 2: Major components of *Build-a-Tree* include (from left to right) species tokens, trait tokens, branching tokens, and the microscope.

Species Tokens: Circular tokens with silhouetted images of particular plants and animals are used to represent different species. Some of the species included in this game are bats, humans, dinosaurs, spiders, birds, frogs and crabs. In constructing their trees, players must group species tokens together according to the traits they share. Placement of species tokens is not fixed, meaning that players can experiment with their position in order to test ideas about relationships among the species.

Trait Tokens: Brightly colored square tokens are used to represent morphological and genealogical traits. Some of the traits included in the game are eight legs, internal skeleton, hair, bipedal walk, lizard-like skull, and exoskeleton. Players must position trait tokens in such a way as to ensure that particular pairs or groups of species inherit certain traits while others do not. Players can reposition trait tokens as many times as needed.

Branching Tokens: Grey triangular tokens are used to create branches. Branches represent the moments in time when species diverged from one another, inheriting traits advantageous to surviving in particular environments. Branching tokens allow players to create branches upon which they can place particular species tokens to indicate proximity or distance of species relationships.

Microscope: Not all traits are apparent by looking at the species tokens. Players can drag species tokens onto a microscope near the bottom of the screen. This reveals information about the species, including non-visible traits that it shares with other species. Most importantly, the microscope provides players with a visual representation of the traits in case they do not know what they are (Figure 2, right).

Feedback: There are multiple feedback mechanisms present in BAT. When players place traits and organisms on a tree correctly, green check marks appear on each species tokens after it has been assigned all of the correct traits. Players also receive gold stars, which help them track their progress through the game. Exclamation marks appear on species tokens to indicate that they are missing traits. Red X's appear if species have been assigned traits they do not have. The stars, exclamation points, and red X's, instead of a point system, allow players to experience both rewards and consequences for their actions in a non-punitive manner, making BAT a risk-free game that encourages experimentation.

Evaluation

We conducted a study in a natural history museum where we recruited parents and children aged 6 to 12 to try our game. Upon receipt of consent to be video recorded, parent-child dyads were assigned to one of three conditions: 1) 10-minutes of BAT gameplay followed by object-centered discourse; 2) 10-minutes of viewing of a video on evolution followed by object-centered discourse; or 3) object-centered discourse followed by either BAT gameplay or viewing of the video. To understand how game play might affect object-centered discourse, we gave each dyad a video camera and invited them to spend time looking at objects inside two exhibit display cases (Figure 3). These display cases hold a variety of animal specimens, fossilized dinosaur skulls, plant specimens, and marine fossils. Many of these objects overlap with the species depicted in BAT. We recently concluded our data collection and have a total of 20 parent-child dyads per condition, for a total of 60 parent-child dyads across all three conditions.



Figure 3: Parent-child dyads discuss objects that are in the exhibit cases above.

This study has three key goals: 1) to develop an understanding of the nature of parent-child gaming in museum settings; 2) to investigate whether gaming has an impact on object-centered discourse between parents and children; and 3) to ask how we might reimagine museum exhibit cases to integrate gaming experiences. The findings that follow focus on the first goal and highlight results from our preliminary analysis of game play between parents and children.

Findings

Here we briefly summarize our preliminary findings. We are using a grounded theory methods approach to analyzing the discourse taking place between dyads. Thus far, the data have revealed three key phenomena: 1) multiple interpretations of the rules of play; 2) player discussion of assigning colors to species rather than traits; and 3) shifting participation structures between parents and children due to their different sets of expertise. While we are still analyzing our data, it is becoming clear that these themes impact game play pathways and outcomes. For example, parent-child dyads are often explicit in their discourse about how they think BAT should be played.

Family 114A

Mom: Okay so what...Okay so we're just supposed to move things around...Alright Julie [drags bilateral symmetry token onto tree].

Daughter: Wait, don't move it yet mom. We have to work together.

Mom: Okay. Bilateral symmetry it showed. Alright. What should we move?

Daughter: What do you think? What about this one [points to and taps the plant species token]?

Mom: This one? [drags plant species token] Where do we want to put it?

Daughter: What about right in that circle [points to left side of the tree]?

Mom: [places plant species onto left side of the tree]

Here the child stops her mother from manipulating the tokens on the screen without her input, stating her belief that they are to work in concert to solve the puzzle on the screen. This short statement immediately influences their game play, with both the parent and child posing questions to each other about which tokens to move and where to move them. As the game play progresses, the child continues to make similar statements to her mother whenever she feels they are not co-constructing the tree, making clear her opinion that the game is to be played collaboratively and simultaneously. In contrast, some dyads exhibited a more asynchronous or solo playing style, taking turns manipulating icons or choosing to have one player manipulate the icons while the other player provides verbal or gestural input.

Family 134A

Daughter: It's your turn Mommy [sits down in chair].

[...]

Mom: You do it [does not touch screen].

Daughter: Mommy [stands up], you're supposed to like, I think, find how...[trails off, points at screen and waves finger at different parts of the tree] ok umm...[drags and drops cells with nuclei trait token onto tree, mom does not touch screen]

Here we see that the child in this dyad insists that BAT should be played through asynchronous turn taking. Furthermore, despite her statement to her mother that she should take a turn, the mother opts to have her daughter continue dragging and dropping tokens while she offers occasional advice. This leads to the child experiencing BAT as more of a single-player game rather than a multi-player one. As their game play moves forward, the mother becomes more involved, pointing to the screen and providing both verbal and gestural guidance to her daughter. These two small examples demonstrate that players' interpretations of the rules of play and their playing arrangements have consequences for the degree and type of collaboration between players as well as how they interact with the multi-touch display.

The second phenomenon apparent in the data is the variety of ways players discuss traits. Many dyads alternate between discussing whether a species needs colors or traits during their game play while other dyads more exclusively reference traits by their names *or* by their colors. See examples of this below.

Family 125A

Son: How about we switch the red and the green [referencing hair trait token (red) and the internal skeleton trait token (green)]?

Dad: There.

Son: But the bats aren't getting red [referencing hair trait token].

Dad: Then we gotta put this here [drags and drops hair trait token, assigning it to the bat species token].

Family 138C

Mom: Now this is bats and birds. Now look here. It says internal skeleton and hair [points to trait tokens]. So which one of these have hair [points to bird, bat, and human species tokens]?

Son: Um, this one has hair [points to bat species token] and that one's gonna go there [drags and drops hair trait token, assigns it to bat token].

Mom: Does this one have hair [points to human species token]?

In the excerpts above, the father-son dyad discuss how bats “need the red” rather than discussing that bats have hair. In comparison, the mother-son dyad do not reference color in their exchange and instead directly refer to traits by their proper names. Many questions have been raised as a result of this difference in trait discussion. Is there a difference in the learning outcomes between dyads that refer to traits as colors versus dyads that refer to traits by their name? When dyads refer to traits by color, are they using the symbology of the game only to infer the mechanics to “win” or are they assigning meaning to the representational forms to interpret and understand the relationships between species? Alternatively, are dyads doing a bit of both? It is our hope to answer these questions as they have clear implications for both the design of the game and outcomes for players.

The third phenomenon is the manner in which participation structures change between parents and children as they negotiate their differing and developing sets of expertise (game, content, or device expertise). This is made evident by each player's access to both the conversational floor and the interactional space. The conversational floor is defined as “an evolving, socially negotiated space in which one or more particular people are allowed to present conversational contributions to a discussion” (Engle, Langer-Osuna & de Royston, 2014 citing Clark & Schaefer, 1989). The interactional space is typically defined by visual salience and visual attention as well as how individuals affect each other's spatial access (Engle, Langer-Osuna & de Royston, 2014). Here, we focus on the latter aspect, the degree to which one player affects another player's spatial access to the display.

Family 114A

Daughter: Wait. I have an idea...that one could go there [drags and drops bird species token onto a different part of the tree], and that one could go there [drags and drops lizard species token where bird species token was previously located]. Wait [removes plant species token from tree]. And that one has to get a [starts to drag and drop lizard species token to another part of the tree]...

Mom: Oh, wait, what was that showing when you moved it [drags and drops plant and lizard species tokens]? Hold on, hold on [interrupts her daughter's attempt to touch plant species token]. It popped up a thing when we were movin' it [long presses plant species token].

[...]

Mom: So that...where else could that go...okay let's take [removes lizard species token from tree]...oh wait [puts lizard species token back on tree in same location]. Were we right [waits for visual feedback from game to gauge accuracy of tree]?

Daughter: Hmm.

Mom: Hold on [blocks daughter's attempt to move branching token]. Let's move one of the triangles Julie [removes branching token at base of tree and creates branches on another section of the tree]. 'kay [interrupts or ignores daughter's attempt to move bird species token] let's move this over here [drags and drops bird species token from one area of the tree to another]. Let's bring that one over to this side [daughter drags and drops bilateral symmetry trait token from one area of the tree to the other]. 'kay let go.

Daughter: What about [points to plant and/or lizard species tokens]...

Mom: Now put that over there [points to bird species token and points to an area of the tree; daughter drags and drops bird species token to where mother is pointing]. And bring this over here [mother drags and drops cells with nuclei trait token].

With this excerpt we revisit dyad 114A later in their game play and we note that the collaboration they exhibited at the start of the game has shifted as a result of the parent's developing expertise of the game mechanics. She blocks her child's attempt to access the conversational floor, which interrupts the idea her child is attempting to express. Furthermore, she limits her child's spatial privileges through verbal cues (e.g. "Hold on, hold on") as well as non-verbal cues (blocking and interrupting her daughter's attempts to manipulate tokens). It is possible that the mother's developing expertise is potentially constraining her daughter's opportunities to develop her own expertise, at least in the short term. This interpretation stems from the fact that the daughter's actions are a result of directives received from her mother rather than the product of any ideas the daughter is constructing about the mechanics of the game or the science content that is organizing the game structure. Parents often seemed to want to take on an "explainer" role and would spend some time leading the effort to explore the game mechanics.

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Program-to-Play Video Games: Developing Computational Literacy Through Gameplay

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Introduction

The ability to express ideas in a computationally meaningful way is becoming an increasingly important skill (National Research Council, 2010, 2011; Papert, 1980, 1993; Wilensky, 2001; Wing, 2006). diSessa (2000) argues that being able to express ideas in a computationally meaningful way can serve as the foundation of a powerful new literacy that will have widespread positive effects on society. Central to this new literacy is the ability to read, share, and express ideas in a form that a computational device can interpret and execute. Traditionally, these practices have been confined to the domain of computer science, but this view is being challenged by researchers and educators who argue that computational literacy skills are beneficial in a wide range of disciplines (Guzdial & Soloway, 2003; Wing, 2006). Part of the challenge of introducing learners to the skills foundational for computational literacy is designing learning environments that support the act of computational expression in a way that enables them to have early successes in a meaningful context. This paper presents the program-to-play approach, a design strategy for creating game-based learning environments designed to support novices in expressing ideas in a computationally meaningful way. Using RoboBuilder (Weintrop & Wilensky, 2012), we introduce the program-to-play paradigm and present data showing how this design approach scaffolds learners in developing computational literacy skills.

Prior Work

In response to the growing recognition that students can benefit from learning to express ideas in computationally meaningful ways, educational researchers have been developing “low-threshold” programming languages that are easier to learn but still permit significant expressivity. Beginning with Papert and colleagues’ Constructionist Logo project (Feurzeig et al., 1970; Papert, 1980), there have been many efforts to bring learning environments for supporting computational expression to a wide audience of learners. diSessa (2000), in formulating his conception of computational literacy, used Boxer as one example of what form such tools might take. Boxer uses a graphical interface based on the naïve realism theory of mind to create a “glass-box” programming environment where “users should be able to pretend that what they see on the screen is their computational world in its entirety” (diSessa & Abelson, 1986, p. 861). A second notable line of work stems from Wilensky and colleagues who have responded to this design challenge by creating low-threshold, programming environments that focus on students building computational models of emergent phenomena (Wagh & Wilensky, 2012; Wilensky & Reisman, 2006; Wilensky, 1999, 2001; Wilkerson-Jerde & Wilensky, 2010). A third approach to low-threshold programming environments utilizes a graphical, grid-based model in which learners define states and transitions that enable the creation of games and simulations in two and three dimensional worlds (Ioannidou, Repenning, & Webb, 2009; Repenning, Ioannidou, & Zola, 2000). Yet another approach taken by Resnick and colleagues (Resnick et al., 2009) employs a blocks-based programming language, that leverages a blocks-as-puzzle-pieces metaphor, to enable young children to express themselves through creating games and stories.

A second active area of research studying the affordances of technology for creating learning environments is the growing literature on video games as a medium for learning (Barab et al., 2005; Gee, 2003; Holbert & Wilensky, 2014; Shaffer et al., 2005; Squire, 2003). This work looks at the potential use of games in both formal (Clark et al., 2011) and informal settings (Stevens, Satwicz, & McCarthy, 2007), and has created a great deal of excitement due to the increasingly ubiquity of video games in youth culture (Lenhart et al., 2008). While games have been designed to teach a diverse range of content areas, computer science educators have been particularly active in the use of video games as learning contexts as there is a natural match between the computational context of a video game and computer science content (Barnes et al., 2007; Bayliss & Strout, 2006; Li & Watson, 2011)8,13]]}}}, {"id":1735,"uris":["http://zotero.org/users/352934/items/53G2GGNE"],"uri":["http://zotero.org/users/352934/items/53G2GGNE"],"itemData":{"id":1735,"type":"article-journal","title":"Games as a \"flavor\" of CS1","container-title":"SIGCSE Bull. ","page":"500–504","volume":"38","issue":"1","source":"ACM Digital Library","abstract":"Introductory programming courses have a specific set of expected outcomes. One of the most often heard complaints in such courses is that they are divorced from the reality of application. Unfortunately, it is difficult to find areas for application that all students have the background knowledge for and that are engaging and challenging. One such area is computer games and we have developed a cohesive CS1 course that provides traditional outcomes from within the context of games as an application area in both the lecture and lab components of the course. This course was piloted as a ten-week distance program for incoming computer science students with the defining features that the program carried no academic credit and offered no end grades. We discuss the overwhelming interest in this course as

well as objective and subjective student experiences. One of the most important outcomes of the summer course was that it brought students with similar interests and goals together. We discuss this and the different ways we have found to discuss computer science course topics from within a games context.”, “author”: {“family”: “Bayliss”, “given”: “Jessica D.”}, {“family”: “Strout”, “given”: “Sean”}], “issued”: {“date-parts”: [[“2006”, 3]]}], {“id”: 1204, “uris”: [“http://zotero.org/users/352934/items/JEG375KV”], “uri”: [“http://zotero.org/users/352934/items/JEG375KV”], “item-Data”: {“id”: 1204, “type”: “paper-conference”, “title”: “Game-based concept visualization for learning programming”, “container-title”: “Proceedings of the third international ACM workshop on Multimedia technologies for distance learning”, “page”: “37–42”, “source”: “Google Scholar”, “author”: {“family”: “Li”, “given”: “F.W.B.”}, {“family”: “Watson”, “given”: “C.”}], “issued”: {“date-parts”: [[“2011”]]}], “schema”: “https://github.com/citation-style-language/schema/raw/master/csl-citation.json”} .

Our own work has focused on the goal of designing learning environments that make the skills associated with computational literacy more accessible and appealing to a broad range of learners. Towards this end we have developed the program-to-play design strategy that situates the practice of expressing ideas in a computationally meaningful way in a game-based learning environment where learners compose small programs in order to play a game. While a similar approach has been used in the educational game space, such as the IPRO learning environment (Berland, Martin, & Benton, 2010) and PlayLOGO 3D (Paliokas, Arapidis, & Mpimpitsos, 2011), this paper seeks to formalize the design strategy, provide theoretical justification, and present evidence towards its effectiveness for teaching skills associated with computational literacy.

The Program-to-Play Approach

The central activity of program-to-play games is players defining instructions for their in-game characters to follow through a programming, or programming-like, interface. This is in contrast to a conventional video game interaction where players control their on-screen avatars directly as the game unfolds. The challenge that underpins all program-to-play games is for players to conceive of a strategy for their character and then figure out how to encode that idea using the tools provided by the game’s programming interface. Players’ learning how to express their own ideas and intentions in a way that the computer can interpret and execute is a key component of computational literacy. In looking at the use of video games as a context for computational expression, it is important to distinguish the program-to-play approach from tools designed for game authorship (Jones, 2000; Kafai, 1994). While learning environments that have students design and build games have been found to be a successful and motivating way to introduce learners to programming, the program-to-play model we present herein has additional, desirable features that build on the strengths of the game authorship approach. These strengths stem from the parallels that exist between the act of playing video games and the practice of programming.

For example, when playing a video game, players do not expect to be successful on their initial attempt, instead, game norms dictate that players will need multiple tries to accomplish an in-game challenge; trying different approach, refining strategies, and learning from prior mistakes along the way. In this way, games are low-stakes environments where failure is a part of success (Squire, 2005). Programming shares this feature as programs rarely work correctly on the first try. Instead, writing working programs requires many attempts. Trying different approaches to see what works and learning from prior mistakes without getting frustrated at a lack of immediate success are critical in the practice of programming. By aligning the construction of programs with the act of gameplay, players are situated in a context where early failures are expected and provide valuable learning experiences.

A second productive parallel between gameplay and programming that the program-to-play approach leverages is the iterative, incremental nature of both activities. When playing a game, players often attempt the same challenge a number of times, then, upon completing that task, proceed to the next, having gained experience and knowledge along the way. Programming shares this feature, as the completion of one component of a program leads to immediately working on the next, but with gained experience and new functionality to show for it. Additionally, the iterative, incremental characteristic of program-to-play games provides a natural, unobtrusive way for the game designer to scaffold players in moving from simple to more sophisticated programs that utilize more complex constructs. As players progress in a program-to-play game, the challenges become more difficult, thus, players need to respond by creating more sophisticated programs. This characteristic is unique to this design approach. In a game authoring learning environment there is no motivation provided by the tool itself to use advanced language features or create larger, more sophisticated challenges. Similarly, other open-ended, exploratory programming environments such as Scratch or Alice do not natively have a way to encourage more sophisticated constructions. In program-to-play environments on the other hand, as players progress, the game creator can design challenges that encourage and reward players for using more advanced programming constructs and creating more sophisticated programs. In RoboBuilder, this takes the form of opponents that demonstrate progressively more sophisticated concepts using a strategy we call “Learning from Your Opponent” (Weintrop & Wilensky, 2013a).

Meet RoboBuilder – A Program-to-Play Game

RoboBuilder (Figure 1) is a blocks-based, program-to-play game that challenges players to design and implement strategies to make their on-screen robot defeat a series of progressively more challenging opponents. A player's on-screen robot takes the form of a small tank, which competes in one-on-one battles against opponent robots. The objective of the game is for players to defeat their opponents by giving their robot instructions to locate and fire at their opponent while avoiding incoming fire; the first robot to make its opponent lose all its energy wins.

To facilitate this interaction, RoboBuilder has two distinct components: a programming environment (right pane of Figure 1), where players define and implement their robot's strategy; and an animated robot battleground (left pane in Figure 1), where players watch their robot compete. Players first interact with the programming interface to define their robot's behaviors before hitting the 'Go!' button,

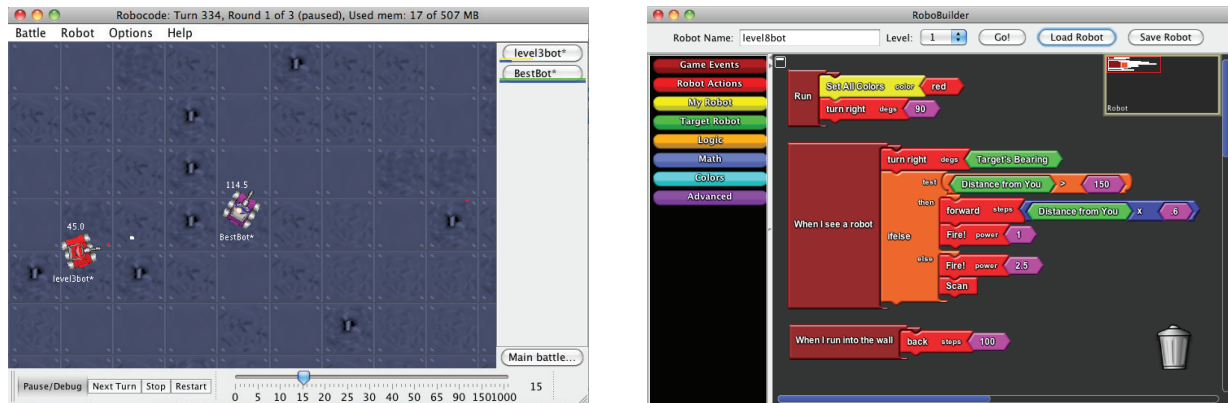


Figure 1: RoboBuilder's two screens: the battle screen (left) and the construction space (right).

which launches the battleground screen. To program their robot, players are provided with a custom designed graphical programming language in which color-coded blocks encapsulate basic robot actions, such as "turn right" and "fire!", that snap together to form robot strategies. Players are made aware that all of the opponents in the game were created using the same set of blocks that they are given; thus, it is always possible to recreate the strategy of an enemy robot. Once the battle starts, the player cannot interact with or alter their robot. RoboBuilder was designed for learners with little or no prior programming experience and has been played by a wide range of users including university graduate students and by students as young as ten as part of an after-school program.

RoboBuilder is a combination of two open source projects: Robocode and OpenBlocks. Robocode (Nelson, 2001) is a problem-based learning environment initially designed to teach students how to program in Java. It has been used in introductory programming classes, where it has been found to be effective and motivating for students (O'Kelly & Gibson, 2006). RoboBuilder's programming interface is a modified version of the OpenBlocks framework (Roque, 2007), an open source Java library used to create graphical, blocks-based programming environments.

Methods

The data we present is from a study designed to explore how players interact with program-to-play games and to identify which features of the environment were utilized to succeed in the game.

Procedure

Our primary data collection activity was an hour-long, one-on-one interview during which a researcher sat alongside the participant as he or she played the game. At the outset of the interview participants were told that they would be playing a video game. They were then shown a pre-recorded robot battle to introduce them to the central challenge of the game. The interviewer then further described the objective of the game and explained the program-to-play method of gameplay. They were then introduced to the construction space including a high-level description of RoboBuilder's programming language, and shown how the blocks could be assembled to create a robot strategy. This first portion of the interview usually took around ten minutes, leaving roughly 50 minutes for gameplay.

Gameplay during the RoboBuilder interview followed a three-phase iterative protocol. In the first phase, participants were asked to verbally explain their intentions; either how they intended on defeating their opponent, or what changes they planned on making to their current strategy. Next, players were given the opportunity to implement their strategy using the provided programming language primitives. Once they were satisfied with the program they had created (or with the set of changes they had made), they launch the battle screen, which begins the third phase of the iterative protocol. During this final phase, players would watch the battle and explain what they observed, paying particular attention to whether or not their robot was behaving as expected. Players had the ability to end the battle at any point. After the battle screen was closed, the next iteration would begin with players again verbally explaining their goals for their robot strategy. Each RoboBuilder session was recorded using both screen-capture and video-capture software. We also stored a digital copy of each robot strategy constructed during the RoboBuilder interview for further analysis.

Participants

Our main criterion for recruiting participants was that they be comfortable using computers but have little or no prior programming experience. Seven university-aged participants (3 female, 4 male) were recruited from a Midwestern university. Eight high school aged participants (1 female, 7 male) were recruited through relationships with members of the university community or through their affiliation with a community center in a Midwestern city that serves a predominantly African-American, low SES community. Participants played for an average of 48 minutes and 43 seconds (SD 8 minutes 39 seconds) and constructed an average of 11.5 unique robot strategies (SD 4.9). Each participant took part in one RoboBuilder session with the exception of one participant who agreed to four RoboBuilder sessions, each held a week apart. This resulted in a total of over 200 robot strategies being constructed and roughly 19 hours of RoboBuilder footage.

Playing a Program-to-Play Game

We begin this section by presenting a vignette of gameplay to provide a sense of the dynamics of playing a program-to-play game, before providing data showing how the full set of participants progressed over the course of their gameplay experiences. We start by looking at the first iterations of one interview to show what it looks like to conceive, then computationally express, a RoboBuilder strategy. After being introduced to RoboBuilder, this participant was asked how he was going to defeat his first opponent. He talked through a few ideas, then finally summed up his strategy this way:

So my master plan is to, like, be continuously moving, so it's harder to hit. If I get hit, kind of change the path so it's different than what you might be expecting however the sequence is running, and then, during that path, adjust to what the opponent is doing to hit them.

He then brings up the composition screen (Figure 1, right side) and starts implementing his idea. Over the course of six minutes, he builds up his strategy, shown in Figure 2, beginning with the `Run` action then adding four more actions, defining and implementing the behavior for each as he goes.

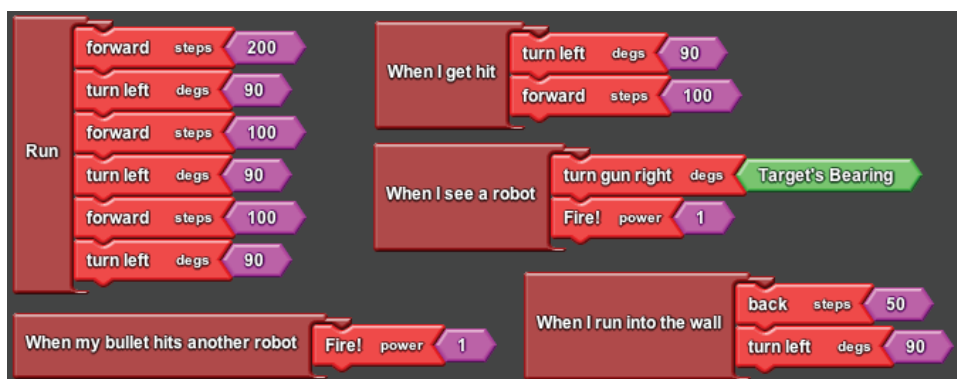


Figure 2. A participant's first robot strategy.

In this composition we can see aspects of his “*master plan*” reified, as well as additional components he added as he implemented his strategy. In the quote above, the participant articulated three distinct ideas, each of which are included in his program. The first verbalized strategy: “*be continuously moving, so it's harder to hit*” was implemented in the `Run` method of his program (left side of Figure 2). This series of instructions will result in his robot remaining in constant motion. His second tactic: “*if I get hit, kind of change the path so it's different*”, can be found encoded in his `When I get Hit` event block. The two commands that will execute when his robot gets hit will

cause the robot to change its heading and move forward out of the current line of fire. His final idea: “*adjust to what the opponent is doing to hit them*” is captured by his implementation of When I See a robot (bottom right of Figure 2), which will result in his robot’s gun adjusting to the location of his opponent and firing at it whenever his robot spots its opponent. The participant also added two additional behaviors to his strategy: to backup and turn when he hits a wall, and to first after his robot successfully hits the opponent. These two strategy improvisations emerged based on the suggestive, idea-generating capacity of the language that was frequently employed by players as they developed their strategies (Weintrop & Wilensky, 2013b). In subsequent iterations, this participant incrementally added new behaviors to his robot strategy. The practice this vignette highlights, that of computationally realizing an idea, is central to computational literacy and a key dynamic in program-to-play games.

Of the 15 programming novices who played RoboBuilder, 14 were able to successfully compose a strategy to defeat the first opponent with 9 participants advancing past level 3. While the size and complexity of players’ constructions varied, programs generally got larger and more sophisticated as players progressed. Because of the iterative nature of program-to-play games, players’ progressions are visible in the sequence of programs they construct. Beth, a vocal performance major with no prior programming experience, was the participant who agreed to four RoboBuilder sessions, resulting in a total of 46 distinct programs that we can use to map out her trajectory. As Beth progressed through the game, the size and complexity of her programs grew (as can be seen by the number and variety of commands). Figure 3 shows her winning robot strategies for levels 1, 2, and 4 (moving left to right).

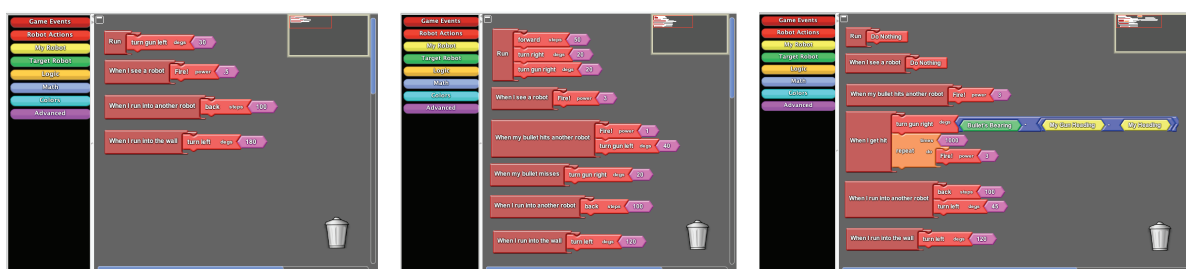


Figure 3. Three of Beth’s Robots, progressing from earliest (left) to latest (right).

As she progressed, her robots grew larger (used more blocks), more complex (implemented more events), and more sophisticated (used a larger variety of blocks). Figure 4 depicts the trajectory of her programs over the course of her entire four hours of gameplay. Each line depicts the frequency of different types of blocks being included in her program, with the top line being the total.

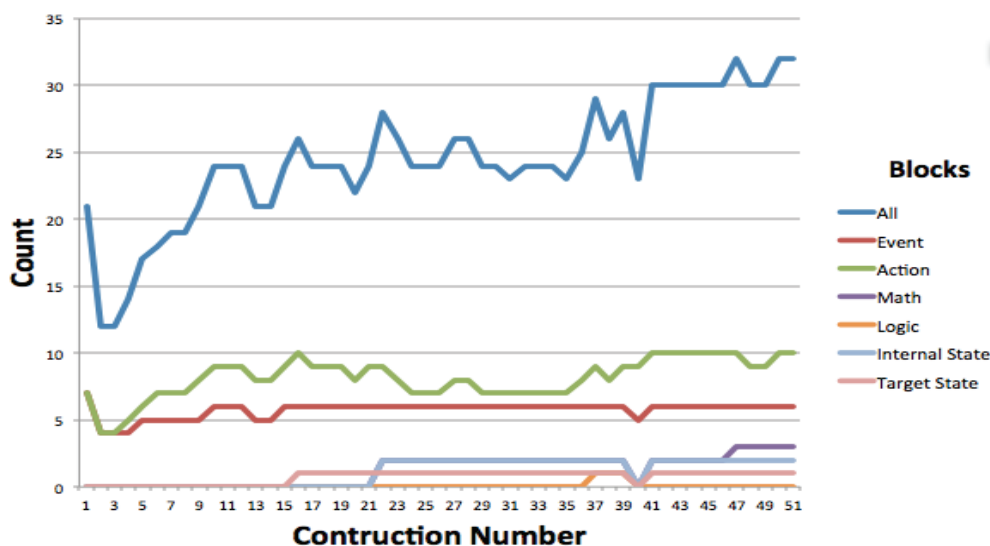


Figure 4. The blocks in Beth’s robot constructions over the course of her gameplay.

Looking across the full set of participant, we can see how Beth’s trajectory was typical as most participants progressed from small, simple programs to larger, more complex robot strategies. On average, each participant added 1.6 blocks to their strategy for each level they advanced. If we only consider the cases where participants revised their robot strategies between successful battles, the number of blocks added per level increases to 3.3 blocks for each new successful robot construction. Only two players’ robot constructions got smaller as they progressed

through the game; a third player's strategy remained at a fixed size; the remaining players' constructions grew as they progressed in the game. Figure 5 shows the trend lines for the size of each participant's robot construction over the course of their RoboBuilder sessions. By evaluating the novices' success in expressing ideas within the medium provided, we can see how the program-to-play design approach resulted in players not only creating successful programs, but over the course of a single hour of gameplay, moving from small, simple constructions to larger more sophisticated programs.

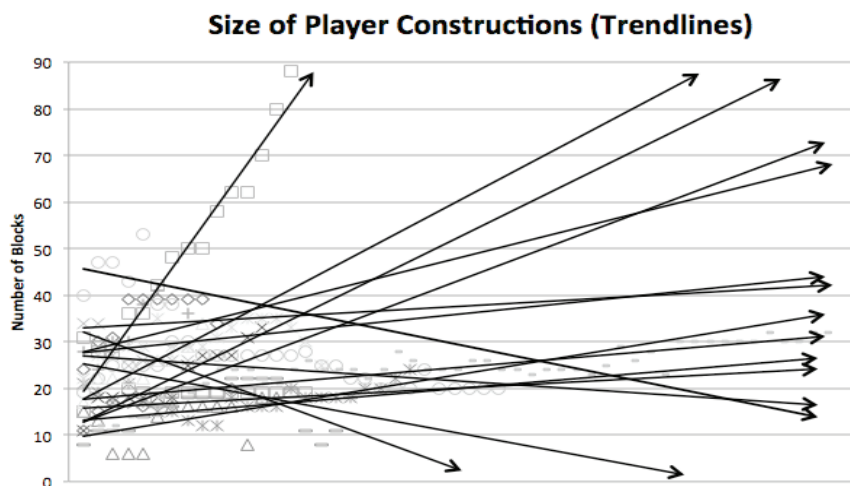


Figure 5. The trend lines of the changing size of players' constructions (projected forward).

Conclusion

The ability to express ideas in a computationally meaningful way is quickly becoming a core literacy one needs to succeed in our increasingly computational society. In this paper we introduced the program-to-play design strategy; an approach to creating game-based learning environments to teach fundamental computational literacy skills. This approach draws on video game norms that parallel programming practices and are productive when trying to express ideas in a computationally meaningful way. Using RoboBuilder, a program-to-play environment of our own design, we provided evidence for the potential of this approach. Novice programmers using RoboBuilder were able to create successful, sophisticated working programs in a short amount of time with minimal instruction. Our hope is that program-to-play games can serve as effective tools that fit within youth culture and can be meaningfully used to give young learners the experience of expressing their ideas in computational meaningful ways, helping us move towards a computationally literate society.

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Symposia

Supporting Ecosystem Integration: Game-Infused Learning Trajectories for Teachers

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Statement of the Problem

There is currently a sizable gap in innovative, engaging, and high-quality products designed to support middle school students strengthen their writing and science skills in a manner consistent with the Common Core State Standards (CCSS) and NextGen Science Standards (NGSS). Literacy skills in the United States are failing to keep up with growth in other countries, with a third of 8th graders being proficient in reading and writing, and similar challenges exist for science. More generally, more than one million American students drop out of school each year – almost one student every 9 seconds. A primary reason youth cite for dropping out of school is a lack of engagement, due in large part to the perceived lack of relevancy of the school curriculum. To address these challenges, we need new curriculum models that excite and inspire our youth, not simply to remember or even apply academic content, but to foster in them a confidence and commitment to apply academic concepts to real-world problems.

This requires the creation of new curriculum based on innovative learning theory, and that is intended to position academic content, individual learners, and those situations in which the content has value as interrelated. Videogames in particular are being touted as providing a powerful learning technology with the potential to transform education (Barab, Gresalfi, & Ingram-Goble, 2010; Gee, 2003; Shaffer, 2009; Squire, 2006), with many educators, researchers, designers, and even industry partners working to develop new forms of game-based curriculum. Digital games are increasingly being used in education to help youth learn traditional school content and to foster 21st century skills, and even to build dispositional change as they develop a recognition for the real-world value of the content they are learning.

Games can make learning engaging, social, and relevant. Well-designed games and game-infused experiences offer a delicate balance of challenges and rewards that can drive deep levels of engagement and time-on-task, enabling players to advance at their own pace, fail in a safe and supportive environment, acquire critical knowledge just-in-time (vs. just-in-case), iterate based on feedback and use this knowledge to develop mastery. They enable players to step into different roles (e.g. scientist, explorer, inventor, political leader), confront a problem, make meaningful choices, and explore the consequences—even rewriting the narrative of the Self. Our theory of change posits that game-based experiences are most effective when treated as services (as opposed to products) that are integrated, managed, and continually optimized for ecosystem integration, ongoing sustainability and scaled impact.

In this symposium, we present data and insights from two of our student-facing games implemented with over 800 middle-schools students with low socio-economic status in a number of comparison studies. A core finding in this work was that having agency and consequentiality was a key learning value, and served to create a strong connection among player, content, and context. We also learned that we underestimated the challenges of ecosystem integration, prompting us to focus on game-infused teacher professional development in the second year implementation. Consistent with our notion of games-as-services, in year two we situated our teacher-bounded games as part of a network infrastructure available to teachers that resulted in higher expectations for student learning.

Underlying Theory of Change

When it comes to using bounded games for supporting the learning of academic content, much of our work has been based on the theory of transformational play, a 3-fold theory that argues for the positioning of *person with intentionality*, the *content with legitimacy*, and the *context with consequentiality* (Barab, Pettyjohn, Gresalfi, Volk, & Solomou, 2012). The idea of transformational play highlights relations among the three interconnected elements of person, content, and context. In these games, learners become protagonists who use the knowledge, skills, and concepts of the educational content to make sense of a situation and then choices that transform the play space and the player—they see how the world changed because of their efforts. Such play is transformational in that it changes the context in which play is occurring, while at the same transforming the player and his or her potential to interact with the world.

In order to produce meaningful impact, we recognize the importance of situating these bounded game experiences within what James Gee (2013, personal communication) refers to as the Big “G” context. Big “G” game infrastructures are open-ended and seamlessly integrate the small “g” games into a larger, flexible ‘meta-game’ structure and affinity space that fosters user-driven extensions and adaptations in support of real-world goals and outcomes. Small “g” bounded games are self-contained and finite, pre-optimized to introduce, cover or re-enforce a particular lesson and well suited for learning in a safe, simulated and structured environment. However, it is with the Big “G” components (i.e., learning and management infrastructure, data and analytics dashboard, social communities and affinity spaces, achievement frameworks with gamification layers) that we transform individual experiences within a game into a dynamic interaction that extends learning beyond the fictional game world.

We view this as especially relevant when one treats teachers as a key component of the implementation infrastructure, and as having the potential to catalyze game-infused student learning within their classrooms. Therefore, a key focus in our work has been to develop game-infused professional development that includes a combination of bounded game and ongoing collaborative interactions with other teachers. Beyond the technical components, this has involved establishing an aspirational vision for student learning and positioning the games as one component of a larger teacher-owned implementation. Such positioning transforms the teacher from an individual responsible for following our procedural rules to an agentic and empowered partner who is leveraging a powerful tool to realize a shared vision. This sort of positioning is consistent with Gresalfi and Barab (2011) who discussed the implications of different forms of engagement: procedural, conceptual, consequential, and critical engagement.

Relevant to this study is the distinction between *procedural engagement* (using procedures accurately but without a deeper understanding of why one is performing such procedures) and *consequential engagement* (recognizing the usefulness and impact of disciplinary tools; that is, being able to connect particular solutions to particular outcomes). When students are engaging consequentially, they are able to move beyond rote understandings to apply their ideas. This notion of shifting learners, whether students or teachers, from procedural engagement to consequential engagement, is consistent with our belief that the latter is more likely to cultivate the underlying dispositions or “ways of being” necessary to thrive in the real world—not simply on the one we designed for them. Learning innovator John Seely Brown (2014, March) has argued that we “teach knowledge, mentor skills and literacies, and cultivate dispositions.” With respect to cultivated dispositions, or ways of being in the world, at the core of our work is an **engaged and purposeful learner** who is open to new experiences, curious how the worlds works, and excited to lean-forward and take on personal, community and even global challenges.

More specifically, the intent of these designs is to support the cultivation of an engaged and purposeful learner with the more disciplinary-specific emphasis on being a **disciplined investigator** who is motivated to understand how the world works through quantitative and qualitative analysis. Additionally, for both the student and the teacher, we also wanted to cultivate the disposition of a **persistent optimizer** who is enthusiastic to persist past challenges, seeking out relevant feedback to continually improve solutions. Although Language Arts or science disciplinary skills and literacies were necessary for success gameplay, it was our belief that if we did not also cultivate an underlying disposition then the literacies would only be used within the defined context of the game implementation (or constrained assessment tasks), but not in those situations in which the task failed to overly structure how to apply the literacy.

Design-Based Implementation Research

In realizing this agenda, we adopted a design-based implementation research framework (Penuel, Fishman, Cheng, & Sabelli, 2012). Whereas some notions of design-based research have focused on how a design passes through theoretically-inspired translations and iterations across multiple implementations, we argue that from a research perspective it becomes difficult if not theoretically naïve to treat implementation contexts as separate from the design, an instead one must consider *designs as services* (not products) whose effectiveness is always integrated with how well the design engenders the ecosystem to optimize its success—fundamentally coupling design and implementation (Penuel et al., 2012). It is in this way that our notions of what we are designing and how they relate the ecosystems in which they will be realized has become increasingly complex and, potentially, transformative.

Here, we illuminate how we operationalized our theory of change through the implementation story of two-student facing, game-infused experiences and the subsequent building and implementation of a game-infused teacher professional development designed to position their engagement with the student experience in a manner that would begin to cultivate the broader dispositions mentioned above. The two student-based trajectories were first implemented in 2013 with ten teachers and over 800 7th grade students in a border-district with 90% having free-and-reduced lunch and a similar percentage being Hispanic—many of whom were English as second language speakers. Roughly, each designed trajectory involved 8 classes assigned the control and 8 assigned the experi-

mental condition, an equivalent curriculum unit that also lasted 2-3 weeks was created with teachers and we used a pre-test and post-test as part of two earlier studies on the games (Barab, Pettyjohn et al., 2012; Barab, Zuiker, et al., 2010). These games, along with the teacher facing games and professional network, were implemented in 2014 with the same teachers along with an additional 30 science and language arts teachers—making an additional 2500 students across both experiences.



Figure 1: Screenshots of the Doctor’s Cure World (left), and the embedded essay submission tool (right).

Doctors Cure - The Doctors Cure is a 3D immersive game that positions players as protagonists in a virtual world where they must use their understanding of persuasive writing and how to gain evidence from complex texts in their role of investigative reporter. Inspired by Mary Shelley’s novel Frankenstein, and set in a gothic world, students take on the role of a citizen reporter via their avatar, and complete a series of missions to uncover a moral dilemma involving Dr. Frankenstein’s work. As reporters, students actively collect evidence through interviews and investigations, build logical arguments to support their theses, submit these to an in-game logic machine for evaluation, and get feedback about the alignment between their evidence and reasoning.

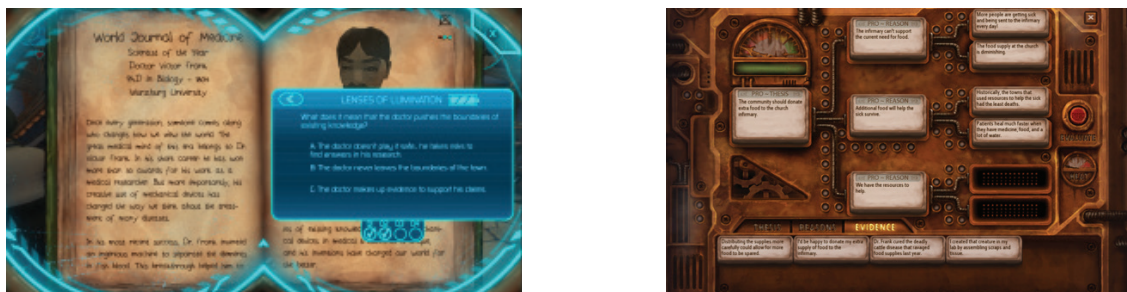


Figure 2: Screenshots of the Document Analysis Tool (left), and the persuasive argument analysis tool (right).

Players are intentionally positioned as agents of change whose purpose is to help the village of Ingolstadt decide if they should allow “Dr. Frank” to keep looking for a cure in spite of his questionable research methods. Players soon learn that persuasive writing is a necessary tool to resolve the game’s narrative conflict. As the game progresses, players experience how their choices and use of persuasive writing dramatically change Ingolstadt, its citizens, and even the students’ own identity as a writer and leader. In-game tools provide support in the interrogation of texts, as well as a model for testing the logic of their argument, and immediate feedback in the process. This design was implemented in an experimental design research study with 8 classes assigned the control and 8 assigned the experimental conditions—about 450 total kids with just over 400 completing both the pretest and the posttest. In terms of the 2013 implementation:

Results show that the both the treatment and the control conditions had statistically significant learning gains, and that there were no differences between groups for the multiple choice/short answer questions. However, when comparing the less-structured standardized essay prompt, there were significant differences favoring the eight treatment classes, with a large effect size.

- *Results also show that when asked why they were completing the current classroom activity, 74% of the students in the treatment condition chose “because I was interested in the task,” as opposed to 22% of the control. In contrast, 75% of the control chose either “to get a grade” or “teacher told me to,” while only 23% of the treatment condition chose this option.*

Differences in engagement and learning are credited to player agency, affordances of the embedded scaffolds, and the power of consequential outcomes. The fact that the experimental condition was able to perform higher on the open-ended writing prompt was particularly interesting because it suggests that these students were able to leverage the persuasive argumentation trope successfully in ways that the comparison students did not, even though they tested equivalently in terms of knowledge items. In both groups, however, teachers did not leverage the writing revision process, often accepting weak essays, and often let the game do the teaching as opposed to deeply managing the learning experience. Such issues speak to the importance of the platform integration and prompted the re-design of the unit with better collaborative tools a new pre-service teacher education game focused on feedback for student work. Additionally, we developed social network and community-engagement components, along with more achievement layers for teachers all with the goal of better supporting ecosystem integration.



Figure 3: Screenshots of the Taiga River Virtual World (left), and the scientific model analysis tool (right).

Mystery of Taiga River - The Mystery of Taiga River is a game-based science experience (water quality and scientific inquiry) designed with the goal of positioning middle school students as investigative reporters who must investigate, learn and apply scientific concepts (scientific investigation, water quality indicators, eutrophication, etc.) to solve applied problems in a virtual park, and restore the health of the fish without alienating various stakeholders. A core challenge in this work was balancing deep engagement in a game-based immersive world with the learning of scientific content. Players are positioned as agents of change, as water quality scientists, whose purpose is to help the Taiga National Park in uncovering the cause of the fish decline, a problem threatening the park’s very existence.

Players soon learn that an application of science inquiry and systems thinking, coupled with understanding of water quality indicators, are all necessary to resolve the game’s narrative conflict. As the game progresses, players experience how their choices and use of science processes and inquiry dramatically change Taiga National Park, stakeholders, and themselves. As a form of embedded assessment, their chains are scored according to a pre-determined coding system, and they eventually learn whether: 1) they crafted the best chain of reasoning possible from the evidence at hand, and 2) whether the argument proves or disproves the hypothesis. Students use the constructed argument to write several scientific reports that are reviewed by the teacher. In the end, student choices determine the outcome of the river, with different students advancing arguments that result in different endings.



Figure 4: Screenshots of in game data collection of erosion (left), and a virtual fish tank experiment (right).

This design was implemented in an experimental design research study with 7 classes assigned the control and 7 assigned the experimental conditions—about 400 total kids were in the initial sample and 351 completed both the

pretest and the posttest.

- Both the treatment and the control conditions had statistically significant learning gains, and when comparing the seven control classes with the seven experimental classes they were significantly greater for the experimental conditions with a large effect size difference.
- Qualitative analysis show different levels of engagement with the experience, and more first-person references in the experimental condition, and richer in-class discussions where students interrogated particular learning interactions.

While the game demonstrated significant learning gains, students received impoverished feedback on their essay submissions and teachers did not make connections between the learning activities and supporting Common Core writing standards. Teachers also had difficulty managing the implementation, feeling somewhat alienated from peers, and used the teacher toolkit as a student management system rather than a place to inspire revisions and deeper engagement. This lack of cross-disciplinary fertilization, especially in terms of the Common Core Literacy Standards not being used to inform the persuasive arguments in science, prompted the design of a writing revision game for teachers, along with a game-infused professional network that pulled player score data and teacher review counts.

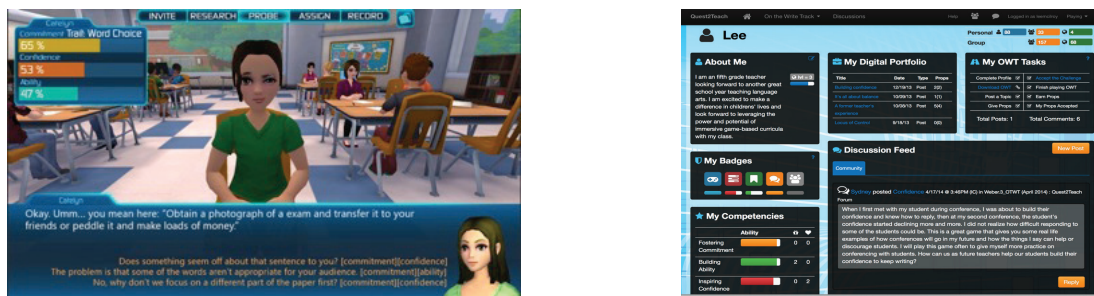


Figure 5: Screenshots of a teacher professional development game about student-teacher conferencing and support (left), and the integrated social network with meter fed from in-game activity (right).

Teacher Dashboard, Network, and Game Modules. Consistent with our notion of games as a service, the teacher dashboard allowed teachers to monitor student progress, access in-game student document summaries, identify key decision points for in-class discussion, and accept or reject student work. The dashboard allows for procedural management of student progress, but does not validate teachers for their hard work or allow them to network with other teachers. Based on a number of interviews and observations, and consistent with our broader theory of change, for the second round of implementation in 2014 we expanded the teacher offerings and connected these new features directly into the teacher dashboard efforts of the teacher. These designs were implemented in 2014 with the following goals:

- Creating a meta-game context around being a 21st Century teacher, emphasizing growth and participation as legitimate and supported;
- Acknowledging the amount of work teachers were doing in the review process, and connecting this into their social identity as a professional;
- Providing additional experiences with those skills and literacies that were essential to the successful implementation of the student experience;
- Shifting their role from a procedural one focused on student management to a more consequentially motivated focus on cultivating student dispositions.

The bounded game, On the Write Track, was adapted from the Quest2Teach project focused on pre-service teachers and implemented at Arizona State University. This game is an immersive world game where teachers conduct virtual Writers Workshop to provide students with critical feedback that inspires effective revisions of student work. The challenge is to ensure that the feedback identifies current writing weakness, but simultaneously increases ability, confidence, and commitment to revise. The virtual conferences begin with student-led sessions and then involve supporting students as they conduct a peer workshop, each of which results in scores representing the

virtual students' ability, confidence, and commitment to revise their work. Game meters and other in-game analytics are fed back into the real-world professional network, leveraging gamified achievement layers to validate and extend their digital experiences, via network of supportive colleagues.

In addition to game completion, the larger professional trajectory involves a sequence of challenges the player completes, including their online profile and accepting the commitment to evolve their practice, playing the game followed by the sharing real-world examples from which they can earn peer-awarded validation "props" that translate in-game achievements (meter scores from virtual characters) into a social currency to validate colleagues as they reflect, craft, and evolve their impact stories of how they are translating core learning concepts to the real world. The focus of this network is on supporting extended interactions and providing teachers with experience in collaborative learning communities focused on integrating game-infused strategies into classroom practices.

More than simply offering social and emotional support to transform teacher practices and shift conventional instruction, teacher communities provide technical and professional resources that encourage peers to work together and challenge each other. Therefore, a core goal has been to integrate professional networking tools and achievement layers to support a community that engages in collaborative sense-making and leverages bounded learning experiences and gamified achievement layers toward real-world professional growth and impact. To support more consequential engagement, we also used the network to create aspirational goals that positioned teachers to focus more on cultivating the larger dispositions, rather than simply focused on the skills and literacies or moving them through the game.

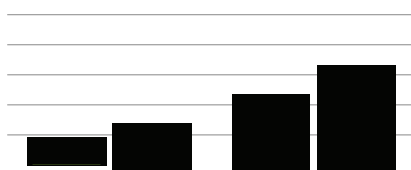


Figure 6: Change in Reports Accepted and Revised.

Our first round of implementation studies using the On the Write Track game and the broader professional network included teachers who participated in the 2013 study along with 30 additional teachers who signed up to participate for the first time in 2014 (total $n = 28$ LA, $n = 15$ science teachers). Preliminary analysis of teachers participating in both implementations focused on the degree to which teachers, on average, gave more feedback to their students in 2014 compared to 2013. Teacher feedback is expressed as the number of revisions per student teachers require of them as they progress through the game and the number of submissions that teachers accept. Findings illustrate that on average, students in 2013 were required to submit approximately 4.5 revisions based on teacher review of their work and that 1.5 submissions were accepted. In 2014, these figures increased to 6.5 required revisions with 2.5 accepted submissions—a 30% increase in required revisions and 40% increase in acceptances. The 2014 averages are consistent with teachers who implemented the games in their classrooms for the first time in 2014 and indicate it was not simply due to the previous year of experience with the games.

Summary

Across the two years of implementation we moved from bounded (small “g”) experiences to building a rich set of experiences and infrastructure (Big “G”) around the games, especially in the case of teachers. Consistent with this thinking, we further transitioned from a focus on games-as-products to games-as-services with a deep concern and commitment to supporting meaningful ecosystem integration. In terms of a design heuristic and visual representation of the argument, one might imagine charting player agency versus productive constraints on the y-axis and designed product versus on-going services on the x-axis. Here, one cannot relinquish responsibility for instantiating an expert model (whether it is underlying disciplinary literacies or the learning trajectory) to drive learning and engagement, nor can one ignore the power of player agency and local ownership of the implementation. The goal is not to position one’s innovation too heavily in any one quadrant, and when properly designed one could even imagine a player’s simultaneous experiencing of all four. However, in terms of a design and conceptual heuristic, the distinction has proven useful. Another useful shift in our thinking was from the treatment of a game as a bounded event to thinking more deeply about the surrounding Big “G” infrastructure, and the distributed learning trajectory through which players develop the literacies and dispositions.

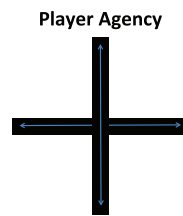


Figure 7: Design Tensions.

Our notion of a learning trajectory is consistent with the description put forth by Penuel, Confrey, Maloney, and Rupp (2013, p. 346), who describe it as “a researcher-conjectured, empirically-supported description of the ordered network of constructs a student encounters through instruction (i.e. activities, tasks, tools, forms of interaction and methods of evaluation), in order to move from informal ideas, through successive refinements of representation, articulation, and reflection, towards increasingly complex concepts over time.” Given our interest in leveraging game-infused experiences and the importance of contextualizing these experiences as part of meaningful purpose, we translate this articulation into the concept of a Quest. A quest is a researcher-conjectured sequence of instructional challenges that leverage multiple modalities, diverse types of feedback, and a culminating “boss” deliverable to support an engaged and purposeful learner. While a particular collection of Quests might foster a specific set of literacies, across the various learning experiences it is the dispositions that orient one’s actions towards particular ways of being that likely lead towards successful application of the underlying literacies.

Our work is now positioned to focus on building journeys that leverage multiple modalities and experiences, and that cultivate life dispositions. Toward this end, we have established a public-private partnership, and have built a journey-builder infrastructure with the goal of providing a cross-curriculum, game-based learning platform and community to help research-grounded, game-based-learning products make sustainable impact. In the case of the two student games introduced here, they are being revised and extended with supplemental materials and experiences to create rich learning trajectories focused on scientific inquiry and persuasive argumentation—as students who complete both trajectories will experience the power of specific disciplinary tools and literacies for addressing particular situations at the same time they gain an appreciation for the cross-disciplinary dispositions. The key walkaway is not what our specific platform will become, but to realize that games for impact must be built on a clearly articulated theory of change and with a deep appreciation for ecosystem integration challenges and opportunities if we are going to maximize the impact of this medium.

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The Challenge of Game, Learning, and Assessment Integration

Abstract: The potential of games as learning and assessment tools can be met only if replicable methods for aligning game play with learning standards and formative assessment objectives can be developed. In addition, we must be able to adapt traditional measurement methods to new types of activity and data. The goal of this symposium is to present key aspects of the interplay among games, assessments, and learning based on a large-scale game development project. Using examples from SimCityEDU as illustration, design, data tools, psychometric modeling, and evaluation studies will be discussed.

Presentation 1: Designing Fun Learning and Assessment Games

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SimCityEDU

Before the discussion of design, a brief summary of the developed game will provide context for the work described throughout the paper. *SimCityEDU*, based on the popular *SimCity* commercial game, asks players to solve problems facing a city, generally requiring them to balance elements of environmental impact, infrastructure needs, and employment. The game scenarios are designed to assess systems thinking. Often named on lists of 21st century skills, systems thinking is also a cross-cutting concept in the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). Essentially, it is the understanding of how various components of a system influence each other. Table 1 presents a summary of the systems thinking learning progression used in *SimCityEDU*.

Level 1 - Acausal The player is not reasoning systematically about causes and effects.
Level 2 - Univariate The player tends to focus on a single causal relationship in the system
Level 3a - Early Multivariate The player has considered multiple effects resulting from a single cause
Level 3b - Multivariate The player has considered multiple causes in relation to their multiple effects
Level 4 - Emergent Patterns The player attends to and intervenes on emergent patterns of causality that arise over time

Table 1: Systems Thinking Learning Progression from SimCityEDU

In the Jackson City scenario, the player enters the city (Figure 1a) and is told that residents seem unhappy and are leaving the city. Interaction with the Sim characters reveals that they are having trouble with air pollution. Players can explore data maps that show which buildings are polluting (Figure 1b), how power is dispersed in the city, and how various areas are zoned. Players discover that coal plants are the biggest cause of pollution in the city. However, coal plants also provide much of the power in the city. Power impacts both resident happiness and jobs (unpowered businesses close down).

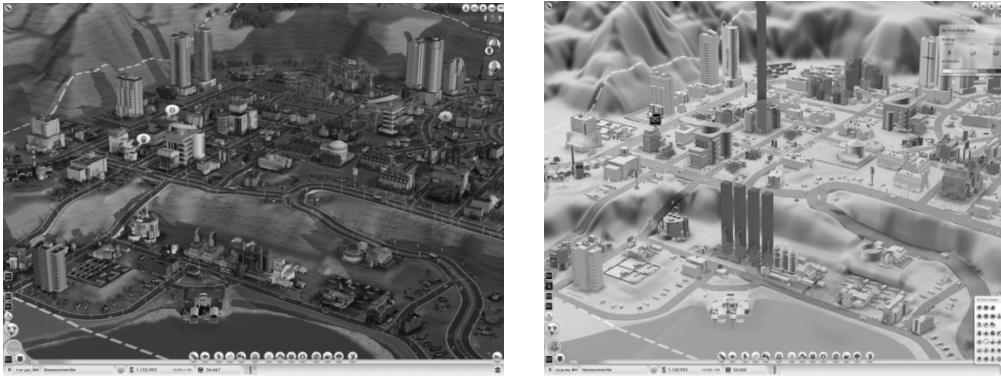


Figure 1: View of Jackson City from overhead (a) and via pollution map (b).

In the game, players can bulldoze buildings, place new power structures (wind, solar, or coal generated), build new roads to expand their city, and zone and dezone residential, commercial, and industrial areas in order to achieve their goals. They can monitor the effects of their actions on pollution and jobs with the on-screen thermometers. The players' actions are captured and provide evidence in a Bayesian Network (BN) trained to provide probability estimates that individuals at each level of the systems thinking would be observed engaging in each activity, activity grouping, or sequence.

In the design and development of game-based formative assessment, the primary challenge is how to create the compelling experiences that exist in good video games with the learning and assessment goals that are valued by parents, educators, and policy makers, and kids. Creating a successful videogame without learning and assessment is hard – videogame developers claim the success rate for games that go into production is worse than the success rate for movies. Combining commercially successful learning and assessment in a technology-based environment without gaming is also hard. Combining the affordances of games with academically valued learning and assessment creates a design problem with a new combination of criteria and constraints – and there are not that many truly successful examples.

This project used a variety of approaches to solving the larger “games for education” design problem. Our focus is formative assessment, which we see as a central connection point among games, learning, and assessment. The challenge we are embracing is to grow a studio that develops successful examples of game-based formative assessment, along with methods and machinery for others to use and build upon. Our approach is to bring together experts in commercial game design, researchers and developers in learning, and assessment development to create solutions to this jointly-constrained design problem.

Figure 2 presents goals and constraints across game, learning, and assessment design that must be aligned in a game-based formative assessment for it to be successful as a game, promote learning, and provide useful evidence and inferences about what students know and can do. At the macro-level, the meaning of the game, the learning goals (knowledge and skills to be acquired), and the constructs to be assessed must support each other. At the micro-level, deeper into the design, the game mechanics (actions), learning activities, and evidence collected for assessment must connect to each other, and also be in concert with the macro-level. Taken together these levels of the three strands and their intertwining define the product. We employ an evolving co-design process we are terming evidence centered game design (ECgD) throughout design and development.

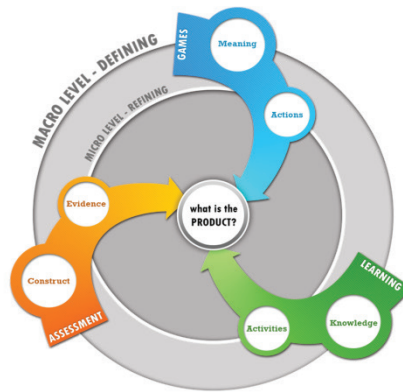


Figure 2: Integration of game, learning, and assessments goals and constraints

Meeting all of these goals in a single product has meant iterating and refining the processes by which the Lab approaches the games' designs. While this process is incomplete, the team has alighted on two key methods of game design, which are used in concert on its products.

Method 1: Emotion to Mechanics

- Key tenet of this method: begin with a desired emotion or insight, and design mechanics and aesthetics to invoke this emotion.
- Example from commercial games: *Journey*. Explores the emotion of connection (vs. loneliness) through novel online game play technique.
- Example from research team: *SimCityEDU*. Explores the fact that resolving environmental issues requires engaging difficult and unstable systems, using systemic and semi-opaque mechanics.

Method 2: Competency to Gameplay

- Key tenet of the method: begin with a deconstruction of a competency, and then find aligned mechanics which can be woven together into a gameplay experience.
- Example from commercial games: *FIFA Soccer*. The competency of Soccer can be deconstructed into *ball control*, *pass*, and *shoot*; the computer game in its core mode uses *joystick*, *button A*, *button B* to emulate this competency in clear mechanics.
- Example from research team: The competency of argumentation can be deconstructed into *evaluate evidence*, *form Claim-Evidence (C-E) pair*, and *critique an opponent's C-E pair*; the digital game thus has the core mechanics of *Collect Evidence*, *Construct Core*, and *Argument Attack*.

These ideas inform the discipline that GlassLab uses throughout the process of iteration called for in ECgD. The commercial games listed are each the product of years of production and millions of dollars of investment. These ideas thus are not blueprints but rather are focusing mechanisms to keep the team on a narrow path while the game is iterated around it.

Presentation 2: Uncovering the Unexpected

Kristen DiCerbo and Shonte StephensonPearson
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In describing the core elements of assessment delivery, Mislevy, Steinberg, & Almond (2002) suggest the importance of Evidence Identification (EI) as the process of applying scoring rules to learner work products to produce scores. However, when the work product is a log file of actions a student has taken in a game, it is less clear how to identify the scoring rules, much less apply them. We generally have only weak theories or initial hypotheses about what game behavior relates to the things we are interested in measuring.

Exploratory data analysis (EDA) is a conceptual framework with a core set of ideas and values aimed at providing insight into data, and to encourage understanding probabilistic and nonprobabilistic models in a way that guards against erroneous conclusions (Behrens, DiCerbo, Yel, & Levy, 2012).

Tukey used the analogy of data analyst as detective to describe EDA. Detective work is essentially exploratory and interactive, involving an iterative process of generating hypotheses and looking for fit between facts and the tentative theory or theories. Detective work and EDA are both essentially bottom-up processes of hypothesis formulation and data collection.

Tukey (e.g., 1986) did not consider methodology as a bifurcation between exploratory and confirmatory, but considered quantitative methods to be applied in stages of exploratory, rough confirmatory, and confirmatory data analyses. In this view, EDA is aimed at the initial goals of hypothesis generation and pattern detection following the detective analogy. Rough confirmatory data analysis is sometimes equated with null-hypothesis significance testing that is often what is taught in statistics courses. Strict confirmatory analyses involve the more sophisticated testing of specific relationships and contrasts that is actually less common in research practice.

In the creation and revision of evidence models for *SimCityEDU*, the team used a set of tools suggested by EDA that allow researchers to become intimately familiar with their data. One way to categorize and explain the tools is through four Rs: Revelation, Re-expression, Resistance, and Residuals.

Revelation refers to Tukey's (1977) statement that "The greatest value of a picture is when it forces us to notice what we never expected to see" (p. vi). Graphics are the primary tool for the exploratory data analyst. Graphical representations can display large amounts of information using relatively little space and expose relationships among pieces of information better than other representations. Here we are talking not about visualization for public display, but for finding patterns in relationships. Tools for this include things like boxplots and scatterplot matrices. In addition, interactive graphics form an important part of the toolbox, allowing the analyst to explore relationships with a few clicks.

Using a scatterplot is one of the many tools we can use to detect patterns. For example, let's consider the left of figure 3 below. It aims to explore air quality scores after a player's first and second attempt. By first glance, it may appear as though this scatterplot is just a random scattering of dots without pattern. A closer look, however, reveals that there are possibly groups of players within the scatter. As identified by the circles in the right of figure 3, we can state the hypothesis that there are three clusters emerging from the data and they appear ordered from low to high. We might also form a competing hypothesis that there are actually five groups and an outlier (the bottom picture), separating, for example, the group that starts high and stays high from the group that starts high and decreases on the second attempt. In this case, we generate new hypotheses for each additional cluster pattern we suspect, and then conduct confirmatory analyses to test these competing theories.



Figure 3: Use of basic scatterplots to look at patterns in data.

Data often come to the exploratory data analyst in messy, nonstandard, or simply not-useful ways. This may be overlooked if one assumes the data distributions are always well behaved, or that statistical techniques are sufficiently robust that we can ignore any deviations that might arise, and therefore skip detailed examination. In fact, quite often insufficient attention is paid to scaling issues either in advance, or during the modeling phase, and it is not until the failure of confirmatory methods that a careful examination of scaling is undertaken. Addressing appropriate scaling in advance of modeling is called re-expression and is a fundamental activity of EDA.

Resistant methods are methods that are not easily affected by extreme or unusual data. In general, there are three primary strategies for improving resistance. The first is to use rank-based measures (e.g., the median) and absolute values, rather than measures based on sums (e.g., the mean) or sums-of-squares (such as the variance). For measures of spread, the interquartile range is the most common. The second general resistance building strategy is to use a procedure that emphasizes more centrally located scores, and uses less weight for more extreme values. This category includes trimmed statistics in which values past a certain point are weighted to zero, and thereby dropped from any estimation procedures. A third approach is to reduce the scope of the data one chooses to model on the basis of knowledge about extreme scores and the processes they represent.

George Box (1976) succinctly summarized the importance of aligning model choice with the purpose of the analysis writing: “All models are wrong, some are useful” (p. 3). Residuals allow us to understand how our models are wrong. This emphasis on residuals leads to an emphasis on an iterative process of model building: A tentative model is tried based on a best guess (or cursory summary statistics), residuals are examined, the model is modified, and residuals are reexamined over and over again. In this way, throughout the analysis of the SimCityEDU log file data, hypotheses about evidence for systems thinking in game play were developed, tested, and modified.

Presentation 3: Psychometrics Meets Fun

Yue Jia, Robert J. Mislevy, Johnny Lin, Andreas Oranje
ETS

Educational assessments have been used for more than a century to gather information on what students know and can do and to guide and evaluate their progress in learning. The focus of these assessments has been on fairness, reliability, and validity of the results. In contrast, games are focused entirely on the experience of the interactions themselves and as such have the capability to engage and motivate students in immersive environments, providing goals, challenges, and rewards. Game-based assessments, such as SimCityEDU, drawing on the strengths of games, learning, and assessments, offer a great opportunity to guide learning, and to measure higher order, constructive, and interactive skills that are difficult to capture with traditional assessments (Gee, 2007, 2008).

In familiar educational assessments, a wide range of measurement models and scoring procedures have been developed to support reasoning from evidence to a given purpose or trait. However, as described in DiCerbo and Behrens (2012), most psychometric methods for educational assessments apply to what they call “the digital desert”: relatively sparse, self-contained, bits of evidence gleaned from answers to multiple-choice questions and raters’ scores for students’ essays. For psychometrics to take advantage of the richness of interactions (and associated data captured) in GBAs, we need to adapt, and where necessary extend, psychometric concepts and familiar measurement methods to new types of activity and data, such as model the multiple and interacting aspects of knowledge and skill and the dependencies among actions across time points.

As a promising psychometric framework, this paper focuses on the application of Bayesian inference networks, or Bayes Nets (BNs) for short, to GBAs. BNs are a class of models that have been developed to support probability-based reasoning as a means of transmitting complex observational evidence through a network of interrelated variables (Jensen, 1996; Murphy, 1998). BNs belong to the family of probabilistic graphical models. They can be applied as psychometric models by defining observable variables that depend on unobservable (latent) variables (Almond & Mislevy, 1999; Mislevy & Gitomer, 1996). In a GBA, the features of situations that engage players and the actions they can take to advance play are now viewed as situations that evoke thinking through the targeted learning, and their actions provide evidence about their capabilities. It is here that game design connects with assessment design (for which we draw on the “evidence-centered” assessment design framework, or ECD; Mislevy & Haertel, 2006).

A BN consists of a set of variables (referred to as nodes) with a set of directed edges (represented by arrows) from parent nodes to child nodes indicating conditional dependence relationships between the corresponding variables. Nodes in a BN may take discrete or continuous values. In the discrete case, the directed edge represents a conditional probability table (CPT) for values of the child node, given values of the parent node. More general conditional probability distributions (CPD) are possible, such as Gaussian linear CPDs (Koller & Friedman, 2009). The graphs are acyclic in that following the directional flow of directed edges from any node it is impossible to return to the node of origin (Jensen, 2001; Pearl, 1988). By representing the variables of the model as nodes in the graph and using edges in the graph to represent patterns of dependence and independence among the variables, the model serves as a bridge between cognitive scientists, test developers and psychometric experts. In particular, “hidden” nodes corresponding to aspects of students’ knowledge, skills, and strategies, play the role of person variables in psychometric models, and aspects of performance are modeled as functions of these variables and features of game situations. The general framework can be adapted to a wide range of data types, continuous interactions, dependencies, and learning that are found in serious games.

In the presentation, we will first present the opportunities and challenges associated with using BN with GBAs. We then provide examples of building up BNs as part of an assessment engine for SimCityEDU. We will show how the cognitive models (in ECD speak: student and evidence models) and claims that are made based on those translate to fragments of the BN that was utilized.

Presentation 4: Do Assessment-based Games Keep Their Promises? : Evaluating Underlying Principles, Game Constructs and Classroom Use

Geneva D. Haertel, Terry P. Vendlinski, Britte H. Cheng, John Murray
SRI International

Technology can situate students in settings that simulate real-world environments and accumulate direct evidence of student thinking, problem solving, and understanding (Vendlinski, Chung, Binning, & Buschang, 2011). Recent advances in measurement and statistical modeling support the integration and interpretation of this accumulated evidence to yield valid inferences about student performances (Mislevy & Haertel, 2006). In theory, the Evidence Centered Design (ECD) framework accommodates these recent advances in the learning sciences (both cognitive and situative), technology and measurement. Given that ECD will frame both game, and assessment design and delivery in this project, we explored what constructs assessment-based games developed using ECD are measuring and how these game-based assessments and their associated data are actually being used in classrooms.

Since the infusion of ECD into the game and assessment design process may necessitate changes to both proven game design and student assessment methods, we documented the use of ECD in the design process in detail. Four principles of ECD, which apply to the design of game-based assessments, will be presented. These principles were derived from ECD theory and practice as well as from the experiences and reflections of the team of game and assessment designers as they designed, developed, and modified iterations of the first game (SimCityEDU). Next we will present the results from two empirical studies of SimCityEDU. The first of these studies, cognitive labs conducted on 55 middle school students, provided evidence of the constructs a student used to play the game. In particular, we employed this method to collect evidence that a student used systems thinking in the SimCityEDU game as this was the construct intended to produce successful game-play.

The next study was conducted to ascertain the classroom conditions and contexts, and instructional practices around which the SimCityEDU game-based assessment could be successfully implemented. The data collected for this study included: structured teacher interviews (after professional development and after nine days of classroom use); multiple classroom observations of each teacher; and student surveys of attitude and usage. This study of 10 middle-school science classrooms documents the range of teacher practices and student activities and attitudes associated with successful implementation.

In this presentation, we will first discuss the extent to which ECD principles were implemented in the game and assessment design process: 1) how was the domain of interest (systems thinking) organized and bounded; 2) how were the student, evidence and task models defined; 3) how was the evidentiary argument (student, evidence and task models) represented and iterated over time; 4) what design principles were implemented in the game design process (e.g., avatars, progress menus, game pacing, thermometers and other feedback mechanisms, data and other game views, narrative, looping, rewards); 5) results of cognitive lab studies about whether the construct of systems thinking was elicited during the SimCityEDU game; and 6) results of the study to document the classroom conditions, instructional practices, in particular, formative assessments and learning contexts that surround successful implementation of the SimCityEDU game. Finally, the initial results of on-going analysis of game-event logs will be presented.

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Well Played

Elder Scrolls Online: Cooperative & Social Aspects of Game-play

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Justin Eames, The SEED School of Maryland

Introduction

Elder Scrolls Online (ESO) transforms the single-player worlds expressed in Bethesda Softworks' series of five games about the land of Tamriel into a Massive Multiplayer Online Role Playing Game (MMORPG or hereafter, MMO). These games, especially *Oblivion* (fourth in series) and *Skyrim* (fifth in series) culminated in a rich narrative that includes religion, culture, lore, stunning environments, good vs. evil, and most importantly, the option to run free, following a mostly non-linear path and choosing quests that follow the main storyline or side-quests. "The development of this game [ESO] was going on parallel to the development of *Skyrim*. We always knew that when *Skyrim* came out, that it was going to have a massive impact on how people perceived the Elder Scrolls game ... and we had to adapt our game," (Knonkle, 2013). The ESO narrative includes elements from all the former games, referencing and building upon the four Eras and is set in the Second Era while *Skyrim* is set in the Fourth Era, and *Oblivion* the Third Era. Consequently, you will find no dragons in ESO. I think we are not alone when we say that most players would love to have a dragon and fly to our destinations instead of a horse that we ride to our destinations.



In ESO, the environment is wonderfully crafted with rich details in architecture, furniture, books, flora, fauna, NPCs (non-player characters), and exquisitely-designed weapons and armor. The world is home to realistic weather effects, including a night and day cycle, as well as being populated with creatures that make it feel full and alive. A generation ago, the immersive experience of exploring fantastical worlds was accomplished through the playing any number of imagination-based or tabletop games, most notably *Dungeons and Dragons*. These games share a lot with modern MMOs, including cooperative gameplay, character creation, and random encounters. ESO is compelling on many levels and, as an MMO, appeals to game players who desire social game play and group challenges.

A few basics of the game and its location

When beginning the game, players go through a rich character creation process that involves choosing race, gender, character class, and physical appearance. The choice of one's race (think species, not ethnicity here) determines which of the three alliances your character belongs to and, hence, which surrounding environment the player will spend the majority of the initial game exploring. ESO provides options to play solo, duo, in groups of four, and in Craglorn, there are dungeons specifically designed for four and twelve person groups who are at Veteran Level 10 or higher. Playing PvP (Player vs. Player) one can wage medieval siege warfare in the region of Cyrodil. The PvP areas becomes available at level 10 while reaching the maximum level of 50 cycles the player to the other alliance areas so that each character may play through all of the quests.

In addition, there is Coldharbour, home to the game's antagonist, Molog Bal, a Daedric Prince who harvests the souls of mortals. In fact, like all of the games in this franchise, the player starts in prison and this time Molog Bal has taken your soul! Of course, you must fight to get it back, and during your escape from prison, you grab your weapon of choice (being able to select only one weapon is a subtle clue that focusing on one weapon skill line will benefit you in the early stages). Here, you begin the process of learning the game mechanics that allow you to control your character and the game interface that helps you interact with everything and everyone. After your prison break, you appear in a town associated with your alliance: Ebonheart Pact, Daggerfall Covenant, and Aldmeri

Dominion (Please see Figure 1 above). (See more at: <http://www.uesp.net/wiki/Online:Online.>)

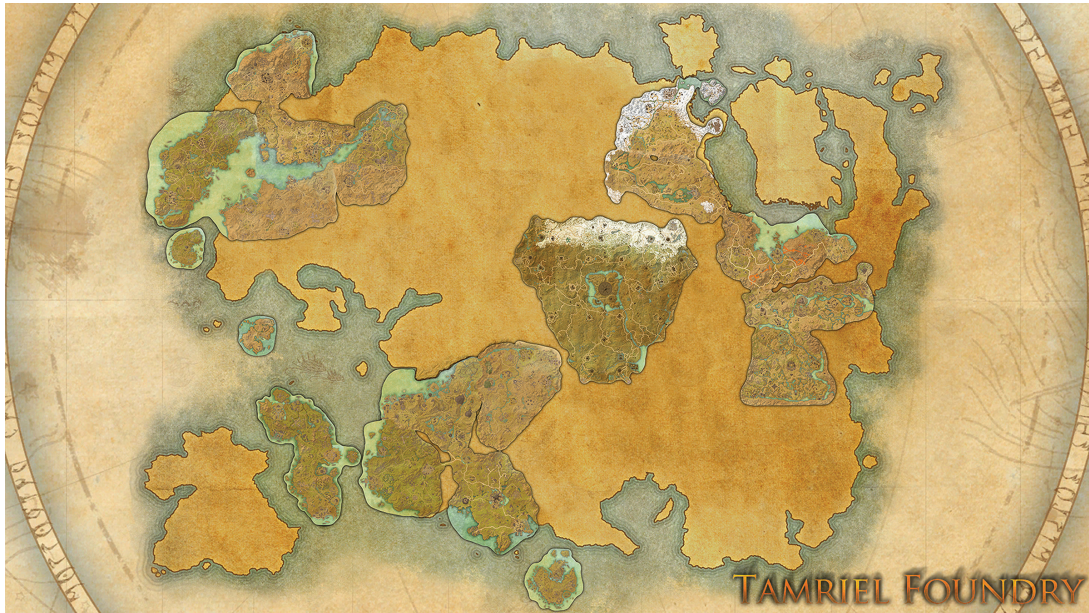


Figure 1. The map illustrates the three PvE areas around the perimeter and the central province of Cyrodiil, the PvP area. The unmarked spaces are places to be added as the game grows. For example, Craglorn was added in May, but is not pictured on the map. Map from: (<http://tamrielfoundry.com/2014/02/interactive-map/>), used with permission.

ESO, Skyrim & Game Narrative

When playing games, some players like to read the story as it is presented from NPCs and then layer on how their participation and interaction in the world matters, creating their own hero story, and others read little or skim the dialogs, picking up on themes without getting the details. Aubrecht and Eames approached their single-player interaction with Skyrim differently because of this difference. Aubrecht found that in Skyrim, she could display the dialogs and quickly skim through, click a choice and still know what to do to complete quests and level up. However, Oblivion required more attention to the NPC dialogs in order to know where to go next, because it lacked the feature of linking the desired destination from the journal of quests to the game map.

In Skyrim, one could play through the main quest line and never pick a side: Imperials vs. Stormcloaks. In ESO, choosing one of three alliances is done when creating one's character. If I choose to be Argonian, then I'm automatically in the Ebonheart Pact and the quests I receive once I get through the initial training area of the game are tied to that specific faction. A breakdown of the factions is here: <http://elderscrollsonline.info/races>.

In ESO, the narrative may be more important than in former Elder Scrolls games because we are all thrown into a war and players are given different scenarios about why they are at war with one another for the PvP aspect. At the same time, the game sets must set up why we all are united against Molog Bal. On the other hand, the repetitive nature of the quests and seemingly inconsequential nature of the player dialog response choices may negate the value of the narrative.

Undermining cooperative play by creating an unbalanced game economy

The way ESO has been sold, which is very similar to how Wildstar is being marketed, may contribute to undermining cooperative play by creating an imbalance in player's resources. It interferes with social hierarchy and player advancement within the game. Players can opt to spend more real money to buy a horse or purchase the Imperial Edition that has other perks as well, including the rings of Mara and the option to craft Imperial armor. Having a horse gives the player several advantages, for example, more storage space. While a horse can be purchased with game gold, it is very expensive. The rings of Mara are available only as a purchase and are then worn by two players who have committed to play together; when so doing, they receive a 10% experience bonus upon completing quests. Having to pay real money for these advantages means that they are not accessible to all players and, thus, creates two tiers of players: those who bought the Imperial Edition or the stand alone horse add on, and those who did not. In addition, the option to pre-purchase the game or opt for the Imperial Edition gives players the option to create a character in any Alliance; that, in turn, undermines the narrative. As Bateluer (2014) states,

“players are being hit with MicroTransactions, Pay Gates, IAPs (In-App Purchases), exclusive preorder content, and constant nickel and diming of the players. This is a cancer that’s rapidly spreading across every genre.” See [Josh’s rant from ShoddyCast](#), (2014) who argues that there is a battle going on for the very soul of the game and has implications for all MMOs. If nothing else, the cited comments point to player’s dissatisfaction with how these marketing strategies identify how players like to play and use that to increase revenue.

In-game incentives to play ESO seem similar to Facebook games, games that make you want to buy something or come back regularly. Recall Tamagotchi, where you had to care for your digital pet? In ESO, every 20 hours, I can feed my horse — each feeding gives me the option to increase the horse’s speed, stamina, or carrying capacity — allowing for upwards of 300 selections total. Playing every day, it will take me nearly a year to maximize all of these areas. In addition, the blacksmithing, clothing, and woodworking crafting skill lines all have the option to do “research” that takes anywhere from 6 hours to a month of real time. Placing an item in the research slot begins the timer and when the time is up you have “learned” how a particular trait such as durability or precision can be added to your crafting of clothing or weapons.

A discussion with Lucas Gillispie (personal communication, 2014), a long-time MMO player and the founder of Harbingers of Light (guild) said that in some ways as MMOs have matured as a game genre and as more in-game features have been added for player ease, it has actually undermined the guild community. In “his day,” harkening back to *EverQuest*, one had to have a website and systems for communicating with guild members to plan raids, have discussions, and provide a guild message board. The effort required resulted in stronger commitments to the guild by guild members. He lamented the loss of downtime: Time spent on guild business out of game allows time for reflection and that reflection can translate into solid guild cultivation and growth. In essence, this is about forced interactions that result from a game support-driven environment vs. one that is player-driven. In ESO there are trading stores and guilds as well. Gillispie explained further that in other MMOs, unlike ESO, an icon floated above player’s heads that represented their guild. Guilds built recognized and valued reputations and letting people know about it was a source of pride. Dikkers concurred with Gillispie’s point that as solo play is made easier and there are fewer barriers to entry, aspects of cooperative play have changed:

End game play in early MMO’s rewarded guild participation through game design elements. Primarily high-end gear required guild coordination to conquer greater challenges that required groups of players. This, in my opinion, incidentally encouraged positive social play. If personal goals were met in and through guilds, negative play didn’t add up for many. Tools that made solo style play were incidentally the same tools that lessened the need for guilds. Some tools that have made solo play easier and guild cohesion more elusive are in-game random queues, lower charter requirements, automated LFG (look for group), scenarios (and faster dungeon runs), smaller raid length, in-game calendaring (good add-on, but removed the need for external organization), and lower cost to server jumping (Dikkers, 2014, personal communication).

The authors are noob MMO players who first played Skyrim

In *Lord of the Rings*, (LOTR) Tolkien populated Middle Earth with believable characters and fantastical creatures, each embodying particular skills and all focused on the battle of good vs. evil — a compelling and profound narrative. When Aubrecht began playing ESO, that sense of battling good vs. evil and being immersed in a world similar to Middle Earth came alive for her. In a profound way, ESO appeals to Aubrecht’s childhood imaginings of what Middle Earth was like, brining them to life, and contributes to her appreciation for this game. She explains that, unlike in the LOTR movies, all characters in the book agreed that defeating Saruman was paramount and agreed to do anything they could to bring that about. For this reason, it is not a stretch for her to accept and imagine that there can be more than one hero in Tamriel (see Eames discussion of playing the hero below). In addition, the MMO experience opens up a wide range of questions that appeal to her research interests and ideas of how people can work cooperatively within a created system and also, individually or collectively, disrupt that system. And, when thinking of disruption, she often thinks of how to improve the educational system (1). In addition, when engaged socially, cooperation is an option; it can shift the player’s thinking from us vs. them to how to best to support one another in order to solve problems.

Eames’ Experience - Skyrim vs. Elder Scrolls

Unlike Michelle, I haven’t enjoyed my time with ESO as much as I expected. As a long-time fan of the Elder Scrolls single-player games and with practically no experience with MMOs, I went into my time with ESO expecting a very similar experience. While there are obvious similarities, I feel the defining traits of these two games are worlds apart.

Marc LeBlanc (2014) theorizes that there are at least eight types of fun associated with playing games. Personally,

I identify most strongly with the narrative, fantasy, and discovery aspects of gaming. With this in mind, Skyrim was a great fit for me. I spent dozens of hours exploring the beautiful tundra of the province of Skyrim, enjoying the wildlife and marveling at the spectacular aurora borealis effects. When I came in from the wilderness, the game provided a rich fantasy narrative, upon which I had a direct impact.

The world of Skyrim always felt vibrant and rich to me and the quests--both main and side--developed my sense of wonder. On the other hand, the first thing one notices when entering the world of ESO the first time are the hundreds of other players inhabiting the space with you. In highly populated areas, such as cities, there are dozens of players in your line of sight at all times. If you visit a local merchant or bank, there are often twenty other players interacting with the NPC simultaneously. When you begin initial side quests, you complete the tasks assigned to you while several other people do the same. I found the presence of so many other players pulled me out of the immersive experience, especially when I had to wait for a computer-controlled adversary to come back to life because another player beat me to it.

The side quests that make up the majority of the time I spent in the game are uninteresting and add very little to the overall narrative. Within a couple of hours, I was no longer even bothering to read the accompanying dialogue from the quest-giver. The details never mattered and anything I could say or ask would have no bearing on the quest. The only real choice offered during quests was whether to kill or spare an NPC guilty of some crime. Once again, the decision never matters, as the outcome remains the same. So, after clicking through the dialogue, I would simply look to my map and see where I was being directed by a waypoint on the map. Usually, the quests followed the same pattern: go there, kill a certain number of those, come back here. The main quests are not much better, and it was not very long before I was also clicking past the details of those, as well.

In hindsight, the lack of quality material is not so surprising. The scope of the world necessary to sustain ESO is staggering. The sheer volume of content necessary to keep players engaged for hundreds of hours would almost necessitate a lowered standard of quality.

So far, I have overlooked the social aspect of ESO, which is obviously the hallmark of an MMO. I must admit to never caring much for social gaming. With the exception of all-night GoldenEye/Mario Kart split-screen binges with high school buddies, gaming has typically been a solitary exercise. I cut my digital teeth wandering the fields of Hyrule as Link and exploring the mysterious ring-world in Halo: Combat Evolved. Aside from possibly having someone in the room, I went on these adventures solo, and I was okay with that. After all, there can be only one Hero of Time, and it might as well be me.

So, although it seems counterintuitive, I entered the ESO world mostly uninterested in the multiplayer aspects of the game, but hoping that the game would naturally change my mind. So far, it has not. Like many of the game mechanics in ESO, grouping with others serves the function of making yourself a bigger threat in order to tackle bigger challenges and gain more experience points. When I did group with others, I was often worried that my inexperience would hold the group back. I failed to form any meaningful relationships that went above the simple need to have someone else in the group to blast away at the super-repetitive enemies. Should I have tried harder? Absolutely. Did the game make me want to? Absolutely not.

Maybe my interest in ESO was doomed from the start. After all, I was hoping to extract a single-player experience from a massively multiplayer game. I was hoping my experience was going to open my eyes to the joys of gaming online with new friends, but so far, that has not been the case. Other than frustration at the lower quality of the experience, the only overriding emotion I feel when playing ESO is a strong desire to return to my old stomping grounds in Skyrim.

Why doesn't what we did as successful Skyrim players transfer to being successful ESO players?

The authors, Eames and Aubrecht, coming from a single-player background, spent a lot of time trying to impose what they knew about how to play Skyrim and Oblivion to ESO ... most of which did not seem to translate to ESO ... because Skyrim isn't an MMO. To understand this, the authors made a list what they have identified as the similarities and differences.

Similarities

1. The story is derived from the Bethesda narratives;
2. Probably what is most deceptive to those transitioning to MMOs ... there are solo quests;
3. Crafting your own gear is better than anything you can find or buy; however in ESO, it takes longer to level up the skills.

4. Loot obtained can be sold to NPC merchants;
5. The Lore Books in ESO are sometimes the same books that populated the bookshelves of Skyrim. Lore Books in ESO increase your mage skill line. Just as in Skyrim, “reading” lore books occasionally causes a particular skill to level up.
6. The economy in Skyrim is somewhat flawed because after a while, you amass an enormous amount of money and there is nothing to buy. Eames contends that this was addressed with the add-on, Hearthfire, which allows you to buy plots of land and develop your own estate.
7. The Collecting Habit. In Skyrim, one searches every dead body and urn. This habit will serve you well in ESO ... the crafting system is quite complex and will take days and days, months really, of collecting and advancing one’s skills to master.

Differences

1. Play daily to progress more quickly – for example by feeding your horse and crafting items.
2. Quests can be done with someone or in a group of up to 20 people, sharing resources with other players helps you tremendously (see below) and is also an incentive to join or form a guild.
3. Completing a quest rewards the player with game money.
4. There’s no way to “stop” the action while you use a health potion.
5. Horses are hardy and never die, even if you jump off a cliff.
6. Food and beverages that you craft can substantially increase your attributes of Magica, Stamina, and Health.
7. In Skyrim, you wear the best, highest-ranked armor you can get your hands on; in ESO, everything has 5 levels from normal to legendary and is also leveled according to the character’s leveling 1-50 and then veteran 1 to 12.
8. Skill Points that factor into one’s character development come from multiple sources: skyshards (finding 3 = 1 skill point), completing certain quests, and leveling up, whereas in Skyrim you got skill points only from leveling up. In addition, each of the 9 character options has a skill tree tied to it. For example, Argonians have a lot of skill perks in healing. Several skill lines are common to all such as weapon and armor skills as well as class specific skills and race specific passive abilities.
9. Group Play – identifying one’s play style and how you will contribute to the team effort – damage per second, tank, or healer. These roles form the unit of four people that team up to defeat difficult bosses and are a staple element in MMOs.
10. Storage is limited. Solutions: join a guild that will allow you can share the 500 bank slots to store crafting materials (or create one, but you’ll need 10 people to activate the bank), feed your horse, pay to increase your backpack and bank size, and mail things to your friends and then ask them to return the email unopened ... then don’t open it for a few days until you have space.
11. In Skyrim, you can buy a house and store everything. You never have to contend with what to do with all your stuff.
12. There are lots of things to spend money on such as redistributing your skill or attribute points, buying and feeding your horse, buying materials from other players, buying glyphs, and increasing your bank space.
13. Most importantly, there are several more ways to escape certain death than in Skyrim ... dodging, drinking potions on the fly, kiting (running backwards while firing a ranged attack), eating food ahead of time for buffs, skill point weapons or healings, plus your weapon of choice and a full set of armor.

Tips for success that MMO ESO players know that single player people don’t.

1. Wear armor that is all either heavy, medium, or light.
2. Strategic use of skills points – place as follows: an armor line, a weapon line, expand repertoire as skill points increase; at least one point for each of your class lines.
3. In the beginning ignore putting skill points into crafting and focus on skills that support questing.
4. Find crafting buddies to up your skill progression.
5. We’re all in this together ... quest with a friend!

There are players who mostly play solo, but playing cooperatively has benefits in terms access to more resources and quicker leveling. In Skyrim, the NPC merchant was your best friend. In ESO, other players are far more beneficial than the NPCs. The cost of buying a sword is over \$1000 gold and selling one obtained as loot yields only 12 gold. Better options are to learn to craft your own, get one from a guild member or friend, or buy a better one from another player. When questing with other players, one can trade items at no cost. For example, I may be in need of a better sword or some crafting materials and my friend is in need of some food for increased health and blacksmithing materials. While standing near one another, we can trade items for free or mail them in-game for a small fee.

Aubrecht's reflection on Guilds in ESO

I've joined three guilds and have three primary characters, one in each alliance. First, I answered an in-game chat call for guild members and joined Hollow Lullaby in Aldemeri Dominion Alliance. I have no privileges in the guild bank and I haven't talked to anyone in the guild since the day I joined.

In Ebonheart Pact, I joined Harbingers of Light (pictured left) because someone I knew out of game invited me to join. They have a website, a process for joining, and members who play other MMOs. Many of the members have been playing together for a long time. They use Raid Call, an out-of-game online talk channel, for discussions and coordinating group efforts. I have talked with guild members, sought advice, have bank privileges, and a craft buddy. He and I craft and exchange daggers so we can gain experience by breaking down each other's items. When we met to do a group photo of the guild and used Raid Call, he found out I was a woman (2).



In the Daggerfalls Covenant, I am in the Lords of Tamriel. A fellow quester, Omega, and I (we are the Vampires, pictured right) decided to form a guild in order to more easily share and store materials. I met Omega when I inquired if he thought a particular puzzle was bugged and he told me how to solve it. We decided to quest together. I suggested that we exchange items we crafted—armor and food. I gave him materials and found motif books that allowed him to learn new armor crafting styles. I shared crafted food items that increase character health. As an experienced MMOs player, he shared ways to improve my character's success and helped me redistribute my skill points to make me stronger. Within this guild, I found another craft buddy and we make and exchange glyphs that we break down to increase our enchantment crafting experience and share runes that we use to create the glyphs.

Conclusion

Although it shares a rich mythology with previous Elder Scrolls titles, ESO must be analyzed, evaluated, and played as something different. Fans of Skyrim who played to experience the rich narrative and explore an engrossing world will find that ESO is meant to be enjoyed in a different way: socially. The need to help one another to advance encourages conversations, selling items, trading items, and working cooperatively. Earlier Elder Scrolls games cast the players as mostly solitary heroes, uniquely equipped to fight the dark forces of Nirn. The solitary hero archetype came with a sense of isolation that meshed especially well with the frozen tundra of Skyrim. ESO, on the other hand, casts the player as one of thousands of questing heroes and encourages players to form community ties that keep them coming back and experiencing the expanding content of Tamriel. It is interesting that Aubrecht and Eames, both fans of previous Elder Scrolls games approached the MMO experience in vastly different ways. In hoping to replicate the single-player experiences he so enjoys, Eames found that ESO fell flat. In the aspects of Elder Scrolls that he values most, ESO comes up a bit short. Aubrecht, in approaching ESO with the intent to engage the community, found much more to be enjoyed. The obvious conclusion is that ESO cannot and should not be approached as Elder Scrolls VI, rather as a completely different experience, which shares a lot in common with its predecessors.

End Notes

(1) Classroom Applications

The Hero's Journey curriculum, while largely focused on *World of Warcraft*, provides learning quests that could be used with other MMOs. This curriculum has been tested with students and resulted in increasing student school attendance rates and advancing their academic skills. Student work is focused on game quests, journaling, group work, and machinima; however, students could potentially bring any number of reading skills/strategies to bear in regards to MMOs. Given that young people are bombarded with digital content and have access to staggering

amounts of information, using time-tested reading strategies to analyze and comprehend new types of media is especially important. “The same techniques we teach students to utilize when reading novels and informational texts can easily be applied, as they take notes, make connections, ask questions, and make predictions” (Gillispie, 2014, personal communication). The MMO has the added benefit of being highly engaging for many students, especially those who already enjoy gaming as a hobby. In addition to the curriculum guide, they made teacher professional development movies. Please find resources and curriculum download of *WoW in School – A Hero’s Journey* here <http://wowinschool.pbworks.com/w/page/5268731/FrontPage>.

(2) Women and MMOs – Aubrecht’s perspective

It seems that the assumption many players make is that everyone in game is male. Gender-bending is common — where men make women characters. My game name, Meash, could be considered gender-neutral so even though my character is female, I have yet to encounter someone who assumes I’m female. If they figure it out, they say it’s because I’m so nice. I usually take the position of don’t ask, don’t tell ... but will counter assumptions from time to time and let people know my gender. According to Nick Yee, (2014) 20% of MMO players are women (p. 96); however, some women don’t let the other players know their gender so that they won’t be treated differently. So even though MMOs provide an object-oriented play space where gender and age have no relevance to ability in game, it is played by people whose stereotypical assumptions insist that it does. Furthermore, Yee points out that when one considers gender similarities, the majority of male and female players in online games like the same kinds of play (p. 109).

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Caveat & Acknowledgements

After the review process was concluded, the gag order from the Beta period was lifted and the accessibility of the game went up and consequently the majority of this paper was completed after the peer-review process due to the confluence/strange timing. Special thanks to Seann Dikkers and Lucas Gillispie, experienced MMO players who acted as post-deadline peer reviewers of this paper.

Religious Experience in *Journey* and *Final Fantasy X*

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Introduction

Final Fantasy X (abbreviated to *FFX*) is a high-budget game in one of the longest running and perhaps the most famous Japanese role playing series (Squaresoft, 2001). It has a huge cast (and a bigger development team) who drive a story epic in scale. Contrast this with *Journey*, the wordless story of just one character's path towards a mountain, created by a team of only thirteen members within a newer American studio (thatgamecompany, 2012). Although these games seem and undeniably are different, there is a key thread, one held more broadly in common with much of human history. These two games, albeit in divergent fashions and with thusly divergent results, both explore important aspects of religion, an ever-elusive and yet ever-pervasive element of society. As an abridgement of a longer, humanistically-oriented work (Caldwell, 2013), the following analysis focuses on the application of close "reading" techniques to gameplay in order to interpret how *FFX* and *Journey* recontextualize ritual actions, construct and maintain sacred space, and (although explored to a limited extent here) situate the goals of religious narrative and in so doing can transmit some of the emotional and social experiences of religion.

Firstly, it must be noted that religion is a notoriously slippery term with shifting understandings and connotations. As used here, religion is best understood as a system of intertwining elements (e.g. emotions, acts, ontological theories, organizational methods) that work in tandem to produce effects within and beyond each individual practitioner. Those effects are defined and emphasized differently even within the field by religious scholars of varying backgrounds, most commonly psychology, anthropology, and sociology. Seminal scholars in each approach have, respectively, defined religion as an inner pursuit of the individual in relation to the world/cosmos (James, 1902), as a symbolic manifestation of social order reinforced through individual emotional responses (Geertz, 1973), and as a dogmatic system that is established and maintained through social customs (Durkheim, 1912) (1).

Regardless of background or focus, however, most scholars of religion would agree that understanding ritual is pivotal to understanding religion. Although scholars again differ on the exact definition of ritual, it almost always includes the behavior of religious participants. Often ritual is described as a prescribed, unchanging set of actions. However, cultural anthropologist and ethnographer Victor Turner (1982) insists that ritual is less about formulae and more about "performance, enactment" (p. 79). By saying so, he notes the connection between ritual and the arts via theatre, which he calls "the most forceful, *active*... genre of cultural performance" (p.104). Such cultural performances allow societies to reflect on its realities, both its strengths and flaws. Thus, by participating in such performances, a society aims to transform itself and its individuals. Turner develops this argument further in his key work *The Ritual Process* (1985), asserting that ritual is necessarily a series of actions that comprise a transformative process, which is catalyzed by, coalesces in, and produces symbols (p. 53). These are "social and cultural dynamic systems" that are observable through the senses and carry meanings that are both malleable and multifaceted (1982, p. 22). These symbols vary; they could be an image, an object, a person, a word, an action, a dream— anything that can condense an ontological state into a perceivable metaphor. Symbols are a form of language, and in fact, languages are systems of symbols, as are rituals. Thus, symbols enable communication. The actions we take, the stories we tell, and the art we create are the ways in which we express our culturally situated identities.

Video games, like other forms of individual and cultural expression, are created from and are comprised of systems of symbols, thus making them a potent means to present or, more deeply, make commentaries or conjectures on the world and its various aspects. Naturally, games like *FFX* and *Journey* do not stand alone in their exploration of religion, as countless works of art, including other narrative media such as literature and film, have been dedicated to parsing what religion and its practices mean to individuals and civilizations. However, video games are unique in that they require interaction between the audience and the medium. This interactive element, felt through the game's response to the player, is shared with both theatre and religion via ritual, the latter as understood as external or internal transformations brought about through sets of actions. As such, video game mechanics, or as specified by James Paul Gee (2012), "all that a player must do or decide in order to succeed," are the key to the medium (p. xvii). For video games, content necessarily follows form, but form is often tied inextricably to content in order to maximize player interaction in what Drew Davidson (2011) calls the stages of involvement, immersion, and investment. Returning to my case studies, *FFX* and *Journey* encourage players towards these stages differently, resulting not only in different kinds of games but different aspects of religious experience to be effectively considered. In *FFX*, we see a more critical view of religion as a social institution, but in *Journey*, we see—and feel—the odyssey as a simple yet intimately powerful inner experience.

The Light along the Way: *Journey*

A vast pool of glittering sand unfolds interminably under a flaming sun, revealing what seems like a desolate cemetery. A twinkling ball of light leads to a figure, not quite human, with hollow yet expressive eyes of light, sitting on the sand somewhere nearby. Then a faint representation of the controller in your hands appears, arrows on either side. Tipping the controller's ends makes the camera (your perspective, which is all that is shown by the screen) revolve around this figure in the deep vermilion robes. It stands; you may now move as indicated by the controller on the screen. This is the opening of *Journey*, a game that defies the conventions of an industry preoccupied by genre. *Journey* is a brief game, but one filled with a power that has moved many players' hearts and minds in a way and on a scale rarely seen in gaming.

Like that of many well-designed games, the experience of playing *Journey* can be described through Davidson's stages of interactivity. Considering *Journey*'s brief length (two to three hours), those stages must be achieved quickly, with completion and likely the best game experience brought about in one sitting. *Journey* does so through very deliberate world building that advances in sections that move almost exclusively as quickly as the player wishes them. In a playthrough of focused but not rushed speed, the player could reach the beginnings of the investment stage in as little as twenty to thirty minutes of play, as traced below.

Davidson describes the first stage, involvement, as the period in which the player first interacts with the game, learning how to navigate the world presented (2011). The scene detailed at the opening of this section provides a large part of this stage, which lasts at least throughout the next five minutes of play. During this time, *Journey* allows the player to develop enough skills with the game mechanics to continue, like many games (see Gee, 2005), but it does this very simply and compellingly, linking explicit but unornamented instruction to experience in order to facilitate the later use of that information. Beyond this, the player learns on his or her own through applying these tidbits of information to the exploration of the game world. Therefore, the player swiftly masters the simple control scheme and can explore the sands through a viscerality that makes the figure a highly responsive vessel for the relationship between player input and the virtual environment.

Even before the controls are mastered and that stage is complete, players get a taste of the next one, immersion. Immersion takes place when players feel confident enough in their understanding of the mechanics to explore the game world (Davidson, 2011). Exploration breeds immersion, but immersion prompts exploration; that is, players make more sense of the game world as they explore it, but they will only undertake exploration if the game world is compelling enough to do so as its system is learned. Here *Journey*'s audiovisual elements are key, especially as there is almost no text in the game experience. Visually, the deserts and architectural ruins of *Journey* are framed and differentiated through light: the sand here does not merely sit in large, impressive dunes; it glimmers in the sun's rays as the figure steps lightly across it. Amongst buildings, the light mutes, softening in the shadows. By moving about and manipulating the camera, the player can experiment with that light. But to experiment with light is to experiment with sound, as throughout *Journey*, light does not exist without it. Most of the sound, including the music, is based on the player's interaction, retaining a performed element in the sound design as well. The sand crunches under the vermilion figure's feet, and players can prompt the figure to emit bubbles of light with illuminated glyphs from which a chirrup echoes. The trill sound allows communication with animated pieces of cloth in the environment that respond with a chorus of similar glyphs and chirps.

Thus, *Journey* quickly crafts a sensuously rich space that involves players through the influence they have on the world. This is the prerequisite for Davidson's (2011) final stage, investment, during which the player pushes on towards the end of the game. As its name implies, investment requires that the player is enough interested in the game world and the character(s) he or she controls to see what is in store for both. As such, this stage often relies on the game's narrative, which is usually introduced alongside involvement and developed further during immersion. In *Journey*, the narrative at first is no more than the presence of a mountain that lies in the distance, yet seemingly within reach. The player continues towards it during the immersion stage, exploring first the dunes, then a built structure. Here, the red figure activates a pedestal through its call and sits calmly cross-legged in a circle of light at the base of the pedestal. An unplayable vision appears, in which the figure is approached by a similar but larger, white-and-gold-robed figure. The white figure shows what seems to be a visual history of the objects present in the game world (the mountain, the glyphs of light on the figure's robes and "speech," the white figures, and the cloth pieces). The narrative is not yet made clear, so the red figure stands and continues. After rebuilding a cloth bridge between tall towers in the sand and seeing another vision, the figure comes upon more dunes, this time guided by cloth that move like a dolphin or bird. Soon the figure comes to a darker place in which towers churn within a sandstorm. The dolphin-like cloth's movements become urgent and its chirps mournful. Its brethren are trapped within the towers. The player is compelled to free the trapped cloth, an action that not only advances the player's progress but also poses him or her as a singularly important agent within the world. What else can the player do? That question and the expectation that the answer lies ahead is what brings players to *Journey*'s

investment stage and onwards to the end of the game.

Journey's exceptional design is seen through its immediate but permeating power, one that parallels real world religions as studied by Turner and his ilk. The game does not achieve this power through quickly paced gameplay; rather, the player decides the pace of play. Yet, the immersive potential remains deep no matter which pace is taken. In this regard, *Journey* is most closely aligned with mystical religious practices, those centered around experience rather than theory, feeling rather than describing or discussing. Mystical practices occur at least tangentially in myriad religious systems worldwide, including the visions of some Christian sects, South Asian yogis and ascetics, Jewish Kabbalah, Buddhist meditation, Islam's Sufi dervishes, and so on. The latter are of particular note here due to *Journey's* visual connections to Sufism, an esoteric branch of Islam that focuses on spiritual unity with the omnipresent divine, Allah. The facades of the game's ruined architecture amongst desert sands and the form of the glyphic verbalizations of the figures and cloth pieces suggest roots in the stylings of the Islamic architecture of medieval Persia or Mughal India, where Sufism and other Islamic traditions flourished. Echoes further resonate through the emphasis on geometric forms that filter light into complex patterns, as often seen in the windows of mosques, and an architectural coloring reminiscent of sandstone, ubiquitous in Mughal India. *Journey's* glyphs resemble the kufic script found across Islamic art and representation, and like those glyphs, kufic script is often found as inlays of precious material, sacralizing the word of Allah through light and color. As noted above, light is a dominant presence in *Journey*, and the precedent for this can be found in those traditions that bask in light as the manifestation of divinity (see also Pentcheva, 2011). When *Journey* borrows these real-world aesthetics, it borrows a shortcut to what is already culturally interpreted as sacred.

Prominent religious scholar Mircea Eliade (1959) has argued that making a space sacred through rites, aesthetics, or declaration sacralizes the actions within. This is haptically expressed in *Journey*, as the actions themselves suggest the same kinds of sacrality that the visuals do, still in reference to the mystical practices of bodily meditation and contemplation of divinity. During the involvement stage, the player learns that when the robes and the cloth pieces glow, they allow the figure to swirl upward into the air and glide. In this world, the player can transcend the limitations of his or her real form by virtually calling out to an unknown yet benign force to be lifted upwards. The animation that results is satisfyingly peaceful, and the process mimics many real-world forms of meditative practice that aim to separate the mind or spirit from the body, allowing the former to do things that the latter cannot. This connection extends beyond the first moments of flight; as the little robed figure runs, walks, stumbles, cowers, and soars, the player's actions feel like an extension of his or her thoughts through these responsive animations, blurring the distinctions between player and avatar, between real and virtual environments, into a mindful awareness of each moment that is a key component in meditation. But in *Journey*, a player need not train in esoteric meditative techniques in order to experience this mindfulness; they may merely press start at the title screen.

At its core, which has captured the attention of fans worldwide, *Journey* finds the player acting in a ritual fashion, as emotions are conveyed through the controls, translating into the actions of a little vermilion-robed figure. Like ritual, the performance of a transformative process as developed through symbols, the figure's actions have the potential to aid the player's internal transformation through his or her participation, during which the player may contemplate the intersection between the virtual and the inner journey. Through the red-robed avatar, the participant becomes the entity experiencing the events of the story, as in performative, dramatic rituals of the type considered by Turner, Eliade, and others. Thus, *Journey* can prompt an affective response that finds itself within the realms of religion. To refer back to our religious scholars, this response is the effect of the player's "feelings, acts, and experiences" (James, 1902, p. 31) that interpret "a system of symbols" to "establish powerful, pervasive, and long-lasting moods and motivations" (Geertz, 1973, p. 91) that are "relative to sacred things... set apart" from everyday, profane life (Durkheim, 1912, p. 2), in this case by the game's necessarily contained mediation. *Journey* is therefore a concise crystallization of a certain kind of religious experience, one grounded in introspective meditation on existential realities, into a multimedia experience.

Acting on Fayth: *Final Fantasy X*

The experiential mysticism that makes *Journey* powerful also resonates in parts of *Final Fantasy X*. However, *FFX* is about people and society. Its characters weave and drive the story, the world, and the mechanics through their thoughts, expressions, abilities, and interactions. *FFX* moves along Davidson's stages as *Journey* does, though over a much longer time and with more complexity. The game is as rich in religious ideas as it is vast, requiring an excerpted analysis here. However, even in just the passages parsed below, *Final Fantasy X* uses its mechanics, game world, and narrative to examine socio-cultural aspects of religion, challenging institutionalized religion while recognizing the power of religious affect.

In *Final Fantasy X*, the player is cast as Tidus, a young man displaced from his era and his home city of Zanarkand to a world called Spira, one thousand years in the future. The game is categorized as a Japanese-style, turn-based role-playing game (RPG). This genre tends to limit player interaction significantly through what game designer Darby McDevitt (2013) calls “Destiny” mechanics, allowing these types of role-playing games to transmit a rich story with strong character development and an expansively detailed world. As such, *FFX* presents very few points of interaction, the primary point being combat management. However, during certain portions of the game, the player solves environmental puzzles in a mode that is decidedly ritualistic.

The first of these situations occurs on Spira’s island of Besaid. Here the game is still in its involvement stage, so Tidus is learning the social etiquette of Spira, much of which is derived from the worship of Yevon. It is somewhat unclear if Yevon is a god, an institution, or both, but it is clear that Yevon did not exist in Tidus’s Zanarkand. He does not carry within him Spira’s deeply entrenched “social facts,” which are, according to our religious sociologist Émile Durkheim (1895), “ways of acting, thinking, and feeling that present the noteworthy property of existing outside the individual consciousness” and are “endowed with coercive power... independent of [the] individual will” (p. 2). Tidus is thus cast as an outsider to this collective will, though he soon gains an ally to guide him through this society. Wakka, a native of Besaid, acts as a guardian to a novice summoner, a cleric of sorts in Yevon’s religious hierarchy. Wakka admires Tidus’s skill in the sport of blitzball, a common thread between the two worlds, and decides to help him adapt. To introduce Tidus to Yevon, Wakka encourages him to visit the island’s temple. There, Tidus asks questions about what he sees and what occurs within. Although he is at first embarrassed by his disconnect from Spira’s social facts, Tidus soon learns of a crisis: Wakka’s summoner ward is performing a ritual deep within the temple and has not emerged for days. Tidus, outraged by an apparent disregard for the summoner’s safety, ignores the villagers’ prohibitions, breaking into the depths of the temple. He is soon confronted by the Cloister of Trials, the environmental puzzle the player must solve to advance.

Unlike in *Journey*, the player is informed that he or she has entered a sacred space and that all actions within are (or ought to be) kept as sacred. Yet, like the space in *Journey*, the temples claim a sacrality beyond what the player is told. Certain audiovisual elements cause the temples to *feel* sacred beyond an explicit acknowledgement. These elements gain power later in the game through deliberate repetition, but even the early Besaid Temple carries that sacrality due to its roots in real-world religions. A marked difference from the airy, bright village and coasts of Besaid, the temple welcomes Tidus into a dimly lit, high-ceilinged but small rotunda that branches out into antechambers and up into the Cloister of Trials, itself leading to a room separated from the main sanctuary by a retractable door. The rotunda features colossal statues of high priests and other clerical figures from Spiran history, and many of the surfaces are inscribed with the rounded letters of Spira’s liturgical language (not to be confused with its common written language seen elsewhere, which resembles highly stylized Roman letters). The religious runes more closely resemble Sanskrit written in a classical script, which would account for their inclusion in the circular diagrams of the sanctuaries, which are themselves akin to Japanese and Indian esoteric Buddhist mandalas (2). These, used primarily for meditative practice, invoke deities represented by their “seed syllables,” or, in essence, their monograms (Bogel, 2002, p. 49). Along with the imagery, the music heard in the village is separate from that heard within the temple walls. “The Hymn of the Fayth” (Hamauzu, Nakano, Uematsu, 2001) is a mantra that, as heard in the rotunda in its default arrangement, is sung in harmonizing sections by a chorus, reminiscent of real religious music. A variation of the hymn plays in the sanctuary beyond the Cloister of Trials, featuring only one vocalist, representing the spirit (the Fayth) residing in the sanctuary. Once visited, this spirit can be called upon by the summoner to fulfill the latter’s purpose in Yevon’s hierarchy.

Thus, the sacred stage is set by the time Tidus reaches the Cloister of Trials. Technically, Tidus is operating outside of ritual, as his outsider status calls into question the sacrality of his actions. Durkheim categorizes such prohibited actions as taboo (1912, pp. 221-229), which run against social facts and threaten the sacrality of ritual. Tidus has little investment in these social facts, instead focusing on what he knows, which is simply that another person is in danger, and no one is acting in assistance. Nevertheless, the puzzle of the Cloister stands in the way. Since that element cannot be bypassed by Tidus or the player, it seems that the puzzle would be intended within the temple to purify the solver’s body and mind through contemplation of these actions. I offer this theory with precedence; Durkheim notes that “material maneuvers are merely the external envelope concealing mental operations” through “a kind of mystic mechanism,” like the rite of baptism in Christianity (1912, p. 314). Thus, Tidus moves around glowing, colored spheres to manipulate the rooms of the Cloister, but under that, he and the player must to some extent reflect on the physical and spiritual movement from the profane world in the village outside to the highly sacred world of the sanctuary.

Although it is beyond the passage read above, it is worth considering a nonplayable scene from the game to further illustrate *Final Fantasy X*’s methods of ritualization. The summoner found at the end of Besaid’s Cloister of Trials is a dynamic and kind young woman named Yuna. Throughout the game, Yuna creates fluid ritual settings via the actions made available to her by Yevon. At one such time, Yuna must perform a dance in order to guide the

spirits of those who had been violently killed to their final resting place. This visually and aurally striking sequence, the Farplane Sending, arguably sets the emotional tone for the rest of the game. Dusk has settled into the sky with pink and orange hues bouncing off of the surface of clear water. Yuna's bare feet step gingerly over the surface of the water as memorials float gently under her. She stops a few meters from the dock where onlookers gather. She looks out over the water, blinking in the bright light of the sunset as she holds her staff. Her eyes close; she breathes in deeply, and she begins to dance. The Hymn is sung slowly, accompanied by stylistically Japanese instrumentation as Yuna's sleeves and skirt flow out around her. Tidus stands on the dock; just moments before he had been asking why the party was stopping there. Now he is silent, a look of somber awe on his face as he watches Yuna and as the mourners collapse beside him in their grief. The spirits of the dead, materialized as balls of light trailed by chromatic shimmers, rise from the memorials and join in Yuna's rhythmic pirouettes. Soon a spiral of water ascends below her feet, lifting her onto a liquid stage colored by the sky and the spirits. The sequence then fades to black. This dock was not sacred before the party's arrival, but there is no doubt that Yuna's dance makes it so. She guides the spirits from Spira to the Farplane, freeing them from the liminal plane between life and death (see Turner, 1985, p. 95). This scene, though more emotionally potent and affective, continues and socially legitimizes what Tidus's actions in the Cloister of Trials begins: sacralizing the player's role in the game world through the characters under the player's command.

Conclusions

In both *Journey* and *FFX*, the mechanics and the worlds and stories in which they are situated are inextricably connected. Both games draw upon symbols from real religious systems, borrowing their powerful connotations when constructing virtual sacred space. However, where *Journey* allows the player to directly experience religiously imbued actions (through the shorthand mediation of the controller), *FFX* has the player guide characters through religious actions within a social system. Through this difference, the two games mirror different styles of religious practice and, like the definitions of religion, can serve divergent functions in religious analysis.

The pursuit of such religious analyses of and in games is a critical one for religious/humanist scholarship and game design alike. For humanist scholars, new media represent people's new ways of interacting with culture through creation, consumption, and inspiration. It is crucial to the humanities to find effective, i.e. contextually appropriate, means of "reading" such new media. To do so is to keep the humanities relevant to the current possible experiences of being human. For game designers, the humanities and the cultures it encompasses hold a wealth of information on the most powerful motivators for human action and experience. By tapping into this corpus and into areas like religion, game designers can make richly compelling games, ones that successfully lead players through Davidson's stages and thus through a complete, satisfying experience while also moving players. This can also be leveraged in education. Religion can be a difficult subject to teach, due to its deep, complex roots in contextual experience. By designing video games that can condense such experiences into a space that will not interfere with cultural practitioners, game designers will be able to create games that can teach about religious practices in a way that captures at least elements of what makes those practices compelling. In so doing, religious scholars and students, or faith leaders and converts, may be able to gain an educational tool that encourages exploration, fosters emotional investment, and nurtures the cross-cultural understandings that are the ethical ideal of humanist studies.

Endnotes

- (1) These scholars are exclusively from Europe and America in the nineteenth and twentieth centuries, yet their works remain highly prominent in their academic fields. Their theories appear here because they are useful and well-established foundations upon which current religious studies build further, primarily through adapting these older ideas to distinct historical situations, such as that of video games in the twenty-first century.
- (2) One player put in significant amounts of visual comparison to decode these glyphs and letters and to provide theories related to their origin in Siddham and Japanese *kanji*, coming to many of the same conclusions. Unfortunately, it is hard to verify his or her sources beyond the game itself, as citations are limited primarily to links to Wikipedia and other non-verifiable sites. However, the piece is a fascinating read, and I will cite it here for additional reference. See Helluin. (n.d.) *Final Fantasy X* symbols and glyphs. *Squidoo*. Retrieved from <http://www.squidoo.com/final-fantasy-x-symbols-glyphs>

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Creeping Systems: *Dota 2* and Learning In an e-Sport

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Introduction

As the field of games and learning has matured in recent years, we have found ourselves spending a great deal of effort detailing how games “work” as instructional tools, and how they may leverage the interests of youth toward simulations that encapsulate extraordinarily complex systems (Squire, 2002). As a field, we have perhaps shifted our gaze away — if just a little bit — from a focus on understanding the forms of play implicated through play in commercial entertainment games. In this paper, we forward the argument that the investigation of “games and learning” necessitates an understanding of both the complex reasoning practices embedded within the play of contemporary videogame genres, while also posing a number of questions that may help to frame future directions in “entertainment games and learning” research. The “well played” format is ideal for this exploration, given its emphasis on understanding play as it arises from the designed elements of games.

In this paper, we outline a productive case study of the “multiplayer online battle arena” (MOBA) game *Dota 2*. A new entrant in the MOBA space, yet with perhaps the oldest of MOBA pedigrees, *Dota 2* presents a complexity that begs further study as a space for learning in the one of the most socially-negotiated and (potentially) economically significant of current game genres. *Dota 2* is a prime example of how commercial and entertainment games demand — and can potentially teach — *systems thinking*, through awareness, positioning, decision-making, and an understanding of how to function within the game’s vast mechanical and social ecosystem.

And yet, how might an investigation of *Dota 2*, also notable in its role as an up-and-coming “e-sport,” contribute to a rethinking of what we consider relevant in understanding a game’s potential for learning? How appropriate is the framing of a “game” for understanding this kind of social and technical space? How does a look at *Dota 2* help to clarify the differences between “games” and “e-sports” and the potential learning implications of both?

From MOBAs to *Dota 2*

To begin, we need to situate ourselves in the relatively recent but eventful history of the MOBA. *Dota 2* is only one of many recent games in this genre, all of which originally spawned from the *Warcraft III* modification (“mod”) titled *Defense of the Ancients (DOTA)*. The mod was developed and released in 2003 using the “World Editor” of *Warcraft III: Reign of Chaos*. As *Warcraft III* is a real-time strategy game in which strategy focused around the development of heroes supported by an army of units, the *DOTA* mod shifted its focus to the development of a single hero, and units became AI-controlled. *DOTA* laid out the basic landscape for the MOBA genre and its unique mix of real-time strategy, roleplaying, and combat characteristics, as well as its signature map (based on the “Aeon of Strife” *StarCraft* map; see Figure 1, below). Several authors maintained the specific scenario that evolved into *DOTA*, but the longest running developer, the pseudonymous “IceFrog,” has maintained the project since 2005.

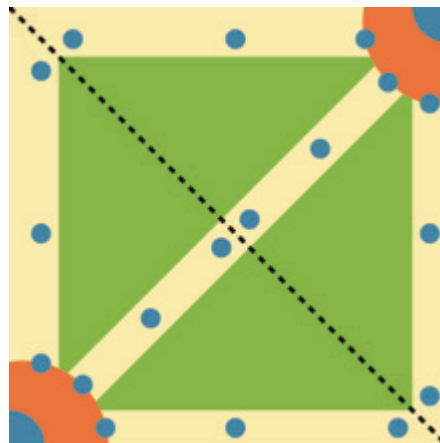


Figure 1: A prototypical MOBA map, action moving between the bottom left and upper right corners.

Dota 2 may not be the most popular *DOTA*-clone — *League of Legends* can boast a staggering 27 million players *daily* (Tassi, 2014) — but it is widely recognized as one of the most nuanced, competitive, and unforgiving games in the genre. Though all MOBAs originally evolved from *DOTA*, Valve Software (the developer of *Dota 2*) is notable for its desire to expand the original *DOTA* into *Dota 2*, and develop the game into one that can be played competitively on many levels. Staying true to the original formula, Valve went so far as to hire *DOTA*'s IceFrog as lead designer. This is not a new model for Valve, who has developed mods like *Counter-Strike* and *Team Fortress* into successful videogame franchises in their own right, as well as crafted new franchises by hiring the developers responsible for productive game demos (e.g., the hiring of Kim Swift, based on *Narbacular Drop*, which led to *Portal*). In both instances, Valve purchased the intellectual property and hired the developers of the original modifications to lead the new franchises, while in the case of *DOTA* to *Dota 2*, there has been some degree of legal contention with Activision Blizzard over the appropriation of the name “DOTA” (hence Valve’s subtle change of title away from the “DOTA” acronym to “Dota”).

Dota 2 plays like the mash-up of a single session, accelerated, massively multiplayer online role-playing game and a focused real-time strategy game in which players control only a single unit. During each session, or match, players command a hero in real-time on a standard map, leveling up, acquiring skills, and buying powerful items. Two teams of five players — the Radiant and the Dire — square off in what Valve calls an “action real-time strategy game” or “ARTS,” shifting the framing of *Dota 2*'s genre even further from the “MOBA” acronym, and to a term of their own making.

As with many board games and tactical wargames, every match of *Dota 2* is played on a single, common map. The map is divided into three lanes with a river running through the middle (the diagonal in Figure 1). Each lane has three defensive towers followed by a barracks that must fall sequentially. From the barracks, streams of AI-controlled “creeps” spawn every thirty seconds and mindlessly march up or down the lanes. Next, player-controlled heroes enter the picture. Two teams of five heroes start on opposite ends of the map, kill creeps, destroy towers, and clash with enemy heroes from the opposite team. The game ends only when one team pushes into the opponent’s base and destroys a large central structure called the “Ancient.”

This is *Dota 2* at its core — a team game with a relatively direct common goal, albeit one that sits within a collection of complex systems that must be managed to achieve this goal. For some, it’s a model multiplayer “sport,” in which the game’s complex and balanced design ensures a level playing field, and winning is based on execution, experience, and sometimes a little luck. “Well play” of *Dota 2* is implicit in the nuanced details of the tactics employed by players and the players’ understandings of the game’s multiple, interlocking systems. In the next section, we’ll look in more detail at how the systems of the game interact, and consider the ways that *Dota 2* play might be understood through a focus on systems thinking.

Systems Thinking

Contemporary learning research has highlighted systems thinking as a critical skill in our increasingly complex world, and as a form of reasoning that can be supported through games in particular (see Squire, 2002). Facility in systems thinking is a difficult skill to obtain, and there are varied approaches to improving the teaching of systems thinking. By their very nature, the dynamics of what we typically label as “complex systems” exist outside of everyday familiarity, appearing as phenomena that appear random or, in some cases, hopelessly arcane to the casual outside observer. The nonlinear relationships present within such systems in the natural and social world — weather systems, the stock market, ecological interactions — make them difficult to predict, and often quite perturbable by small disruptions at critical junctures (e.g., the well-known “butterfly effect”).

Understanding complex systems involves identifying the interactions of many systemic elements, and grasping deeply non-linear systems requires developing an extensive knowledge of function, relationship, and structure (Hmelo-Silver & Azevedo, 2006). Yet, we desire to learn about complex systems to satisfy common human needs and curiosities to solve real world problems of consequence. Formal classroom environments can have trouble developing the conceptual backbone required to understand these systems, because individuals tend to focus on one-way causal relationships, while in the presence of dynamic and complex relationships. In light of this, game play and game design has been identified as potentially a useful means through which to acquire systems thinking skills (Torres, 2009), as games provide a degree of consequentiality to the player — if you fail one’s team in *Dota 2*, you’ll hear certainly about it from the teammates you let down.

And so, single-player videogames are artificial but defined problem spaces, where players navigate complex systems of interacting parts as part and parcel of playing within them, and where the state of a game can be described in terms of a system’s conditions. The player can move through the game, iteratively testing and receiving feedback against an artificial (albeit often stochastic) system. The player has limited control over the variables

that influence the system, and to the extent in which the player has authority of variables, this can be thought of as the game's "dynamic range" (Arsenault, 2005). This range exists within complex structures that can be further defined as "emergence" or "progression" frameworks (Juul, 2002). Emergent game systems are nonlinear and grounded in a simple rules that when compounded lead to variation, whereas a progressive game system the player is offered a series of predetermined challenges. Though complex, both emergent and progressive systems are relatively static and predictable. *Dota 2* should thus be considered an *emergent* system; however, it adds a distinct layer of complexity, as it is designed for a strictly competitive, multiplayer environment in which players' decision-making processes are influenced by the game's system(s), and the player's resulting actions change the state of these system(s). Multiplayer games present a dynamic problem space, with systems that *need to be* transformed through player interaction.

Therefore, understanding the role of the player's learning of systems and action within sets of systems in complex gaming environments necessitates an understanding of player intent, the impact of player action, and player goals. Understanding systems in gaming environments thus may help us to situate ourselves in dynamic, complex systems, understanding how we develop a grounded sense of "systems thinking," and also how we see our roles as players who can change these systems toward one's own ends. This goal, while perhaps incommensurate with certain perspectives on, say, complex thinking in ecological systems that do not value the disruption of such systems, may be important for understanding how games may foster a different understanding of complexity than are found in other systems thinking literatures. And, as we will explore further, the case of *Dota 2* highlights that these games inherently involve accommodating the goals and intents of other players, and even the goals imparted by economic and cultural framings of the gaming activity ("e-sports").

The Systems of *Dota 2*

Next, however, we should elaborate exactly how the systems within *Dota 2* "work" to craft sets of experiences for the player, and how these experiences situate the player in the middle of a number of consequential systems that he or she must manage to succeed at the game.

From the perspective of an individual player, the set of systems embedded within *Dota 2* can be broken down into a series of layered micro-systems, three of which can be described as: *creeps*, *hero interactions*, and *economy*. Each microsystem independently fulfills one part of the system's purpose but remain interconnected. Uncovering systems thinking within *Dota 2* means first understanding how each system that the player has direct contact with interacts in relationship to each other. Other than through communications with other players, a single player only has agency over his or her hero; all other systems are predictable and only change only based on player actions, from which the system offers feedback. Meadows (2008) defines a system as "a set of elements or parts that is coherently organized and interconnected in a pattern or structure that produces a characteristic set of behaviors" and, in *Dota 2*, these "behaviors" are revealed through player agency. Given that ten players are simultaneously interacting with the same deterministic systems, complexity can arise very quickly.

As each of these micro-systems interacts with each other in significant ways, it would be impractical (and perhaps impossible) to list every interaction. However, we can see a simplified depiction of the structure, behavior, and function of *Dota 2* systems in Figure 2, below, which grossly reduces the complexity of the interactions to a single path for the sake of explanatory simplification. In this example, the economic system (represented in game as gold) stays in equilibrium for all players, i.e., every player reliably receives 0.6 gold per second. However, players can increase their gold by *killing creeps*, which is not a reliable and regular accrual of gold, but one that occurs due to the player permuting the game's systems. This unreliable gold feeds a heroes ability to buy items (increasing stats and/or offering unique abilities, increasing a hero's overall power and, therefore, ability to accrue more unreliable gold. Moreover, certain heroes are considered to be item dependent, and such heroes are inherently tied to the game's economic system, influencing the behavior and decision-making of the player. This example demonstrates the potential inter-dependency of the *creeps*, *hero interaction*, and *economy* systems and how changes in their interactions connect to changes in player behavior. These nuanced systemic interactions can be seen most clearly in *Dota 2* through player actions tied to the game's "creep system."



Figure 2: A linear mapping of *Dota 2*'s economic system

Understanding Creeps

Creeps are units that interact within the game's systems and with players in the game, but are unable to be controlled directly by players. Unlike troops in *Starcraft* or pets in *World of Warcraft*, creeps are completely automated. The structure of the creep system (see Figure 3, below) illustrates a hierarchical clustering of factors that influence creep behavior in *Dota 2*. Yet, interactions with other systems have an affect on the behavior of the creep system. Player agency interfacing with the creep system can generate noticeable transformations. There are a variety of creep control techniques players can use to manage this system, enabling a team to build strategic advantages over their opponents. Strategies have emerged, known as "creep control," which allow players to indirectly influence map control, hero advantage, and economic reward.

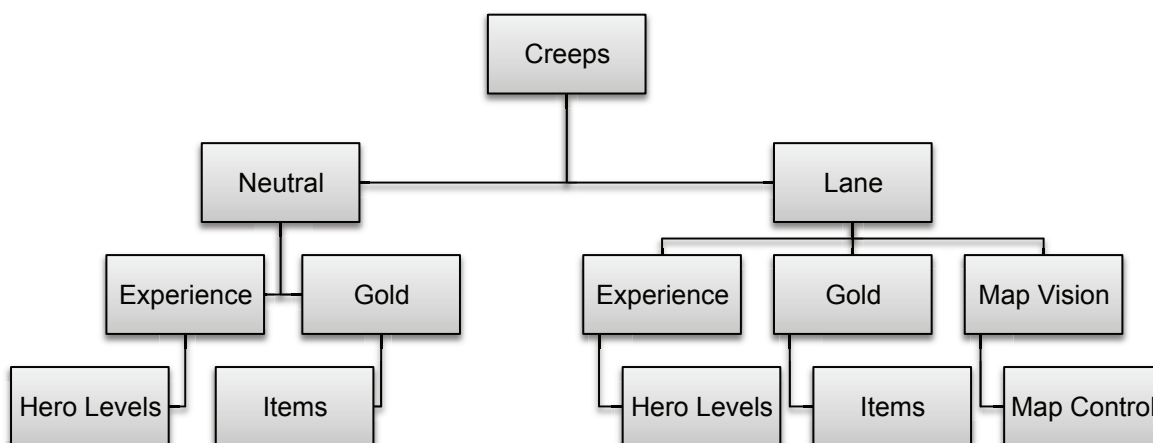


Figure 3: The creep system of *Dota 2*.

As seen in the figure, there are two varieties of creeps on *Dota 2*: "lane creeps" and "neutral creeps." Lane creeps spawn every thirty seconds from both teams' barracks and march toward the opposing base, only stopping to fight enemy creeps and heroes, or to help destroy towers, barracks, and the opposing Ancient. There are three categories of lane creeps: melee, ranged, and siege. As the game progresses, "creeps waves" increase in size and receive permanent statistical bonuses. Additionally, both sides of the map contain camps of neutral creeps. These creeps do not leave their camp unless provoked. Lane creeps and neutral creeps provide heroes with gold (for purchasing beneficial items) and experience points (level progression). Neutral creeps do not provide vision on the mini-map.

Lane creeps interact with other systems in a variety of ways. First, they give players vision on the mini-map (part of the *Dota 2* "heads-up display"). Mini-map vision allows a player to "see" what is happening on that corresponding area of the map, including the presence of enemy heroes and influencing *hero interactions*. Knowing the location of one's enemy is, of course, tactically advantageous and vision is fundamental to map control or the ability to influence or limit one's opponent's location and mobility. Players can influence the creep system of by killing enemy creeps, thus "pushing" the creep wave to deny access to important areas of the map. Moreover, each base contains three barracks at the beginning of each lane. If a team is able to reach and destroy an opposing barracks, the creeps in that lane gain a permanent bonus. These "super creeps" are able to push the lane without the help of heroes, giving a team significantly more map control.

Lane creeps demonstrate a fundamental mechanism of systems and a key element of systems thinking that can

be learned through *Dota 2*: a *feedback loop*. Until players interact with the creep system, the feedback loop remains in equilibrium. By players influencing the creep system, such as “pushing the lane,” one creep wave will have a stronger impact on subsequent actions. This “shifting dominance,” or change of the relative strengths of competing feedback loops, is a primary characteristic of complex systems (Meadows, 2008). “Shifting dominance” in the creep system is complex and can be either a strategic benefit or disadvantage, depending upon timing, location, and a multitude of other factors. And, we note that it is to players’ advantage to not just perceive these feedback loops, but to learn to *exploit them*, in order to gain advantage in the game.

Creeps maintain equilibrium independently: creep waves will continue to meet in the middle of a lane until disrupted by the player or other factors. As heroes attack creeps, they push a creep wave down the lane. Though seemingly counter-intuitive, quickly killing creeps may be detrimental, as it can put your lane out of position. Early in the game, being far away from the safety of your tower may leave you susceptible to being killed by the opposing heroes. In fact, creep equilibrium is so important that players will intentionally obstruct the pathing of creeps in order to “creep block,” forcing creeps to meet closer to their tower. In these cases, players apply *negative feedback* to their creep wave to achieve a positional advantage. Understanding the inter-dependent relationships between the creeps and the system’s other structures helps players make tactical decisions such as determining the best moment to push for map control, how to maintain a safer state of equilibrium, or even where to purposefully apply negative feedback to the creep system.

Finally, the creep system is inter-related with game’s *economy*. *Last-hitting* is a term used by players to describe landing the killing blow on a creep. This is the only way to receive gold from creeps and accounts for the majority of the gold earned by heroes. Therefore, the ability to last-hit creeps is fundamental to how much gold a player can accrue. Items can provide significant bonuses to stats and offer unique activated abilities. A player’s ability to efficiently last hit creeps is manifest in their ability to acquire items at a rate faster than their opponent. *Denying* is last-hitting your team’s creeps in order to prevent the opponents from gaining gold and the full amount of experience. Evenly *last-hitting* and *denying* will maintain *creep equilibrium*. Put together, players and their team gain a tactical advantage by understanding how to utilize the creep system and manage feedbacks in order to gain gold, map control, items, and experience points.

The creep system illustrates how just a few of the micro-systems of *Dota 2* interact with each other to create a complex system that is greater than the sum of its parts, and embed the player in a series of interlocking systems that he or she must manipulate to gain advantage in the game. And yet, while a nuanced system-level understanding of the game is vital to successful play, the games most vibrant “system” may in fact be the ten players collaborating or combating with one another in the virtual space of *Dota 2*. Unlike other multiplayer online games, MOBAs’ competitive, player-versus-player structure is *mandatory*, and there is no such thing as a meaningful single-player version of *Dota 2*. There is no avoiding the intentions, behaviors, and goals that other players will project into the system, unlike many other multiplayer games where a player can proceed through the game without deeply interacting with other players (say, “player vs. environment” servers in *World of Warcraft*). In *Dota 2*, players are assigned roles, objectives, and strategies based on hero selection, style of play, and experience. And as with any inter-personal experience, the intent and emotion behind the play can heavily impact the experience.

Learning in MOBAs

Gee (2007) characterizes one of education’s greatest dilemmas as how to overcome learning through overt “telling” by forwarding a model of situated learning that values immersion in practice. To learn, humans need a balance of information upfront and practice in context. Gee identifies the potential of videogames to deliver just this experience, arguing that videogames stick to a model of distributing information incrementally and when appropriate in concentration. This allows the player to practice a skillset in context and receive “just-in-time” information (Collins & Halverson, 2010). The videogame is, in and of itself, the teacher, the content, and the framework. Many videogames have nearly perfected this model, and deliver a gratifying learning and play experience.

What is notable about this case is that *Dota 2*’s model of instruction is virtually entirely *practice in context*. Tutorials and practice rounds versus AI-controlled “bots,” offer minimal forms of basic instruction: understanding the interface, controlling a hero, demarcating rules, and defining objectives. But then in the player’s first real match (and perhaps with cruel intentions), Valve gives players the entire complex system without explanation or further tutelage. A player can play or play against any of the over one hundred available heroes – each with four unique abilities – and must navigate a deep pool of items. In response to this depth of choice, the *Dota 2* community has produced an endless stream of guides, hero builds, and advanced tactics. Player-created guides are available in game and can be up-voted and bookmarked. These detailed guides advise item choice, skill progression, and tactics. Right now, Steam’s community forums hold over 115,000 guides for *Dota 2*.

Still, even for the most dedicated player, practice in context is insufficient. Mastery of *Dota 2* hinges on a variety of factors: the execution of skills and abilities (fine motor skills), awareness, positioning, decision-making (strategy and tactics), and management of the game's systems (systems thinking). Practice in the specific virtual context of the game can potentially lead to improvement in execution and decision-making; however, no experience or instinct can lead complete system level understanding (e.g. creep control strategies, the nuances of items, or hero synergy). Learning *Dota 2* requires entering the game's affinity space (Gee, 2005; Duncan & Hayes, 2012) as a participant. This involves doing one's homework, by engaging with the game's paratextual, instructional materials: YouTube contains a wealth of material ranging from basic strategies for beginners to detail guides for advanced play. Popular YouTube channels have guides with views in the millions.

And, after learning the basics, perhaps the best way to improve play is to watch the best. With the increased prominence of e-sports and academic interest in them (e.g., Taylor, 2012), we need to account for the learning potential of professional *Dota 2* players streaming live matches, coaching players, and playing in live tournaments.

Toward an “E-sports and Learning”

And so, how useful is the term “game” for understanding this kind of social and technical space? Certainly, there is an interesting set of mechanics in the game, as we've described around creeps (and dozens of other systems in the game which we do not have the space here to describe). *Dota 2* is marketed as a game, but does the term “game” do it justice? Does the term “game” put undue focus on *Dota 2* as a technical artifact, and not as sets of activities and as a community of gamers?

If *Dota 2* represents an interesting case of complex systems which necessitate some form of systems thinking in order to develop competency in the game, then we need to investigate what keeps players involved, drives their learning of the game, and pushes them to further master the game's intricate systems. Why would anyone jump into a game that provides little instructional content, requires a great deal of individual and group participation in the game's systems to learn, and can be brutally competitive? What motivates continued, repeated, and dedicated play of *Dota 2*?

Perhaps the framing of an e-sport allows us some provisional ways to answer these questions. Second only to *League of Legends*, *Dota 2* is an extremely well followed e-sport, with professional competitions, and rather sizable prize pools. In 2013, *League of Legends* grossed a prize pool of over \$5,700,000 USD, while *Dota 2* followed close behind with a total prize pool of over \$4,400,000. The growth in popularity of e-sports can be seen through its rise as a form of public, internet-streamed *competitive performance* — professional and amateur games from across the globe are streamed live on Valve's *Dota 2* interface and via online streaming services, such as Twitch.tv. Over the course of the last year, Twitch has reported that *Dota 2* viewership has seen an increase in minutes watch at a growth rate of 508% (Morris, 2013). As such, gameplay must be clear and recognizable. Those who are able to navigate the system should be able to clearly keep score, navigate unfolding events, monitor advantages or disadvantages, and make predictions. E-sports are increasingly big business, and viewership is a potentially strong way to drive players into the game.

Much like the design of Activision Blizzard's *Starcraft 2* (Browder, 2011), *Dota 2* was explicitly intended to be used for team-based competitive, professional play. And, as Kow (2013) claims, studying learning within competitive e-sport communities raises a number of questions regarding the lived experiences of players, as well as the influence of a shared, competitive purpose on the learning practices within a game community. Valve has paid particular attention to assuring *Dota 2*'s success as an e-sport (LaFleur, 2012), and in doing so, have shaped communities driven to not just play but also *watch* the game. The consideration of *Dota 2* as an e-sport has affected the game's design, and we suggest is a key motivator and factor in helping some players to improve.

And yet, e-sports are not interesting simply because they are viewable rule systems, no more than non-e-sport digital games are simple programmed embodiments of these rule systems. The *Dota 2* case illustrates that even while we attempt to account for the systems thinking practices of players of the game by detailing the elements of the game, we still miss a major part of the picture. The “systems thinking” of *Dota 2* is not completely explicable until we consider *why* players are involved in *Dota 2*. The framing of *Dota 2* as an “e-sport” thus further opens the door to considering the social, cultural, and economic factors that influence the systems thinking found within games.

While the games and learning world has focused its efforts on understanding the designed elements of “games” as a way of understanding the “well play” of these experiences, perhaps we should begin seriously considering how we might want to revise our framing of “games and learning.” *Dota 2* is clearly intended to be more than just a “game,” at least a game in the way that much of the games and learning community tends to conceive of them — technical artifacts, understandable primarily through reductive analysis of the game's mechanisms. The *context*

within which a game is presented to a player can be of consequence not just in leading them to the game experience, but also in driving their persistence toward learning the game. Difficult, complex, and complicated e-sports such as *Dota 2* raise the possibility that social organizations around the game are part of how the game drives players to learn its systems, and that the design of games for learning can gain from further exploration in this area.

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Magic the Gathering

A Learning Game Designer's Perspective

Dan Norton, Filament Games

Introduction

Magic: The Gathering is not a new game, nor is it indie, or even controversial. It is a paper-based card game (although a digital form exists) that involves the purchase, collecting, arranging, and playing of cards against an opponent or opponent who has done the same. The combination of long-term planning (deck-building), chance (card drawing) and tactical strategy (card playing) gives the game a lot of interesting dimensions from a learning game development perspective. In this Well Played session, I hope to connect my experience with Magic: The Gathering with the design and development of learning games.

Who am I?

I am a professional learning game designer. That means I wake up most days, put on some form of pants, go to work, and hammer on the problems and opportunities of designing games that are about teaching something in particular.

I am also a lifelong game player, which while far from interesting, but relevant in the sense that out of all the games I've played, Magic has offered something fairly unique as a played experience, and hopefully worth articulating.

What is Magic the Gathering?

Magic: The Gathering is a card game. There are many variants, but all forms of Magic I've played involve taking on the role of magic-wielding heroes called "Planeswalkers". As a Planeswalker, you summon forth giant monsters and deadly spells to do battle with and defeat one or more other Planeswalkers. Conveniently, all your universe-shattering powers take the form of cards. There are an inconceivably large amount of cards, and an even more astounding amount of ways you can arrange these cards to create your own specific deck.

Once you have chosen the cards for your deck, you take turns with your opponent playing and activating your cards for the purpose of destroying them. Some cards are subtle, some cards are direct, and some cards only reveal their power when paired with other cards. Finding and exploiting interesting interactions between cards is one of the joys of the game.

Why Magic The Gathering For Well Played?

Simply because someone has played a game, even if that game is good, does not mean it's worth reading or hearing about. As a learning game designer, I create and test games about a wide variety of subject matter, which makes my job pleasingly esoteric. That means I also try to play strange things, as well as play as many things as I can, in general. Recently someone in my office found that you could purchase a "core set" of Magic cards, giving you more than enough cards to build a deck and play for under twenty dollars. Myself and about six or seven other staff bought them to get started. Some were seasoned Magic veterans (the game is twenty years old at this point, with new cards coming out every year), and some were rookies, like myself.

I've played Magic for several months now, including the hosting of some friendly office tournaments. In the world of Magic players, some people have been playing for over a decade. I'm by no standard of anyone an advanced Magic Player, but even now I feel like I've gotten a lot of benefit from my short time with it. Hopefully the things I've learned are of interest and of use to the GLS community.

Playing by the Rules and Changing the Rules

As a designer, there are a lot of things about Magic that are challenging and interesting. Normally when you design a game, you construct a set of rules that the agents inside that game conform. Monopoly pieces move clockwise, Halo players wait in cover to recharge their shield, etc. Players who seek to master these games must master and exploit the seams of these rules to triumph. For example, a good medic in the game Team Fortress 2 knows that a full overheal fades in 10 seconds, so they know when to begin and end overhealing cycles on teammates. Esoteric, but it's the kind of small rule that a dedicated player can use to make a difference.

In Magic, however, it's a different story. As the rules for Magic say, "When a Magic card contradicts the rulebook, the card wins." (Laugel, 2013). The Cards you play aren't just agents in the game world- they frequently can undermine or alter the rules of the game itself. For example, certain spells can only be cast on your turn, before or after combat. However, there is a dragon creature that can be summoned, that aside from being a dragon, which is pretty cool, it also changes the rules so that all of your spells can instead be cast whenever you like (Figure 1).



Figure 1: A card that changes the rules of the game itself

That's just one of the countless shifts in rules that take place over 10,000 different cards, the combinations of which are simply staggering.

Build Your Story

Players are encouraged to "tell a story" with their deck, deciding on a theme and purpose for their deck. Then, through play of Magic against opponents, they can see whether they win and lost, and perhaps more importantly, *how* they won or lost. Based on this feedback, they can alter and improve their deck to "clarify" the story, adding or taking away cards that better focus their goals. They can change their decks story or enhance it. Like a well-constructed argument, a good magic deck provides both the context and purpose for victory, defining how it will win and why.

For example, my current favorite deck is based on the idea of summoning small, relentless soldiers that attack as quickly as possible. All of my spells are cheap and instant (Figure 2), allowing me to cast them at will, usually to help my soldiers attack with more damage or more quickly. Not one of my creatures is essential, which makes it hard for other players to decide who to kill or when to kill them. I've played with this deck probably thirty or forty times, changing it meaningfully ten times or so and adding modest tweaks another 15 times.



Figure 2: A card that can form a key narrative for a deck

In this way, players of Magic get to participate as game designers in their own right- obviously that design has constraints, but so does all other good design. Players can conceive of combinations of strategy that can create local revolutions or arms races amongst peer players, and players can even go so far as to create decks to specifically counter other player's decks.

This gives players of magic a "behind the curtain" component of game and even narrative design, letting players take an extremely deep perspective on how to master Magic.

Different Kinds of Depth

There are, simply put, a lot of cards in Magic. Looking at the online Magic the Gathering Database, there are well over 10,000 playable cards (cards that aren't frivolous or banned outright). A player is allowed to construct their deck in most forms of play in a deck size of roughly 40-60 cards, usually with a suggested minimum or maximum cap, depending on the type of play. Constraining players into even focusing only on contemporary cards still gives the player a very large possibility pool to choose from (about 1000 cards).

Even so, the *quantity* of cards is matched by the *systemic* complexity of the rules themselves (Harrington, 2013). Each turn in Magic is composed of a complex series of phases. Each phase of the game can be "responded" to, which means that either player can "retort" an action or phase in the game by doing something that would happen before that event. The simplest comparison might be if Magic were a soccer game, one player could say on their turn "I am going to kick a goal", and the other player could respond with "In response, my goalie will leap and catch the ball".

So in Magic, a player might say "I will cast this spell". The opponent might respond by saying "in response I cast a spell that cancels your spell". The first player then might say "In response to your cancel spell, I will cancel your cancel spell!". These cards form a "stack" of actions, which once both players agree that they are done responding, are then executed in the reverse order on which they were declared- working back down the stack, to continue the metaphor. Understanding the stack leads to the most intricate and mind boggling maneuvers in the game, with occasionally players changing and undoing their own actions in order to create new outcomes.

How Is This Relevant to Learning Games?

Learning games often have to model a "problem space" that is congruent with system or practice in the real world. Often though, that problem space is turned into a rule-set with a constrainable (and understandable outcome. While this makes for a "knowable" (and thus assessable) terrain for players to master, quite often in the real world problems are vastly more messy.

Learning game designers should consider that they can make games about things that are often not entirely knowable, and that in some cases, letting players wade into a problem space in a game with an unknown solution to mastery can create deep play and deep thought that would better prepare that player for grappling with the actual problem.

Similarly, sometimes when designers make learning games they feed the player's need for order by oversimplifying the player's agency. In the real world, sometimes you can change the rules of the game in order to win, or approach a problem from an entirely different angle. Giving the player a second tier of agency that allows them to change the rules of play can allow for thinking that supports multiple layers of systemic thinking, bringing the learning game more into alignment with the types of problems in the real world that we consider non-trivial.

Play is Prototyping

As you play Magic against opponents, you're learning about play at two levels at once. At one level, you're learning and analyzing the game you're playing right at that moment, considering when and how to play your cards for maximum benefit. Additionally, you're analyzing your deck's strengths and weaknesses for the next game. Is a card too expensive to play reliably? Are there cards in your hand that are too specialized, or don't compliment everything else? Does your deck have an obvious weakness that can be exploited by opponents?

Most games of Magic end with a spirited discussion between the two players about the expected and unexpected elements of play that occurred in the match, along with comparisons of the observations on play. Tactical errors will be reviewed, of course, but also macro-level strategy is discussed, to see either deck might be improved ("Your deck is too low on mana, pull out some of those fliers to make room") or whether it was simply a mismatch of strategy that led to the outcome ("don't feel bad, my deck is designed to chew slow decks like yours").

Magic doesn't just teach you to be a better player of Magic (although it certainly does), it teaches you to be a better designer of Magic in future games. Players improve in the micro (tactics of play) and the macro (design of decks) through every play session and observing the expected and unexpected interplay of cards.

Play is Debate

With ever-shifting rules and complicated sequences of events that run in ways that can seem sometimes backwards, players will inevitably come to a disagreement on how a rule actually works. This means returning to the rules and actually participating in what looks suspiciously like municipal laws to determine the finest-grained details of how the combination two rules might work together at the same time.

This feels like bureaucracy in one way, but in another sense the game gives the player the unique thrill of being entirely technically correct. Many of the most ingenious combinations of cards rely on both a grasp of the big picture of the game along with the focused close-up detail of a single card's intricacies. This level of distance between the scopes of understanding in Magic is fairly unique, and it's always entertaining to have a player gleefully explain how in this particular instance of the game why they are winning in a way you had never considered possible.

How Can These Design Goals be Actionable?

Designers can approach systemic depth through two fundamental types of measurement- the number of parts, and the number of relations between those parts. The game of Go for example has very few relationship and rules, but many, many permutations of ways that the game board can be arranged. Understanding Go by memorizing orders of movement is very ineffective (especially when compared to Chess), and effective play is marked by excellent pattern recognition and switching between multiple viewpoints of board analysis. The game of Chess has far fewer board combinations, making it very memorizable or searchable through brute force computing- good chess players are expected to memorize "known" sequences of chess moves to create optimal board position in the beginning and of the game.

When considering your learning objectives, analyze the type of problem the game embodies, and determine if it's a problem that is expressed through difficulty through the number of parts ("player will be able to identify the bones of the human skeleton") and/or through the number of relations ("player will be able to understand and describe the relationship of creatures shown in a food web"). Consider tailoring your games system to be congruent with the objective's problem space.

Additionally, ask yourself if there is room for creative or subversive play with the objective. What types of unorthodox decisions would a player want to have while solving the problem you've given them? What parts of the rules would players want agency over bending or breaking? What parts of the learning objective are murkiest, and might benefit from the player manipulating them by themselves?

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FarmVille. Testing limits. Four years. Level 1446.

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The Facts

Started playing *FarmVille* in February 2010 daily – just interrupted by vacations when there was no access to the internet. Using no money. Taking notes on progress, game mechanics and playing experiences from the start. Main target: levelling up as fast as possible. Right now (January, 29th 2014) level 1446 reached, daily income more than 40 million Farm Coins (1). Still alive – no long-term damages noticeable yet. Many experiences.

Gaming a Non-Game

With the rise of social network services (SNS) such as Facebook (FB), Social Network Games (SNG) have also gained a huge audience. FB based and Zynga provided *FarmVille* (Zynga, 2009) became one of the first genre coining SNG with a peak player base of 80 million daily active users (DAU). Providing a high accessibility via web browser and later by mobile apps, SNGs opened up to a new target audience with a higher percentage of female players and older players in general compared to conventional video games (DataGenetics, 2010; Snow, 2010). SNGs are played in a casual manner; cycles of play can be short. Usually, the Free-To-Play payment model is utilised: Starting the game is free, but certain in-game items have to be paid for.

FarmVille's game play consists of trivial, basic actions: The player starts by placing items on a farm – an isometric playground with grid-bound positions. Items can be plots, animals, trees and decorations. Plots are used for seeding and harvesting crops. Animals and trees are harvested – by clicking on the item. This click restarts a timer – a main game mechanic of SNGs: When the timer elapses the item can be harvested again. Harvesting an item results in a Farm Coin reward. Farm Coins are an in-game currency. Experience Points (XP) are the level-determining, accumulating resource: For seeding crops and placing items on the farm, the player is rewarded with XPs. The placed items are either rewards for missions or have to be bought from the market. Currencies needed for market purchases are Farm Coins and Farm Cash. Farm Cash is the rare “hard” currency which urges the players to invest real money in in-game transactions (Kelly, 2010). Missions mostly consist of placing or harvesting certain items. Another type of missions are resource-gaining interactions with neighbours, often posting a help request to the player's FB news feed. The help request is confirmed by a neighbour's click. Neighbours are also *FarmVille* playing FB users, who get their neighbour status by an invitation-approval procedure. In general this is a rough, but complete description of the elementary rules of play in *FarmVille*.

Such a game play, in connection with no required synchronous interactions between players, almost no story and relatively simple graphics and sound effects, seems not to be appreciated by players of conventional games: It is described as “mind-numbingly repetitive [...] no thrill in playing” (Newton, 2012). The reactions of traditional gamers indicate a kind of cultural shock: The game is not in agreement with any of the development directions of “real” video games, striving to improved graphical effects – powered by continuously sophisticated hardware – as a prominent example. Their production becomes more and more elaborate and costly. In contrast the development of the first version of *FarmVille* has been accomplished by a team of 11 people in 5 weeks (Mahajan, 2010). Admittedly costs cannot be compared to game play, but these figures on their own exemplify why SNGs are an additional branch of video games. Therefore it is no surprise, that SNGs cannot meet the expectations of so called hardcore gamers. Another point of criticism is the option to buy progress in the game. From a different point of view, this business model of in-game transactions could be considered as an official, publisher-organized and more user convenient version of the phenomenon of “gold farming”. This term describes the paid, work-sharing production of game progress (Gilmore, 2010). Gruning (2013) has delivered another in-depth analysis of *FarmVille 2*, the successor of *FarmVille*. She especially examines the value of virtual goods in the social context the game provides.

One culmination of the SNG critics is Ian Bogost's SNG parody “Cow Clicker” (Bogost, 2010a) – a game which shows those game mechanics commonly in SNGs used: simple click accomplishable – and optionally purchasable - game progress, easy post-and-click interactions with FB friends and the use of timers. Bogost (2010b) points out that SNGs' game mechanics create compulsion and destroy even the time when the player is not playing, “through obligation, worry, and dread over missed opportunities.”

When Success becomes Failure: Optimization as a goal

I started playing *FarmVille* for the first time in February 2010 – when I wanted to know how that “new style of game” works and if such a game could be facilitated as an educational tool – an option as development costs were said

to be relatively low. I saw the isometric playground covered by a few items – trees, animals and plots. It took only a few clicks to become familiar with harvesting, using plots and relocating items. Reaching the next levels seemed very fast. When I browsed the market, I recognized items available only for Farm Cash and the different harvesting times of animals, crops and trees. Because I just wanted to get an impression of FarmVille, I decided not to use no credit card. I wanted to be a “real gamer”, who solves all “problems” on his own. Then I became aware that it was advantageous to be connected to as many as possible FarmVille playing FB “friends”. Fortunately FarmVille players had already organized themselves: In gamer forums I found threads in which FarmVille players were looking for co-players. In the next days, these threads became regular reading for me. A higher number of FarmVille playing FB-friends made the “harvesting” of the FB news feed more efficient. Also it improved the probability that my own news feed help requests would be successful.

FarmVille is also known as a decoration game: players arrange items on their farms artistically resulting in a beautiful overall picture or in an idyllic rural landscape. Those farms reminded me on virtual model railways or a sort of digital display case. I did not choose this style of playing as I like the challenge of optimization. Another reason was that many decoration items needed Farm Cash. After a few days – already a regular visitor of my FarmVille farm - I stumbled across the website www.farmviller.com: here I found the information I had missed so far: the harvests of animals and trees, and also the space which certain items require. It was a systematic presentation of FarmVille related information. This site helped me to start optimizing my game play. The goal at that time was to level up since the *Belted Cow*, an animal which delivers an harvest of incredible 3000 Farm Coin each day, could be bought starting at level 75. 3000 Farm Coins each day – 4 *Belted Cows* per plot – this resulted in 12 000 Farm Coins per plot and day. I measured the harvest in this way. All other options had to compete with this benchmark. On the website farmviller.com (2) there were lists maintained which showed such calculations already and which made it easy to discover the most yielding items.

At that point it had already become clear to me that time is an important resource in FarmVille: The first dimension is the time spent on game play. Plowing, planting and harvesting required a lot of time, so I preferred crops with longer harvest times. Also I upgraded my machines as soon as possible to multi plot machines, which saved a lot of time. A kind of revolution was the *Combine*, a machine doing all three processes (harvesting, plowing and planting) at one click. It is very helpful for the ambitious farmer and really worth its price of 500 000 Farm Coins! I also detected at that time the web browser short cut *STRG + Left Mouse Click* to open a link in a new window. This made harvesting the FB news feed far more efficient: Instead of clicking on a FarmVille link, opening the FB page again and positioning it next to the new news feed entry it allows you to click on one link after the other.

Rhythm of play

There is also another aspect of time in FarmVille: the game play needs to be scheduled as crops, trees and animals are characterized by harvest times. To be efficient it is useful to establish a rhythm of play and to plant crops accordingly. On one side the rhythm of play is determined by the harvest time of animals. Fortunately the harvest time of animals always is a multiple of a day. So playing each day at the same time is a good choice. The game design supports this approach: real harvest times calculate with duration of one day of 23 hours. So I could start each day at the same time and integrate game play into my daily routine. The differing harvest times of crops were in an early state of FarmVille subject of emergent game play: There were instructions available how to create a farm with all (i.e. 40 to 50 crops at that time) different crops harvestable at the same time – a goal with no special reward except that snapshots of such a farm could be posted on FB.

On the other side, another determining factor of times of playing is the fact of withering: Crops wither. This is the only occasion in FarmVille when a player gets punishment and loses progress: when a crop has withered it can only be ploughed under, there is no gain left. A cure against withering is the so called *Unwither Ring*. It is one of the most expensive Farm Cash items in the market (worth 250 Farm Cash which can be bought for € 37.50) – so it is unreachable for me. Instead I have planned plant-harvest cycles carefully to avoid that punishment.

Establishing a rhythm of playing was important for me as it ensured a maximum of gain and game progress. In this sense missing the best opportunity to play (and thus reaching not the maximum gain possible) felt like a failure – although in fact there has been progress. This feeling comes close to the phenomenon Bogost (2010b) calls “compulsion”. Being aware of it I tried to tune the game play according to the next planned visit on my farm.

Principles of playing

My progress in FarmVille has been grounded on a few cornerstones: First I tried to use farm space as efficiently as possible, i.e. there was no free space, all space has been filled up with animals, trees or plots. At this point I strived to save all Farm Coins for buying *Belted Cows*, as they are the most lucrative animal. To illustrate the progress: at

the beginning it took 10 days to buy on *Belted Cow*, currently it takes 15 minutes of work a day to harvest the Farm coins necessary to buy 40 of them. At a later stage of the game the Blue Whale became the most profitable animal – but buying a Blue Whale does not result in as much XPs, i.e. it does not help on levelling up directly. Mainly these facts accompanied by perseverance and tenacity are the foundation for levelling up in FarmVille.

My game play is about allocation of resources. Resources are limited and I have to use them in the most productive manner. The first limited resource is land space – so I saved my Farm Cash for farm expansions. Starting from a certain farm size expansions can be bought only by Farm Cash. Up to level 250 each level is rewarded with 1 Farm Cash. This Farm Cash I used in the most effective way, which I identified as buying farm extensions. The next resource is building material: Buildings can be useful in the optimization process, e.g. the Cow Pasture allows storing of up to 100 cows. This saves land space and makes them harvestable with a click at once. Of course building material can be bought, but it needs Farm Cash. The alternative is sourcing it through post-and-click interactions from your neighbours. This turns fellow players into resources, as success is correlated to the number of neighbours. This aspect is often criticized in the context of SNG, but also attributed to other game types, as Yee (2014, p. 193) states, that MMOGs as *World of Warcraft* “turn friends into fungible, disposable resources.” My main sinks for “requested” building material are *Cow Pastures* (for *Belted Cows*) and *Aquariums* (for *Blue Whales*). Another noteworthy destination for building material is the *Fishing Hole*, which itself produces building materials: *Special Delivery Packages* can be converted in almost every building material needed. Each farm, during the development of FarmVille new farms are released in periodic intervals, is able hold only one *Fishing Hole*.

At the moment the most important resource is time: There are almost endless options of work to be done (or in other words: achievable rewards). In order to achieve progress on levels, I start with most productive actions. The first action is to harvest all *Belted Cows* on a farm which is completely filled up with them (It took 4958 to reach this limit. Friends, to whom I showed this farm, accused me of “factory farming”). Interestingly the number of cows has not been limited by available land space, but by a maximum number of items per farm. The next action is harvesting the *Aquariums* on another farm. This gives further boost of 15 million Farm Coins. The third action is a farm which hosts all the *Cow Pastures*, currently inhabited by 2999 *Belted Cows*. Together with the harvest of approximate 4000 trees (the result of an intermediate optimization goal) this farm produces a daily harvest of 10 million Farm Coins. These three actions sum up to 40 million Farm Coins gain and take 10 minutes a day. The problem arises thereafter: Farm Coins have to be converted into XPs in a way which cumulates earning power of the farms: until now the most productive way to reach this goal is buying *Belted Cows*. However to place them it needs either land space or building material and time. All of them are limited resources. At the moment of writing I have piled up the money for 820 cows. Buying a cow from the market takes around 10 seconds, so there is the need to invest at least two hours of work. Yes, it is chore at this point.

The agile game: FarmVille as a continuing and player-including experiment

FarmVille started as a small prototype and has experienced a still continuing development (Mahajan, 2010). Game development is driven by commercial requirements: players need to be attracted and bound to the game (Kelly, 2010). From the developers’ view SNGs have a unique advantage: new content can be tested in the (restricted) field. So-called A/B-testing allows game developers to chose the more accepted alternative for the final roll out (Nutt, 2011). In general a SNG functions as an online laboratory for testing game mechanics with short feedback cycles – an ideal environment for game developers.

Extension by configuration

An important mechanism in FarmVille to provide new content is configuration (Mahajan, 2010). Adding a new crop to the game needs only the configuration of attributes as name, harvest time, seed cost and harvest gain. Additionally images of the crops at well defined stages of the ripening process need to be provided. The mechanism of configuration also can be used for more complex game mechanics: *Animal Breeding Buildings* are such an example. These buildings hold animals of a specific species: the *Aviary* for example takes birds. For each kind of these buildings the contained animal species has to be defined. Also the materials which are necessary for capacity expansion have to be defined and declared. Only these configurations – besides graphics - are needed to introduce a new building without code changes.

In March 2011 – almost two years after the start of FarmVille - an even greater extension was introduced: a new farm, called *English Countryside*. This farm worked in the same way as the original farm, now called *Home Farm*. Directly after the release switching to the new farm set all ripening processes on the *Home Farm* on hold. A few weeks later an option was introduced: the player could choose if the farm should be paused or not during the work on the other farm. It was communicated, that this change has been made on request of players. After the introduction of *English Countryside* new farms were added to FarmVille regularly – now they act as a way to add

new content to the game. An analysis of those game mechanics, which are supported by each farm, reveals a development over time. In farm #4, *Winter Wonderland*, *Snow Treasures* appeared: These heaps were spread over the farm and blocked placing items on their spot. They could be removed by adding a certain number of materials. The removal released an arbitrary item as reward. Now such a heap-material-reward game mechanic is element of each newly released farm. In contrast a not continued example is the limitation of plots: Starting with farm #3, *Lighthouse Cove*, the player was not able to cover the whole farm with plots. Since farm #7, *Haunted Hollow*, there is no longer such a restriction.

From time to time new mini games, which address other motivations of the players, have been introduced, e.g. *Pop The Balloons*, a raffle. The tickets, *Mystery Game Darts*, can be bought or earned as rewards for missions. Every dart results in a reward. There is a set of 6 different rewards, completing the collection of all 6 rewards releases a bonus reward. This mini game aims at players with a preference for gambling and collecting.

Dimensions of goals

Often a game offers different goals within different time frames (Squire, 2011). In the context of FarmVille the current goals are defined in at least three dimensions: First there are the goals the game can offer in different stages of development. In the early years of the game the number of game mechanics was limited. It was possible to play each mechanic of the game. Now the player faces a huge range of game mechanics, s/he has to make choices. Secondly the current choice is regulated by the resource “time”: As there exist more than sufficient options of play the player has to allocate the available time – so s/he may not pursue time-consuming goals. Also the current goals are determined by personal preferences as a third dimension. These goals may be aligned with each other, but there is always a set of current goals.

During my game play I used an online spreadsheet to track the efficiency of my measures by defining “Key Performance Indicators (KPI)”. This approach supported the long term goal of performance. Corresponding to the development of the game the KPIs changed over time: The spreadsheet started with a systematic calculation of the daily gain of all the crops. After that I recorded the status at the specific events, like buying a *Belted Cow*, buying a farm expansion or starting a new farm. Then I introduced the KPI GDI as “Guaranteed Daily Income” – the gain which can be reached by simple clicks on animals and trees without the effort to cultivate crops. In 2013 the most important KPI was “Dairy Level Up XPs” as most XPs earned stemmed from the *Dairy* game mechanic. In the meantime this game mechanic has been subject to a nerf, so it has lost its overarching impact on game progress (cf. below). Another example for a changed goal is the cultivation of trees: In earlier stages of the game it was efficient to harvest trees in orchards. So I filled up a whole farm with more than 5000 trees. Now the relative advantage (i.e. there are other measures which create more gain per time invested) of trees has gone and I have stopped this activity.

Another former activity was connected to my preference to collect items: With the help of orchards trees can be bred systematically. As the offspring of certain forest species is not the same, but another forest species, which was not available to me as it was sold only for Farm Cash, I was able to gain some new forest species by the breeding game mechanic. The mid-term goal of tree collection did not support my long-term, main goal of performance optimization. I gave it up in order to use my available time for the main goal. Another reason to stop breeding trees was that the number of forest species became unmanageable.

Asian Pears, Postier Bretons and Nutmegs – The learning outcome

Video games provoke collaborative knowledge construction and training of meta-skills (Steinkuehler & Duncan, 2008). This applies as well to SNGs (Söbke, Corredor, & Kornadt, 2013). Also it has been shown, that SNGs contain complex problems, which are often player-chosen as solutions of those problems are not rewarded additionally (Söbke, Bröker, & Kornadt, 2012)

Agriculture is the main theme of FarmVille. Therefore a lot of technical terms of agriculture are used. Plowing, seeding, fertilizing and harvesting are terms which can be considered as general knowledge. However names of crops, animals and trees are partly unknown to players before these items are presented in FarmVille. This is true especially for non-native English speakers. Those in the section title mentioned fruits and animals are such examples.

Learning of technical knowledge in games mostly is about the models of the game. If these models mirror real world systems the player probably learns something s/he can apply in the real world. A difficulty which becomes visible in FarmVille very prominently is the necessary distinction of fantasy- and real world items. If on farm #13

Sweet Acres forest species as *Jawbreaker Tree* and *Cake Slice Tree* appear it is obvious that these are not real trees. Over the time a player learns to estimate if an item is a real-world or a fantasy element. If those items spur web-based research, learning is triggered in both cases.

The insisting game – guiding players

Although elementary actions in FarmVille are very simple and easy to execute, the game contains a lot of functionality which guides the player. This functionality works as a kind of game embedded side rail. One result of these assistances is a never dry-running-source of tasks for the players. From the developer point of view tackling these tasks generates a lot of opportunities to sell game-progress-easing items (Kelly, 2010). A good example are the decorating control elements on the main screen of FarmVille: in the screen's left side there are mission icons, each of these missions consists of elementary tasks as harvesting a certain number of plots of a specified crop, harvesting or placing an animal or asking fellow players for certain items (using post-and-click interactions). A mission manager was introduced to improve the player's overview.

In the right side there is the icon for the *Leaderboards* window. This is a weekly changing contest of elementary farming actions, like harvesting a crop or animal. In this window the player can keep track of his performance relative to those of his neighbour players. The same motivation of play, competition, is addressed by the bottom line, where the level of all neighbours is revealed. Right after the start of the game the bottom line is covered with a set of recommendations: items available in the market which require Farm Cash.

Also at the right boarder of the screen there is the entry point for a Farm Countdown, a mini collection game: An item needs a certain number of neighbour clicks to be issued to the player. Each day a new collectible item is released. If the player collects all available items, an extra reward will be issued. Each of the items can be bought using Farm Cash as well as the whole collection can be bought using one click. Nearly once a month the mini game is restarted facilitating new items.

When the game screen appears, often dialogue windows will open to present opportunities of play. If the player does not like the suggested features it becomes bothering to close these windows. Another annoying feature of FarmVille are those FB news feed entries which provide almost no gain, but try to lure other FB friends into the game.

In general there are so many "Buy" options that it is easy to lose one's Farm Cash accidentally – just by incautious clicking. For this reason paying the first time real money is a decisive step in the career of a FarmVille player. From time to time there are charity events which encourage the player under the pretext of a donation to add a credit card number. Once this information is added, further FarmVille related transactions are eased.

Is it still joy or already chore? When Level Up starts bothering

If the daily income in FarmVille has reached 40 million Farm Coins the player gains 4 levels a day (by buying items). Each level up causes a pop-up window to appear, the player has to close it manually, it appears as extra work. If even a positive event like reaching the next level causes work to be done the question for fun arises: Why do I play (or operate) a game that causes so much work? First it is curiosity concerning the limits: When does the game show results of the long lasting play? Where are the differences to a more moderate and casual gaming style? What happens at formerly undiscovered points of the game?

At one particular point of game play there was at least one answer to these questions: The *Dairy* is a self-contained mini game about harvesting and transforming resources, it has been rolled out in January 2013 and maintains its own level status. The original reward schedule issued 1000 XPs more for each level reached than for the previous level. It is possible to level up 2 times per day. As a consequence there was once a reward of more than 230 000 XPs for one *Diary* level up. Each level in FarmVille requires 100 000 XPs, so after 5 months of play the *Dairy* reached the same game progress as the result of 3 years of optimized play before. Furthermore the *Dairy* rewards increased much stronger. In this way the *Dairy* had become the delimiting game mechanic for game progress. Finally a nerf of the reward schedule has been made.

Another motivation to play the game is to experience its lifecycle together with the development of game mechanics. FarmVille is one of the first SNGs and therefore it is thrilling to observe how the game transforms in order to be still attractive to players - always expecting the unforeseen. A further personal motivation is the desire to remove the entropy on the farm – to order items systematically: each item category has its place. There is a farm containing trees, a farm holding pastures, a farm showing mastery billboards, etc.

The game lies in the eye of the player.

The described game play is not representative. The description leaves out some similar important aspects, e.g. cheating, sources of knowledge and common play, as it is a limited selection. Also it is highly connected to my context: Traits of my personality guided the game play as well as my personal situation. According to Bartle's taxonomy (1996) and world-oriented versus player-oriented. An account of the dynamics of player populations is given in terms of these dimensions, with particular attention to how to promote balance or equilibrium. This analysis also offers an explanation for the labelling of MUDs as being either "social" or "gamelike"., "author" : [{ "dropping-particle" : "", "family" : "Bartle", "given" : "Richard A.", "non-dropping-particle" : "", "parse-names" : false, "suffix" : "" }], "container-title" : "The Journal of Virtual Environments", "id" : "ITEM-1", "issue" : "1", "issued" : { "date-parts" : [["1996"]] }, "title" : "Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs", "type" : "webpage", "volume" : "1" }, "uris" : ["http://www.mendeley.com/documents/?uuid=829111f2-d0c6-102d-ae72-0024e85ead87"]], "mendeley" : { "manualFormatting" : "(1996 I play predominantly as an achiever. Also I tend to fulfil my duties assiduously. This seems to be a good foundation for dealing with a game that is attributed as "compulsive" (Bogost, 2010b). Another circumstance which stimulated this once-in-a-lifetime experiment (other SNGs I play only for capturing their game mechanics) has been my personal curiosity in the game mechanics and lifecycle development of such an SNG. Also the sake of procrastination has "fostered" a lot of game progress: As I have to solve often long winded intellectual problems, such game mechanics provide always an instant and positive feedback. However I do not regret the time I spent on FarmVille (I estimate an average of 2 hours a day for four years), because in those moments I had a good time. I could relax during game play: when I had free resources to think about optimized game play, I did so. If this was not the case, I clicked and made as well progress. I made a lot of experiences in observing game development and my own game play. From my view point now the puzzle is solved (Koster, 2004): It needs a lot of perseverance and stamina to compete with real-money-paying players, but it is possible. Only the time is the limit.

Epilogue

The design of FarmVille is highly driven by its commercial background as a Free-To-Play SNG. Similar to ad-funded TV the player as a consumer is supplied with those game mechanics s/he prefers. The pervasive offerings to buy game progress can be ignored in the best case and are annoying in not so good cases. The used game mechanics as competition and interactions with fellow players and the open-ended game style tend to overburden some players. As delineated by Pixie (2010), who seems not be an isolated case, quitting the game is often related to frustration. Harmful effects of excessive play are not limited to FarmVille or SNGs in general, but in SNGs there is an easy possibility of regulation as there is always a connection to a central server. However, the positive traits of SNGs make them another part in the set of tools for learning. It has already been shown that SNGs foster learning processes and the development of meta skills (Söbke et al., 2013). Due to their format they acquire a group of people for gaming which have not played before. SNGs are accepted as a game genre. Development of SNGs can be done in parallel to their productive use with short feedback cycles. Also development costs tend to be lower than those spent on traditional video games. It is worthwhile investigating the game mechanics which are used now successfully to lure the player into becoming a paying customer: If and how they could be used in educational settings to guide player's learning progress.

"Why are you trying to make them do more?" is the concluding question of Jason M. (2010) in a response to Ian Bogost's (2010b) SNG critical article. "Why not taking the good and ignoring the rest?!" is suggested as an appropriate continuation.

Endnotes

- (1) 40.000.000 FarmCoins have a real world equivalent of ca. 22.000 € - using the price of 30 € per 56.000 FarmCoins Zyn-ga charges (<https://apps.facebook.com/onthefarm/money.php>, accessed 01/11/2014)
- (2) This website is no longer available. It has been shut down in 2011.

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Working Examples

PuppyBot Rescue - A Balancing Game

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Example URL: <http://www.workingexamples.org/example/show/624>

This project is taking all the experience from our past games in the ENGAGE initiative and collaborating with Sesame Workshop to build a game under their Electric Company IP.

Seed

Tell us about your idea or project. What's your vision?

We want to get this game into the hands of thousands, if not millions of kids and see if science concepts can be taught at a younger age (ages 6-9), in an appealing way. Will children play our game and learn from it? Will they play it not because it is assigned homework, but because it's fun? One of the ways we are hoping to do this is by working along with Sesame Workshop to develop a game that could be launched onto their newly re-designed Prankster Planet website. In doing this, we would be able to reach larger numbers of users than past projects.

The science content we are teaching comes naturally through age and experience, and so we're trying to structure our game so that younger children that have yet to master it and obtain a grasp of it might understand the more complex concepts sooner. Sometimes kids can understand the action, but not the logic behind it - and bridging the two is our goal.

What problem are you trying to solve and why does it matter?

Teaching kids through games. But not just typical teaching - we want to inspire kids through games that have embedded educational objectives to become interested in science and engineering careers. Simply put, we want kids to find the fun in tomorrow's careers.

What history or context should we know about?

This game is being built on a foundation of knowledge and experience from our past games: RumbleBlocks (<http://www.workingexamples.org/example/show/592>), Beanstalk (<http://www.workingexamples.org/example/show/593>), Teeter-Totter-Go!, and Helios (<http://www.workingexamples.org/example/show/595>).

All of the above games excluding RumbleBlocks were designed and built around research papers written by a Carnegie Mellon University professor, Robert Siegler, based on balancing a beam. For example, see Siegler and Chen, Development of Rules and Strategies: Balancing the Old and the New, *J. Experimental Child Psychology* 81 (2002), (<http://www.psy.cmu.edu/~siegler/siegchen02.pdf>). With this foundational knowledge, we are able to design the challenge of the game relatively easily, while focusing our core effort on the mechanics and the look and feel.

In general, each game is developed in the course of one semester through the combined skills of a multidisciplinary project team. These efforts are guided by iterative playtesting with children. That is, at many points during the semester children play the game and through direct observation, questionnaires, and interviews the development team learns what works and what does not for the target audience. The game is tweaked and made ready for the next round of playtesting. The teams have produced a few papers documenting this process. Beanstalk is discussed further in (<http://doi.org/10.1109/IGIC.2013.6659126>) and Helios discussed further in (<http://doi.org/10.1109/CGames.2013.6632614>) -- see these papers for additional resources on the game design, on Siegler rules, and on the use of playtesting during development.

Controls and Mechanics

With early RumbleBlocks user testing, we found that the younger the child, the more difficult it was to control a mouse, and even more so, a keyboard (even if told to use just a select set of keys). RumbleBlocks utilizes left and right mouse click, spacebar (alternate for right click) and the arrow keys (also alternates for the right click). We found that using the left click and spacebar to rotate a block was the best combo. More on iterative playtesting to develop RumbleBlocks can be found in the conference paper at (<http://doi.org/10.1109/CGames.2012.6314570>).

With Beanstalk, we decided to remove all the complexity of the controls from RumbleBlocks (click and drag, combination of inputs such as hold a block and press spacebar to rotate, and multiple inputs). Beanstalk was simplified so that now a 5 year old could play comfortably - all controls were just a click - no dragging, no combination inputs.

Over time, we found that the over-simplification of Beanstalk's controls were a bit monotonous. So with Helios, dragging was reintroduced, with touch input in mind - and then with PuppyBot Rescue, flinging the blocks as a new mechanic was incorporated. This allows players that can't completely control dragging some freedom to controlling their object.

Inventory

Since RumbleBlocks, we've been advised to put the entire inventory out on display for the players - something we always tried to incorporate, but never found a justifiable way in doing so.

With PuppyBot Rescue, this was highly considered in the design process, and ultimately - incorporated.

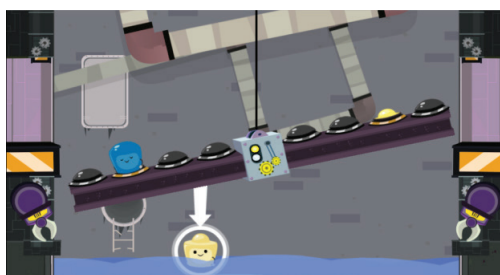


Figure 1: <http://www.workingexamples.org/uploads/Image/711>

Audio & Instructions

With our first few games, we found that audio, when used as instruction, was ignored if there wasn't an equivalent amount of on-screen visuals. With a lot of collaboration and advice from Sesame Workshop, we reduced and simplified the voiceovers throughout our current game, PuppyBot Rescue. Kids have short attention spans, and we must consider that in our designs.

What are your goals and how will you know if you've achieved them?

Our goal is to build an educational game that embeds the educational objectives behind fun mechanics. We then collect data about how the beam is balanced and the contrasting case answers through a logging server to

determine if children are learning from the game.

Types of data that we collect are:

- # Sessions
- # Problems encountered
- # Moves made within a problem
- Amount of time spent on each problem
- Problem start states (e.g., inventory, beam set-up)
- Problem end states (success or failure)
- # Idle states (time of no player activity; not counted as part of time within a problem)
- # Sessions reaching any particular level, including overall win-state at end-of-game

With a massive amount of data, we can determine if, and how, children are learning. This information can help to both improve how this game teaches Siegler rules, as well as how educational science games are designed and deployed. If successful, maybe in 20 years we'll see a rise in engineering and science careers/degrees. In particular, we are incorporating adaptive learning so that for players who are quite successful, the game will remain challenging and interesting by proceeding quicker to more advanced problem levels. For children who are experiencing a lot of failure, the game will move more slowly through problem levels. We are striving to remain in a good state of flow, not too easy to be dull, not too challenging to be frustrating. Since we deal with a big enough age range that child learners have different capabilities, we need to be flexible in our problem advancement approach. Our design is guided by the work of Csikszentmihalyi and by the various game lenses espoused by Jesse Schell in his Art of Game Design book. For struggling players, we offer gentle scaffolding help and on repeated failures more detailed precise help to work through problem levels as needed. The adaptive progression through problem levels and the use of scaffolding are also recorded in the game logs, enabling us to study different types of adaptive and scaffolding strategies.

Who will your work impact? What do you know about them?

Kids! Kids from all over the US. And as we all know, kids are the future. But we're also keeping parents and teachers in mind; from things like audio usage in classrooms to designing the game so that when at home, there are no reading roadblocks.

Our demographic is Kindergarten through 3rd Grade, with a broad age range of 5-11, but with a more core range of 6-9 (our game is adaptive, being able to adjust the content to individual users, so there's no reason to not include someone who may still find the game enjoyable and challenging).

Kids love touch input devices (tablets, phones, etc.) and we've designed our game in HTML5, by-passing the middle man of going through app stores and having to download content, needing just your modern web browser. Hence, the game will also run on computers and other web enabled devices.

*Note: Not tested on all mobile browsers. If you are having problems, please let us know. Tested and runs on Chrome, Firefox and Safari with current generation devices (ca. 2013 forward).

How does this work relate to what others are doing in the field?

There are a few groups out there that are choosing and building HTML5 games as an option over an app installation. There are pros and cons to each, but with HTML5, we can launch one build of the game universally.

In terms of the educational aspect, we are attempting to teach advanced educational concepts, based on research written by a Carnegie Mellon University professor, Robert Siegler, based on balancing a beam (i.e., rules that children don't often acquire before becoming teens) at a much younger age, targeting ages 6-9. Some educational developers are working on tutors, aimed at being complimentary to the educational material being taught in the classroom. Here, we want the game to stand on its own, capable of being used by a child at home without parent or teacher intervention.

How can our community support you? (Expertise, resources, etc.)

Anyone can help! We need lots of playtesters, critiques, teachers, etc. Know someone that fits into our audience? Even better, have them try the game and send us some feedback! Found a bug? Something doesn't look right? Maybe we missed something. The more feedback, the better our product. Please promote our game link to teachers, parents, and children. The more players, the more play data we can collect and then use to revise the adaptive problem level progression and scaffolding techniques to deliver a better experience to players.

With these games, we are trying to inspire more children at early ages to pursue science and engineering careers through the use of fun and entertaining educational games. We like being pointed to other games, seen anything neat out there? Send it our way!

Tell us about the team you have assembled or hope to assemble.

Our team consists of:

Scott Stevens - PI (Principal Investigator)

Mike Christel - Co-PI, Programmer

Matt Champer - Artist & Designer

Samantha Collier - Artist & Producer

Bryan Maher - Programmer

Ricardo Merchan - Sound Designer & Writer

As noted earlier, it builds from a number of Entertainment Technology Center (ETC) (<http://www.etc.cmu.edu>) projects that are listed as separate working examples: see ETC DARPA ENGAGE (<http://www.etc.cmu.edu/engage/>) for further details. PuppyBot Rescue development is supported by DARPA's ENGAGE program.

Sprout

Tell us about your process and how your idea is evolving throughout the project.

The early years; or the evolution of our project:

This project has been an ongoing process over the past 3 years. In that time, we have developed 4 different games and are currently on our 5th. Because of that, our project has a lot of experience and history to draw from. With our current game, we looked back at everything we learned from our past experiences and then thought about what goals we wanted to reach with this one.

We migrated our development platform from Unity3D to HTML5; mainly due in part that schools need to install a plugin to use anything made in Unity3D. With HTML5, we can develop and push out to multiple platforms and skip over app store gates and web browser plugins.

Over the course of our earlier prototypes for what eventually became PuppyBot Rescue, we trimmed down the UI (User Interface) in order to keep the focus on the core game mechanic. After we got a good idea where we wanted to go, we began thinking about a few basic features.

We asked ourselves this:

1. We wanted the interaction to be fun and break it down into its most basic form. How can we make the action of interacting with our game fun?
2. What are some fun mechanics that could reach this goal?
3. How can we keep the game play simple, so the educational objectives are the focus?

We began trying to solve these questions by brainstorming and coming up with a series of concepts. In the beginning, we focused on 4 basic ideas encompassing a few different mechanics and ways of interacting with the game.

With those 4 ideas we made storyboards and game documents to better understand where they could be taken; this process was very helpful. A lot of ideas sound really achievable after you begin to walk yourself through how they would pan out.

In order to make the interaction more fun, we went with a ‘flinging’ mechanic - where you can pull down a little bit and fling the object up by letting go, almost like a slingshot. But we also kept the drag mechanic, because we found that some players attempted to use that mechanic instead - and we shouldn’t punish a player for not using a specific mechanic if they feel something works better. We have tried to incorporate this idea through the game, trying to accommodate different possible interactions that we have observed during playtests.

The ‘flinging’ mechanic was born from collaboration between Sesame Workshop and past playtest experiences and results. Since we find just simply dragging and tapping are somewhat mundane mechanics, we knew we had to spice it up a bit, while still keeping it relatively simple.

What are some of your initial concepts or designs? We’d love to see them.

There has been a great deal of development and changes made to our concept and design along the way.

As mentioned, we started with 4 different ideas. We came up with these by: thinking about what sort of mechanics we wanted to have that would be fun, what would be a cool way to interact with our “beam” that we are using to support our educational content, and keep the focus centered on these things.

What we came up with:

Some of our first ideas were games where you would move an avatar back and forth to throw things on the beam. While you did this, a trouble-maker would be constantly unbalancing the beam causing you to rebalance it until time ran out.

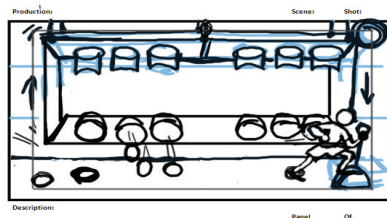


Figure 2: <http://www.workingexamples.org/uploads/Image/519>

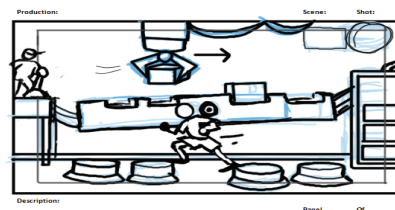


Figure 3: <http://www.workingexamples.org/uploads/Image/523>

Some of our other concepts centered on games similar to ones you would play at fairs. These were more simple concepts that were similar to mini-games.

After looking at all the concepts we had, we decided to stay away from having to interact or control an avatar. We wanted the focus to be centered mostly on the beam. Moving away from controlling an avatar kept our controls simpler, and kept the game in more of a mini-game space; keeping a quick paced, fun and simple game. Also by avoiding an avatar, deploying the game for mobile devices meant not having to come up with a clunky control scheme to control on a touch interface; something we believe is too complex for our demographic.

From the original set of ideas, we narrowed it down to three concepts.

From there, we began to flesh out the interaction by creating detailed storyboards that walked through the whole experience.

Idea 1: Sewer Slime: You are tasked with taking samples of the slime that was building up in the sewers. While doing this, you need to make sure the beam stays balanced. Once the beam was properly balanced, you would pull a lever to raise the beam out of the sewer. It isn’t as simple as you think, not with the baddy bots getting in your way. To keep them from blocking you, you have to slime them, knocking them out of the way.

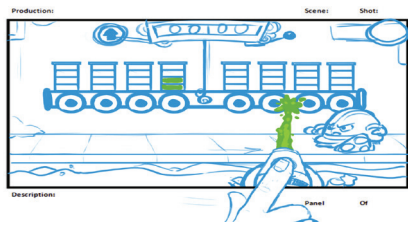


Figure 4: <http://www.workingexamples.org/uploads/Image/524>

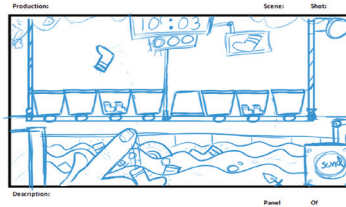


Figure 5: <http://www.workingexamples.org/uploads/Image/525>

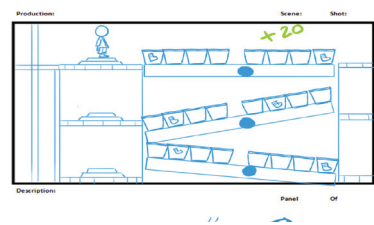


Figure 6: <http://www.workingexamples.org/uploads/Image/526>

Idea 2: Sewer Toss: Things on earth have been going missing: socks, toys, etc. After looking for an answer, we find that they have been falling down into the sewers. To help recover these items, it is up to you to load items onto a beam to take them back to the surface. While trying to recover items, one of the important stabilizing cords break. Now, to be able to get the beam to rise properly, you need to fling items out of the water into baskets while making sure to keep the weight balanced. The faster you collect needed items, the more points you get, but watch out for some of the creatures living in the sewer that could mess you up!

Idea 3: Balancing Act: (This was seen more as a testing mini-game). The tricky pranksters have scrambled 3 beams - only one being properly balanced. You're trying to get out of the sewer but which way is the way out? It's up to you to figure out which beam is balanced correctly.

From those storyboards, we created mock-ups to show the styling of the art.



Figure 7: <http://www.workingexamples.org/uploads/Image/527>

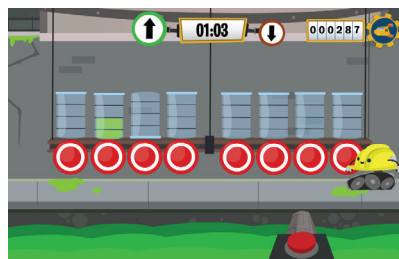


Figure 8: <http://www.workingexamples.org/uploads/Image/528>



Figure 9: <http://www.workingexamples.org/uploads/Image/529>

After reviewing these concepts with Sesame Workshop, we merged pieces of each together until we landed on a solid game. They also suggested changing the gameplay so the player isn't stationary, but rather traveling through the sewer. We hoped that this would give the kids a sense of moving through the space and making progression, to provide accomplishment.

Where did we land?

The earlier form of our current concept was that you would be pulling a beam up out of the sewer carrying some container full of slime. And on its way to the top, you had to make sure it didn't spill. To do this, the player has to keep the beam balanced all the way up, trying to stop the efforts of the bots that are constantly adding and subtracting weight to the beam.

Have your initial concepts/designs changed? Why have they changed? Show us how they're being refined and iterated.

The finalized concept/design we went with has changed dramatically over time. Initially, the game was very systemic, rigid and felt like you were solving a bunch of problems. Over time with feedback from Sesame Workshop and playtests, we've evolved the game into a more dynamic, faster-paced experience, adding fun animations and

movement wherever we can and making the interaction as fun as possible. It has come a long way from its simple beginnings, and has turned into a fun game it's currently growing into now.

Where we started:

From concept to mock-up, we started off pretty simple:

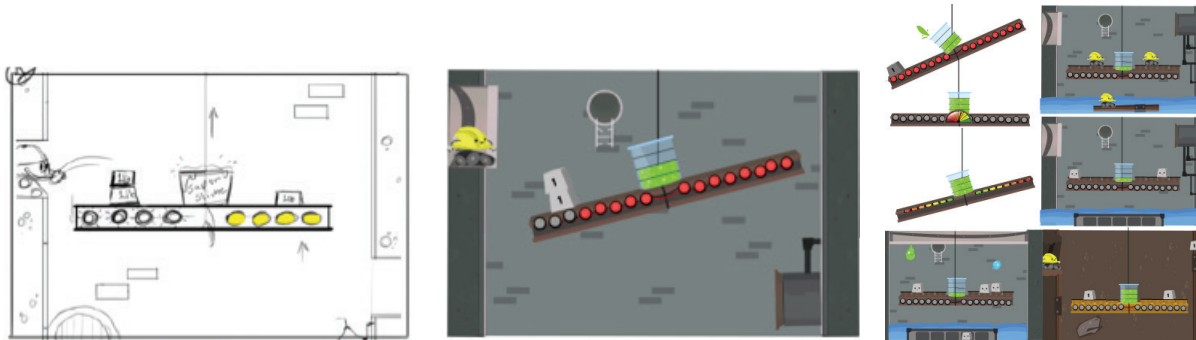


Figure 10: <http://www.workingexamples.org/uploads/Image/538>

Figure 11: <http://www.workingexamples.org/uploads/Image/531>

From there, we began diving into our game. Focusing a lot on how the beam would look, and how to interact with it. Soon, we added water elements and off-balanced pipes that we would need to balance and unbalance the beam to connect.

We quickly realized that the slime meter was a poor choice to show balance. After paper testing, we found children didn't make the connection with the slime and the balancing of the beam. Another element we removed was the complexity of the lights on the beam, creating an overall simpler interface for children to interact with.

Another very important piece to our game was designing the weight. Throughout the game, you would be interacting with this object. We found that children really enjoyed the bots off to the side, and we wanted to carry that over to the weight. We gave our weight-object a personality. Starting off very simple; the first change was to make it friendlier by rounding it out and giving it more animation. We found that the game greatly increased in fun after. From there, the weight changed a lot over the progression until we found what would work best with what we had.

Number one lessons learned:

- Make the object interesting and appealing
- Personality makes a world of a difference
- Make a clear connection between the object and the beam
- Mixing the idea of electrical objects with water was a very bad idea

These lessons lead us to our final design.

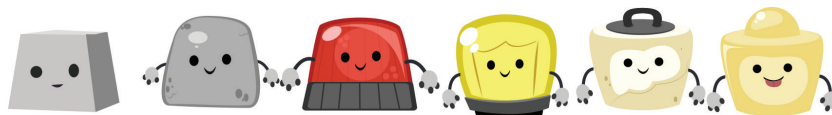


Figure 12: <http://www.workingexamples.org/uploads/Image/540>

After a good bit of progress, our design changed to its current state. Clearly, a long way from its simple beginning...

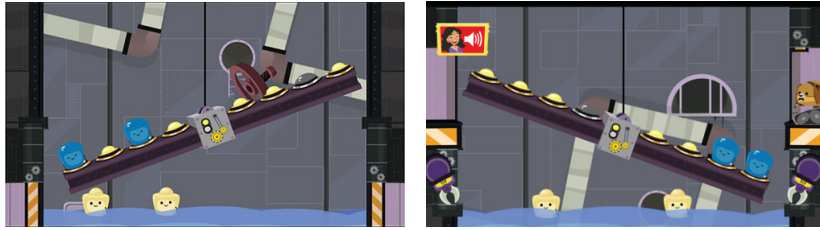


Figure 13: <http://www.workingexamples.org/uploads/Image/546>

Figure 14: <http://www.workingexamples.org/uploads/Image/548>

...Helping a bot out of the sewer by balancing and unbalancing beams so it can travel up a path. While doing this, you need to make sure you solve the beam problems fast enough, or water will come up and short out the gears that are pulling the beam up.

Major Changes and Why:

- No longer working against a bot, but instead you are helping a lost puppy bot. This pulls from kids' desire to help and have a positive motivation.
- Making the objective of why the child needs to balance the beam very clear with showing that the puppy bot is trapped and needs your help.
- Simple beam and block mechanic; stripping away an over-cumbersome UI (User Interface) and interactions. With clear objectives there is less room for misinterpretation.
- Blocks with fun interactions and personality to add life to the action of balancing the beam.

Once we had that design mostly hammered out, we had to make the transition, or the contrasting case part of the game.

The original design was set up more in a way that you had to help Puppy-Bot open a door to continue on to the next level. You did this by answering a question via pushing a button.



Figure 15: <http://www.workingexamples.org/uploads/Image/542>

The only problem with this was that it somewhat distracted the player from the whole game and wasn't interacting much with the environment. That led to our second design. For this, we went back to an earlier design for the game and repurposed it.



Figure 16: <http://www.workingexamples.org/uploads/Image/545>

Figure 17: <http://www.workingexamples.org/uploads/Image/544>

From there, we made some adjustments to combine the two concepts into one; a large transition area that Puppy-Bot needs to travel through to get to the next level.

But we weren't done yet. After building the prototype we realized that this level wasn't very interactive, but was

going in the right direction. To add some more fun elements, we incorporated a moving platform you had to move to direct Puppy-Bot to the correct beam.

After some testing rounds, we found that about half of our users were having difficulty with the elevator mechanic (dragging up and down). While it might be easy on a tablet, a mouse as an input device for kids is a whole other story!

So what we did was went back to the drawing board - and took away any thought-process involving mechanics and design - and went with a simple, fun and rewarding mini-game without any penalties. Kids love simple fun stuff.

Our new Mini-Game:



Figure 18: <http://www.workingexamples.org/uploads/Image/551>

Figure 19: <http://www.workingexamples.org/uploads/Image/664>

PuppyBot Snacks!

PuppyBot rolls onto screen, down an elevator and onto a raft and floats across screen. While PuppyBot is en-route to his next sewer shaft of unbalanced beams, the player gets to help him out by feeding him lots of PuppyBot Treats! Because, well, solving puzzles makes you hungry! To feed PuppyBot, you simply tap a treat and time it so PuppyBot snatches them up in time.

While this seems like a pretty straight-forward task, we did run into some unexpected problems. When creating this, we thought the object of the game would be very clear, but we quickly learned that above anything else, you need to test with kids because as designers sometimes we get too familiar with our work and have a hard time looking at things objectively. When we finally got this in the hands of kids, we were shocked to find that most kids didn't understand what they should be doing during this part of the game. The few that did catch-on, weren't sure of how to interact and stumbled over the controls. Thanks to testing, we were able to address this problem by providing proper visuals to help instruct the player in a simple, quick way that doesn't subtract from the mission of the mini-game.

Hinting System:

We also integrated a hinting system in order for a user who may not be fully getting the difficulty of the problem, or may just not understand the mechanic. After a determined amount of time, and if the beam is close to being solved - but not quite yet - a dotted line appears to show the user that the beam isn't quite balanced yet. This iteration comes from playtests and observing how players think the beam is balanced when it's actually just nearly there.

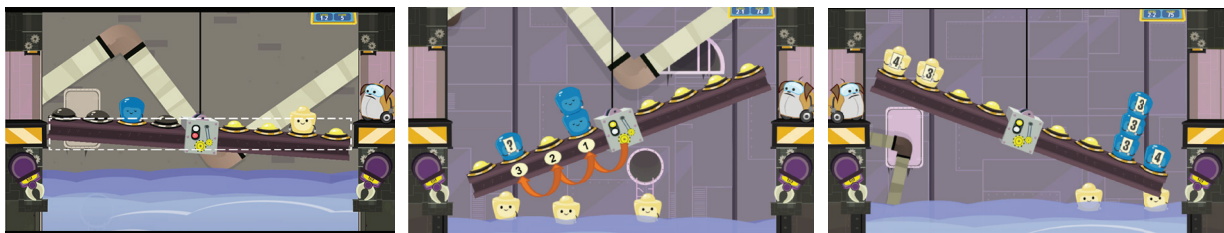


Figure 20: <http://www.workingexamples.org/uploads/Image/665>

Figure 21: <http://www.workingexamples.org/uploads/Image/703>

Figure 22: <http://www.workingexamples.org/uploads/Image/704>

Advanced Hinting

Upon any successive fails, the game loads a more step-by-step instructional hinting system:

Where arrows count one-by-one, each block on the beam and how far it is away from the center. The sleeping blue blocks hold up “?” a question mark to indicate that amount of force isn’t known - yet.

Next, the blocks hold up a card indicating their amount of force on the beam at that location. Kids can experiment by moving them around and seeing how each block affects the beam. In this way, they can count and determine how much each side needs to be in order to get the correct sum on both sides.

What we learned about Audio:

- Certain sound effects were very repetitive and annoying, and so we either replaced them or tweaked their levels to minimize the annoyance factor.
- Running music, sound effects, and voice overs all at the same time muddies the overall effect, and distracts the brain while listening. What we ended up doing is normalizing the decibel levels down to -6 for voices, -10 for sound effects, and -20 for music.
- Voice of the antagonist motivated kids a lot.

How will you make sure that this thing you’re creating will be adopted by your audience?

By getting it on PBSkids.org with the awesome help from the folks at Sesame Workshop. Once there, we will be at the fingertips of millions of kids.

But what if we don’t make it!?

While we are working towards the objective of creating a game that can be skinned in the Prankster Planet IP, we are also creating a version that can go to websites such as Learning.com and BrainPop. Comments welcome: please suggest where a game teaching 6-9 year olds Siegler principles of balance should be placed so that parents and teachers can find it and assess its value, and so children can find it and play and enjoy the fun (and learning) it offers.

How might your project scale to provide greater impact?

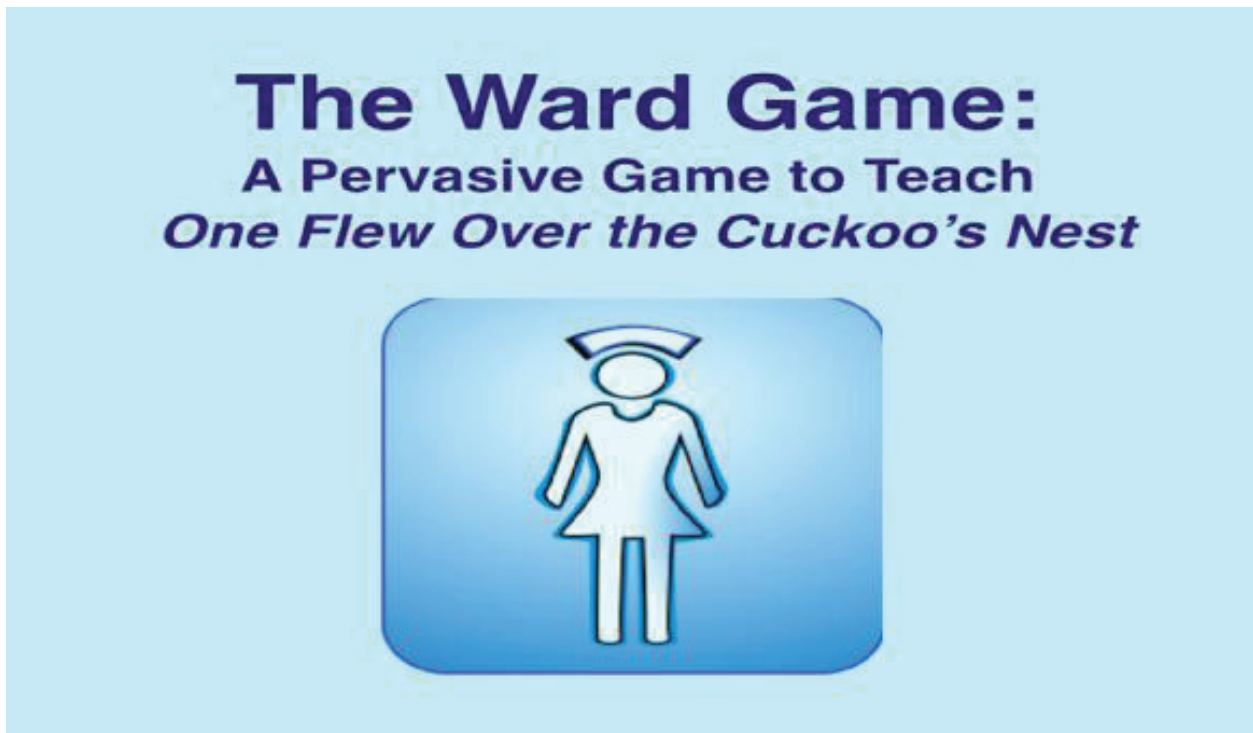
Adaptability:

We’ve just begun implementing an adaptive feature into our game. In brief, that means an excelled user who can manage to continuously get perfect or very good scores will advance further up our problem stack in difficulty. But, when they begin to fail, we start to slow them down to the normal pace, or even bring them back to some skipped over problems.

For users that don’t excel, we keep them at the normal pace, which is built to be very gradual and scaffold actions so that they can learn how to balance and solve the beam. At the moment, we don’t ever drop them back to earlier levels (only skipped over levels), but after a failed problem, we repeat the problem until they advance.

The Ward Game: A Pervasive Novel Study

Paul Darvasi



Example URL: <http://www.workingexamples.org/example/show/632>

The Ward Game is a pervasive game where students experience the world of a novel in an embodied and immersive fashion. Designed to teach Ken Kesey's *One Flew Over the Cuckoo's Nest*, players are transformed into patients and the school's classrooms, corridors, bells and clocks became those of Nurse Ratched's ward. For 30 days, players are plunged into the world of the novel through a modular elixir of video game mechanics, videos, social media, interactive tools and locative activities.

Seed

Tell us about your idea or project. What's your vision?

My vision for *The Ward Game* emerged from thinking long and hard about how to engage my Grade 12 English students in a novel study during the height of senioritis, where they essentially coast to the end of the year once they've been accepted into university. It occurred to me that Kesey's institutional critiques in *One Flew Over the Cuckoo's Nest* were wholly transferable to the education system, as both post-industrial institutions operate on similar principles. The way Nurse Ratched runs her ward is a satirical exaggeration, but the general mechanisms are not much different from the realities of many schools today.

By assuming the roles of patients in the ward, and being subjected to similar systems of oppression and conformity, I hoped my students would feel deeper empathy and engagement by embodying the themes and lessons of the narrative. They would be immersed into a strict world of control and low level paranoia that strove to follow the novel's narrative arc. Ideally, they would not only think about the themes of the story and the treatment of mental illness, but they would also reflect and question their own school experiences at the end of their graduating year.

Despite the game's outward demand for conformity, it would paradoxically bestow total and complete choice throughout. Students could choose to play or not play, accept or decline any mission or task, and even tailor their own missions. Depending on the activity, they had the choice to respond by writing, filming, recording, designing or carrying out kinesthetic tasks like flash mobs and dramatic performances.

Finally, my basic blueprint for engagement was to externalize video game mechanics into the real world to activate elements of the narrative. It was almost a year after the first iteration that I discovered that the best term to describe this dynamic was, broadly, a pervasive game.

What problem are you trying to solve and why does it matter?

When I first took the plunge, it was really just a matter of engagement. Doing something so different, complex and unexpected that I could draw my students in, despite their best efforts to resist.

After the first run, what was most remarkable and moving, was witnessing students who had wilted at the back of the class for 4 years come alive and work tirelessly at a time when they should have been at their lowest levels of motivation. Yet more proof that the hard wiring of traditional schools alienate and snuff out many bright lights. It was amazing to see that an alteration of the system could so dramatically recalibrate student performance. This observation is, of course, largely anecdotal.

There has been some discussion of the crisis regarding boys and reading, and I feel that notions of what a traditional English class looks like have to change. Reading and writing are the critical communication skills that underpin most other media, but English teachers have to consider the diversity of forms and literacies that are quickly dominating modern channels of communication. *The Ward Game* is an attempt to recast narrative in relevant and contemporary forms of communication.

As much as I love and believe in games, I don't think that they are the silver or magic bullet to solve all problems in education, but they are certainly part of the solution. The first run of *The Ward Game* also taught me that not all students like games, or this type of game in particular. An ideal educational program should offer a variety of systems and opportunities to harness the myriad of complex ways that intelligence is manifest.

It was also interesting to note that *The Ward Game* naturally invited multidisciplinary education. It included an economy, art, historical considerations, various forms of media production, collaboration, community service, privacy and surveillance literacy, physics, and narrative study. At the same time that the game, in the spirit of the novel, exaggerated and satirized some of the biggest problems in education, it subtly pointed to a viable set of solutions.

What challenges might pop up?

I've worked largely in isolation and, at this time, *The Ward Game* is more of a patchwork model rather than a cleanly scalable or transferable product. So much of it is dependent on my willingness to alter my personality and act like a doctor for 30 days, as well as the stress of negotiating the game's day-to-day unpredictability. I would appreciate some feedback and ideas as to how to help other teachers adopt and implement this type of game.

Formal assessment is also a big question. I've worked on a basic 100 point system with diminishing returns, that is also fed by an in-game economy and achievements. In some ways, video games are the best assessment tools out there - they provide constant feedback loops on player performance. I'd like to find out about possibilities for more intricate assessments that would more effectively measure student performance and provide ongoing feedback while they play.

As I am not a programmer or software engineer, one big gap in my game is the absence of dedicated software. I spend hours tallying points, distributing achievements, keeping track of missions, etc, but I'm certain that the right tools would free me to better respond to the evolving game rather than getting lost in menial labor.

Finally, I'm interested in the copyright implications of *The Ward Game*. In its current state, it is allowable within fair use laws in Canada. I have no desire to commercialize any aspect of the game, but I believe that it may be a canary to explore how pervasive game narratives might be interpreted by the individuals or institutions that hold the rights to works that might potentially be used.

Looking beyond the Kesey novel, it would be interesting to consider what types of narratives and stories best lend themselves to be developed into pervasive or environmental games.

Sprout

Tell us about your process and how your idea is evolving throughout the project.

My first iteration in 2012 was quite rough, and many aspects of the game diverged from the core *Cuckoo's Nest* narrative. In fact, I didn't really feel compelled to faithfully abide by the dictums of the source text. I used aspects of the main characters, tried to conjure a similar atmosphere to Ratched's ward and created mini-games that were thematically tied to the narrative. Largely, the idea was to create an unstable environment that was at once unpredictable and oppressive. That first run created a deep bond between my most active participants and myself, and

yielded many memorable anecdotes. A great deal of what occurred I made up as I went along (very stressful!), and in so doing, I essentially wrote the game's first draft.

The 2013 run was richer, better organized, more immersive and more faithful to Kesey's narrative. I made wide use of social media, and introduced lotteries, fishing expeditions, mock medication by appointment, a basketball tournament, propaganda videos and posters, a relevant and sophisticated economy, and a hunt for a stolen jar of Dilantin. I also developed a partnership with our Center for Addiction and Mental Health (CAMH) in Toronto. One of the quest chains led students interested in social justice and medicine to visit the facilities and better understand the treatment of mental health patients and the current uses of ECG. Functionally, I tried to make every aspect of the game relevant to the novel.

The second run definitely evolved into what the game development world would call a beta phase, but there remains ample territory for refinement, expansion and improvement.

What interesting patterns or insights have you discovered?

Remarkably, both times I've run the game, the playfully oppressive regime inspired equally playful rebellions. Much like McMurphy's defiant response to Nurse Ratched's authority in the novel, players creatively and harmlessly hacked and disrupted the game, inadvertently externalizing the book's key conflict. Framed in contemporary terms, by creating what amounts to a surveillance state, hacker factions rose in opposition to the systems of surveillance.

The game's elements combined to externalize Kesey's narrative and it unintentionally created a sort of microcosm of the emerging social and institutional issues of the early 21st century. Along the same lines, I believe that games are the defining cultural form of the 21st century, and by playing a sophisticated game many of the oft-cited 21st century learning skills naturally occurred without my having consciously built them into the game.

One aspect of the game I had to be careful about was that some students had trouble ascertaining that I was playing a character. Early in the first and second run, a few students became a bit unnerved and I had to speak to them informally to explain that it was all an act.

Finally, as I mentioned in another section, in both runs of the game, many of my lowest performing students did an about-face and became some of the game's most active and productive players. Something about the ludic dynamic empowered and engaged them. They proceeded with an aura of energy and self-confidence that had been, seemingly, mostly absent until that time. That, to me, remains the single most important element of the entire experience.

Working Example: *Arctic Saga*

Christian de Luna, Christopher Vicari, Thomas Toynton, Joey Lee
Teachers College, Columbia University



Example URL: <http://www.workingexamples.org/example/show/639>

Arctic Saga is an educational board game designed to simulate marine spatial planning, a technique used to resolve stakeholder spatial interests in disputed regions. Players negotiate stakeholder economic interests while working together to maintain the Arctic environment.

Seed

Tell us about your idea or project. What's your vision?

Arctic Saga is a three to four player board game of strategy, resource management, and negotiations. Players explore territory, create a network of developments for profit, and withstand nature's fury for not developing green technology and preserving the environment. Players embody the roles of stakeholders with an interest in the area: Oil, Shipping, Fishing, and Tourism. As players acquire materials and resources, they will often negotiate with other players to improve their own standing via trading. *Arctic Saga's* endogenous mechanics, such as territory placement, negotiations, and environmental conditions, are largely-based on actual science and reality.

We envision our game being played in aboard cruise ships, in classrooms, and in casual environments. Take-aways from game-play will certainly be influenced by these differing environments and we plan to observe these differences in gains during the upcoming year. Ultimately, we hope that players will learn about the Arctic region, negotiation, environmental welfare, systems-thinking, and connectivity.

What problem are you trying to solve and why does it matter?

Arctic Saga is derived from a classroom exercise developed by the Barnard Earth Science Institute titled Arctic SMARCTIC (Strategic Management of Resources in Terms of Crisis). As its title indicates, SMARCTIC was designed as an informative experience for students interested in learning about the current Arctic environmental and economic climate. The purpose behind the creation of *Arctic Saga* was to design a self-facilitated version of the classroom exercise that conveyed the central tenets of the SMARCTIC classroom exercise that could be distributed and played at a number of venues including cruise ships, museums, and classrooms.

The ice in the polar region continues to decline; polar bears and many other wild animals are being endangered because of the encroaching presence of industry and human expansion. Estimates points to complete ice disappearance over the next decades. It's imperative to reach as many audiences as possible to educate them on the

importance of the stability in this region, as well as environment-changing effects that are occurring. We feel that the development of an educational board game is a way we can reach audiences who can learn through playing, while also engaging with the science which forms the backdrop of this game, and understand the stakeholders vying for control of the region.

Sprout

What are some of your initial concepts or designs? We'd love to see them.

At first, we had thought the game was intended to depict the importance of the preservation of ice in the Arctic region. We had begun to conceive a game in which players would attempt to develop on top of the ice and, after continued, reckless development, would cause the ice to melt thereby destroying their developments.

To simulate this, we felt two important learning objectives were necessary to portray: 1) the management of territory and resources and 2) the balance of cooperation and competition through negotiation. To discover ways to convey our learning objectives, we observed the mechanics of a number of popular board games.

For spatial and resource management and negotiation, we turned to the *Settlers of Catan* and *A Game of Thrones: The Board Game*. Both *Settlers* and *Game of Thrones* require players to constantly vie for resources while still maintaining cordial relations with their neighbors lest they fall out of their neighbors' good graces too early in a game, eliminating the player from contention. Designing for this weighted competition was crucial for our learning objectives which called for us to reflect the real-world competitive environment that stakeholders currently vie for in the Arctic environment.

While emphasizing competition, it also was vital to emphasize the collaborative component of operating in the Arctic environment. In the real world, if one stakeholder succeeds in claiming all of the resources to be found in the Arctic region, then that may result in a good payoff for them; however, their selfish actions may put the environmental climate of the region in danger. To simulate these aspects, we turned to collaborative games such as *Pandemic* and *Forbidden Island* which do well in creating an atmosphere of cooperation in the face of impending disaster.

Have your initial concepts/designs changed? Why have they changed? Show us how they're being refined and iterated.

Upon presenting our initial design concepts, ideas, and direction to our PI and the Barnard Earth Institute, we talked to our content expert and learned that we were moving in a completely different direction than desired. Our game was complicated; fueled by our own ambitions to design a game on our own, one that was influenced heavily by Euro micromanagement games, and without any real foundations in actual science. Needless to say, our designs/concepts changed drastically. This experience showed our design team just how much a content expert is required to ground the design in reality, or at least have it move in an expected direction.

Another change was our attitude towards the design process. This was the first game we've ever produced and we felt a mix of excitement, pride, and perhaps even a little bit of a chip on our shoulder. We had limited experience, to put it lightly, but we were confident in our abilities because we felt that all one really needed to design a game was hardcore gaming experience, passion, and a lot of enthusiasm. Eventually, these three aspects proved insufficient. We learned the lesson that having the experience and wisdom to know that we don't know something, or at the very least know that we're stuck in the design process and need help, is essential as well. We started caring less about designing the ultimate game that everyone would want pay and gladly shout "Shut up and take my money!" when we showed it to them, and instead began to really sit down and consider mechanics, balance, narrative, and if everything fit appropriately.

Building on ice? Dropped. A complex trading and resource management only an economics major could understand? Also dropped. We focused on and tested several simple concepts: strong, yet simple mechanics with a foundation in science (the play-space, negotiation, cooperation, and territory expansion). Each mechanic, starting off complex, but becoming further and further refined through play-testing and prototyping, came to represent reality, in a way as best as games can I suppose, but also connected with the original learning goals of the project. This occurred over a period of about half a year and it's safe to say that our current version is pretty much unrecognizable if you compare it to the original incarnation of the project.

Evolution of the Game Board

We first started with the map on the left (Figure 1) that details the combined interests of stakeholders in the region (red = high interest, orange = middle interest, yellow = low interest). From that we attempted to create a territory map that represents areas of differing interest to stakeholders and illustrates areas of contention. This version proved too expansive for simple game-play. We reduced the total number of territories in the third iteration making a more connected board that would allow for more player confrontation. We also incorporated ice-locked areas to represent the learning goal that melting ice has advantages for stakeholders.



Figure 1: Evolution of the Game Board

Victory Paths

The three victory paths in *Arctic Saga* (Figure 2). Titan of Industry and the Investment mechanic were removed as of the last iteration in order to simplify the game-play experience by limiting the cognitive burden on new players. Whether a new victory path will replace it depends on if a new mechanic can be developed that ties into the science



Figure 2: Victory Paths

The Earth

To represent the environment in *Arctic Saga* included two primary components: the EcoMeter and the Season dial (Figure 3). The EcoMeter allows players to receive immediate feedback to their actions and requires them to work cooperatively to ensure that the environment does not reach critical levels of degradation (aka Eco Level 12). The season dial shows the passing of time literally (game turns) and metaphorically (real-world seasons). The season dial also reflects how seasonal conditions in the Arctic environment would affect investor interests. In the summer, players are allowed to explore previously ice-locked territories in the inner regions, demonstrating the advantages of melted ice. In the winter, all production ceases as the elements become too harsh to work in.

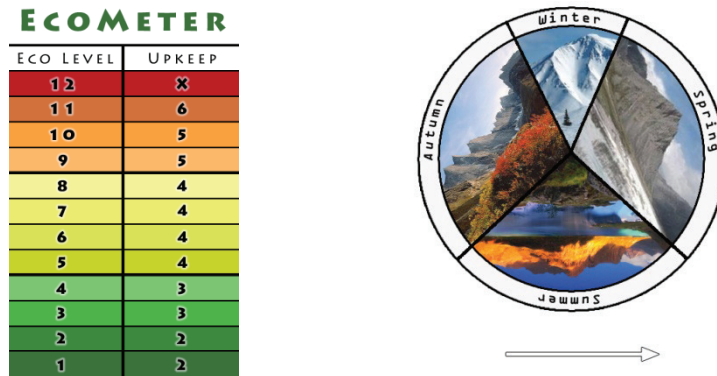


Figure 3: The EcoMeter and Season Dial

Bloom

What were some of your big challenges and how did you handle them?

Upon completing our first iteration, we presented Arctic Saga to our consortium members during a designated game night. Members of the consortium predominantly featured content experts whose experience with board game play was minimal on average. After three rotations of the game, we had learned that the general consensus was that the game was difficult to learn but made sense after continued and repeated play, a common trend among many board games. However, unlike common board games, very few individuals would likely revisit an educational game, such as Arctic Saga, except out of necessity.

On the other hand, we had also introduced the game to individuals who frequently play board games and learned that their biggest complaint was that the game was too simple. Used to games that required more of a competitive edge and in-depth strategy, experienced gamers were unsatisfied by limited complexity that was meant to scaffold the experience of those new game players. For some, if the educational Arctic aesthetic was removed from the game they mentioned that they would prefer play a game with the more nuanced mechanics found in traditional board games.

We are currently in the process of reiterating taking this feedback in mind, but one important lesson we learned is that the difficulty in instructional design lies strongly in user familiarity with the form of the task, in this case a game. Those unfamiliar with games were more concerned with learning how to play the game rather than exploring the embedded learning goals. On the other hand, many of those who were experienced gamers would not encounter those embedded learning goals simply because they would not want to continue to engage with a simple game.

Our biggest take-away from this experience was that simple need not be easy. We are still trying to cut down the number of total mechanics in this game to lower barriers to entry and to enhance learning objectives; however, that does not mean that we are seeking to make the game easier. We feel that the greatest games are those that can convey the most memorable experiences with the simplest mechanics. We seek to make Arctic Saga a game that can endogenously relate content through simple yet compelling mechanics in order to cater to all players.

Dream Flight Adventures — Mission Ops

Gary Gardiner, Dream Flight Adventures
Sarah Gardiner, Dream Flight Adventures



Example URL: <http://www.workingexamples.org/example/show/634>

Mission Ops is a sister product that accompanies Dream Flight Adventures simulators. Whereas the standard simulators are heavily themed immersive environments, Mission Ops is less themed and more suitable for a variety of typical learning environments (classrooms, after school programs, labs, etc.). Dream Flight simulators and Mission Ops work hand-in-hand—the former sending crews of students on epic missions throughout time and space, and the latter enlisting students to work as the “mission control” behind the scenes of these missions. Together, they provide engaging learning experiences.

Seed

Tell us about your idea or project. What’s your vision?

Mission Ops is a companion product that accompanies [Dream Flight Adventures](#) full immersion [simulators](#). It began as a spin-off from these simulators, so it’s important that one has a basic understanding of Dream Flight Adventures before this information about *Mission Ops* will make much sense.

Therefore, we strongly recommend you visit www.DreamFlightAdventures.com to learn about the broader program. Past experience has shown that viewers probably won’t heed this advice, so here’s a brief summary about the program. Dream Flight Adventures works with schools and museums to transform traditional classrooms into fully themed and immersive spaces that resemble the command bridge of a science fiction vessel. Groups of students enter these simulator classrooms, assume a variety of roles (physicist, engineer, biologist, pilot, etc.) and work together to complete a challenging mission that blends science, technology, and engineering with social studies, humanities, and the arts. The students view the experience as an epic adventure, and little do they realize that they are learning crucial curriculum as well as a variety of 21st century skills such as teamwork, critical thinking, and problem solving.

These full immersion simulators are elaborate permanent installations, so despite their tremendous reception and results they are not suitable for all schools and museums. Mission Ops arose as an answer to our question of “How can we repackage this successful learning experience such that it is more accessible in a wider variety of environments?”

Mission Ops uses the same underlying principles of themed, immersive, story-driven learning adventures, but it employs a different format that emphasizes hands-on lab-style projects and specific exercises with less reliance on a technology-rich setting. It has lower technology and environmental requirements, so it can be more readily deployed in a traditional classroom or lab setting.

A specific example will help contrast the two programs. One of the Dream Flight Adventures simulation scenarios is [Vesuvius](#). In it, students fly their simulated vessel into a virtual volcano, take scientific measurements, and determine whether an eruption is imminent. This all takes place inside a decoratively themed immersive environment. Without this environment the learning adventure is not possible.

Mission Ops, on the other hand, offers a learning adventure that teaches complementary topics (the structure of volcanoes, etc.) in a standard classroom. It does this by guiding students through some hands-on activities, such as building a gelatin volcano to learn how magma flows, creating calderas with a box of flour and a balloon, and making a vinegar and baking soda model of an eruption. All of these activities could be done by a motivated teacher in a standard classroom, but Mission Ops packages and delivers them via an interactive story-based adventure similar to what students experience in the immersive Dream Flight Adventures simulators. This layer of interactive storytelling increases the students' interest and engagement level, which contributes to deeper learning.

The two programs can work side by side, but as it turns out Mission Ops also can function as a standalone solution for schools and museums that do not have a full immersion simulator installation.

What problem are you trying to solve and why does it matter?

There are many challenges facing modern education that motivate *Mission Ops* on a deep level, but the clearest and most direct problem *Mission Ops* addresses is one posed by its sister product—[Dream Flight Adventures](#) simulators. These simulators only hold about 17 students, while most standard K-12 class sizes are closer to 30 students. So, when half the class is doing a Dream Flight Adventures mission, what do the rest of the students do?

It's important to note that the Dream Flight Adventures simulators are extremely complex systems, with each of the 17 student stations tightly interconnected. Due to game design, balance, and space constraints, it simply isn't feasible to make a simulator that supports up to 30 students. Instead, the program opts to divide a standard class in half, allowing one half to use the full immersion [simulator](#) while the other half does other activities. But what are these "other activities"?

Our initial answer to this question was a series of projects that the students could do in class—multimedia projects, creative writing assignments, group discussions, etc. However, these were a bit too mundane (especially in contrast to the Dream Flight Adventures simulator) and never really caught on. It quickly became clear that we needed something more special and compelling.

That said, we didn't want to fall subject to the same constraints as the Dream Flight simulators. Namely, we didn't want to require extensive construction, decorative theming, or expensive technology equipment. Furthermore, we wanted to support a wider variety of project-based learning (things like chemistry experiments, messy building projects, arts & crafts, etc.).

Mission Ops was created as a spin-off product that fits within these constraints and still delivers an engaging story-based learning adventure. It had some surprising and positive side effects too, which we'll elaborate on elsewhere in this Example.

What are your goals and how will you know if you've achieved them?

Mission Ops has a variety of goals that seem to oppose each other at times. Getting them to all work nicely together will be tricky... but then again, all worthwhile things are tricky at times. Besides, it's what we love to do. These goals are:

- 1 Create a framework that can readily accept all types of educational projects (from full-blown labs and classroom activities to mundane drill-and-kill exercises).
- 2 String these projects together into an interactive story that motivates, entertains, and teaches students.
- 3 Package the entire experience such that educators in essentially any setting with minimal technology and funding will be able to implement the experience.
- 4 Develop a scalable process so content can be expanded easily and cost-effectively down the road.

One of the first metrics to gauge success in these goals is simply measuring adoption. If schools and museums learn about *Mission Ops* but don't use it, that's a clear indication that we missed the mark on at least one of our goals.

Once schools do implement the program, success can be measured by observing the students and comparing their interest, attitude, and academic performance against students who do not participate in the program.

Who will your work impact? What do you know about them?

Mission Ops is designed to accompany Dream Flight Adventures simulators, which means that it will be embedded within elementary, middle, and high schools, as well as in museums and community centers.

That said, our goal is for *Mission Ops* to be flexible enough that it can stand alone as a viable and attractive experience for teachers nationwide (if not around the world), even without a full Dream Flight Adventures simulator.

Teachers everywhere struggle to keep their students motivated and engaged. Game-based learning principles have caught on quite a bit lately, but their adoption is still rocky at times, and teachers often wonder if their attempts are effective (rather than inadvertently providing a "playtime" that lacks sufficient educational value). *Mission Ops* is our attempt to package rich educational experiences in a motivating story-based adventure that simultaneously entrances students while satisfying rigorous educators.

How can our community support you? (expertise, resources, etc.)

Mission Ops was born out of [an idea that didn't quite fit what modern educators need](#), so the idea was twisted and tweaked until it took its current shape. This twisting and tweaking will undoubtedly continue. We hope to continue to work with this community to get feedback, validate ideas, and shape our development.

Once *Mission Ops* is complete we also hope to test it and deploy it at classrooms accessed through this community.

Sprout

Tell us about your process and how your idea is evolving throughout the project.

The first implementation of *Mission Ops* will be at a high school in the greater Pittsburgh area. Our original hope for the program was to embed content and activities from the school's science curriculum into *Mission Ops* to create a compelling STEAM Lab for the school. However, as it turns out, the school didn't provide any science projects or group activities for us to build upon. Instead, the burden fell upon our team to design the lab and its related activities ourselves. Although we're working through this challenge and are still on track for a successful launch in the summer of 2014, the situation is clearly less than ideal and it has taught us important lessons regarding how we expand the program to more schools. Specifically, at the very earliest stages of working with a school we have learned to verify that it has curriculum-based activities in place. We're much better at making exciting interactive experiences than we are at writing curriculum, so we want to partner with schools and leverage their expertise: they provide the qualified content, and we provide the layer of engaging interactivity.

Another important challenge we've faced is the problem of bottlenecks. In *Mission Ops*, classes of students are divided into small teams of 4-5 students each. Each team receives an iPad running our custom app, which guides them step-by-step through curriculum-based activities. However, some of these activities require special equipment (e.g. a microscope), but not all labs will have enough of each piece of equipment for all the teams to use them at once. As a result, we have to be careful in how we design the experience to ensure that groups move between equipment in an orderly fashion that avoids potential bottlenecks with multiple groups trying to use the same piece of equipment at the same time.

What interesting patterns or insights have you discovered?

One of the exciting things that we've learned through this project is the applicability of *Mission Ops* to a wide variety of labs and classroom settings. We originally designed the program to be a companion to our Dream Flight Adventures simulator classrooms, but we've discovered that *Mission Ops* can effectively stand alone as its own experience, even without a simulator classroom.

We've also been pleased with the versatility it offers. The program is essentially a fancy mechanism for delivering instructions to students and capturing their responses—a high tech worksheet, of sorts—that lends itself to use in

a variety of situations. We originally envisioned it being used in science labs and STEAM rooms, but we've begun to see teachers and schools consider using it in more settings as well (e.g. in a school library, etc.). We're excited to see where this will ultimately lead.

What are some of your initial concepts or designs? We'd love to see them.

Here are some screenshots showing the iPad software with a mission designed around an elementary-level volcano unit.



Figure 1: Welcome screen on student team mobile devices.



Figure 2: Sample multiple-choice screen.

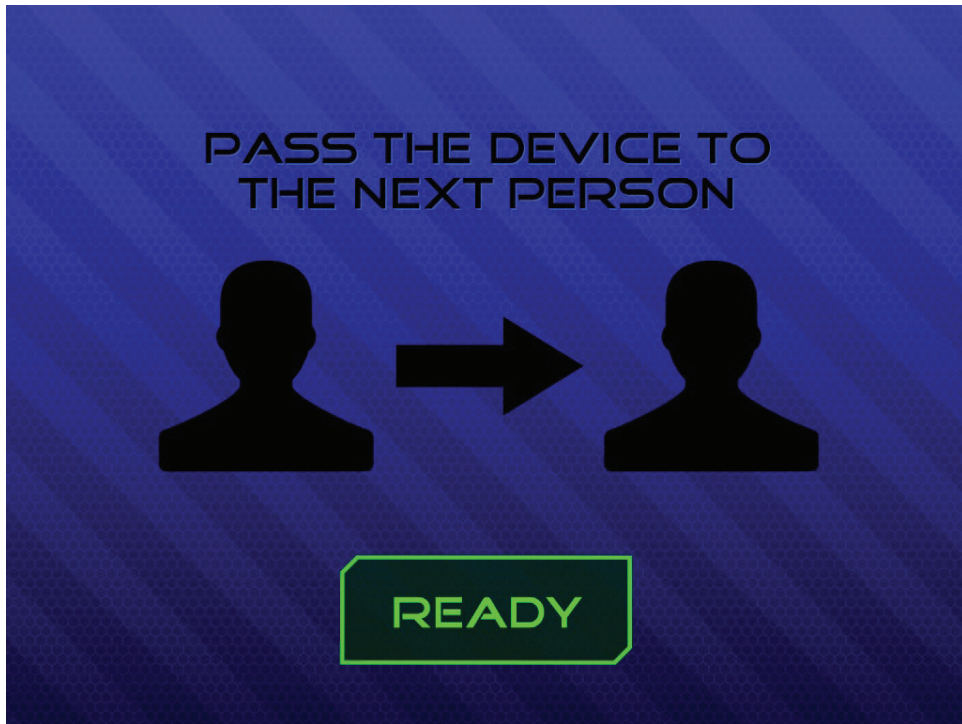


Figure 3: Sample student prompt.

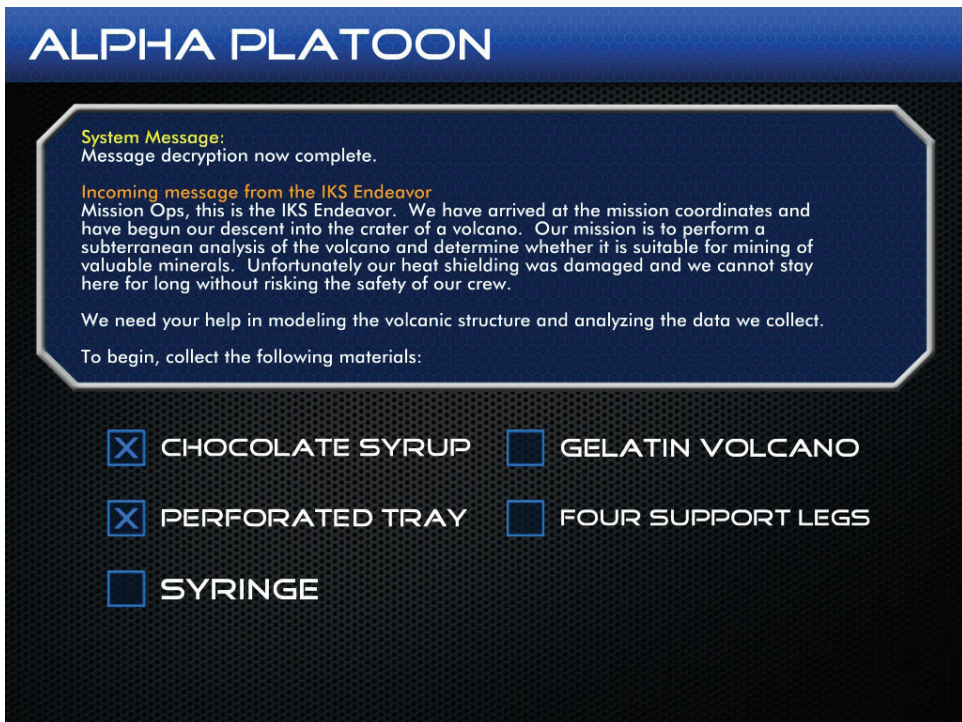


Figure 4: Sample checklist screen.



Figure 5: Sample photo screen.

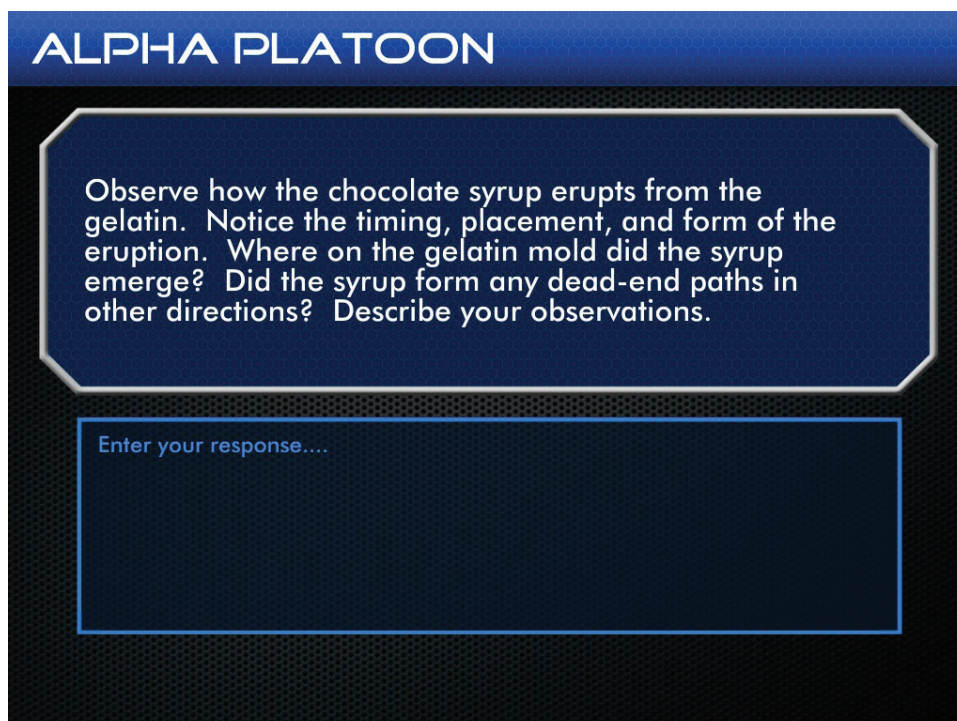


Figure 6: Sample free response screen.

GradeCraft

Caitlin Holman, Stephen Aguilar, Barry Fishman, Michelle Carr,
Michelle Fiesta, Adam Levick, Sara Molnar, Lauren Rocco,

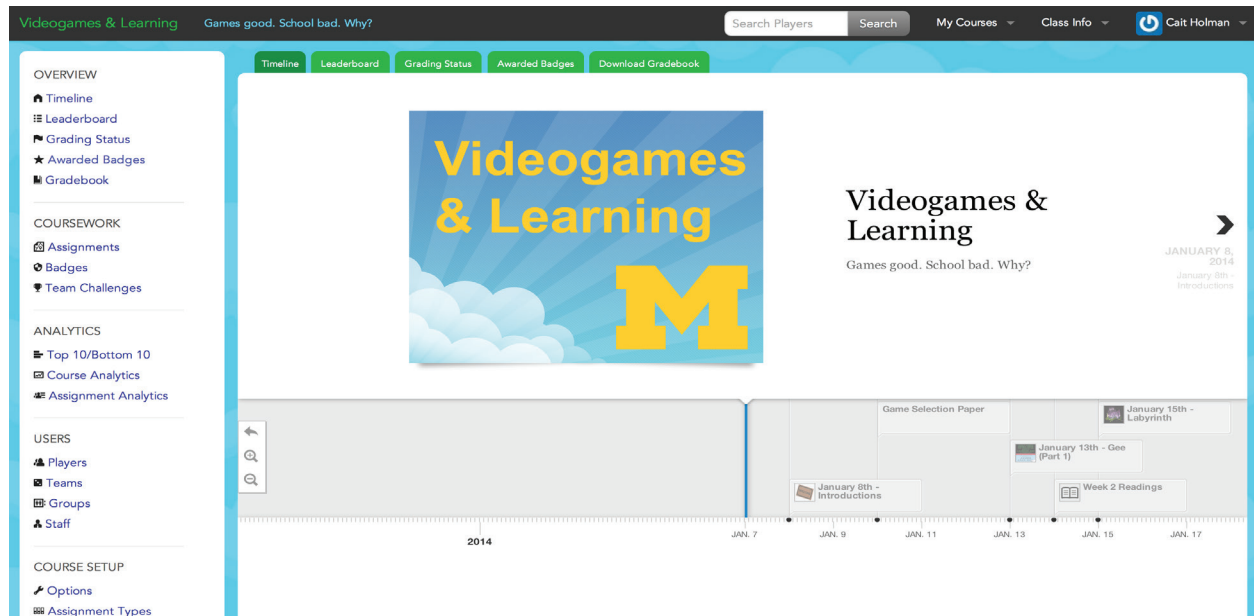


Figure 1: GradeCraft Homepage

Example URL: <http://www.workingexamples.org/example/show/640>

Project Summary

A growing number of teachers are transforming their traditional course designs into gameful systems, with the goal of creating an environment that allows students to autonomously select a path through the course content, enables them to take risks in their coursework and recover from potential failures, and asks them to work together to collectively accomplish class-wide challenges. Managing this multifaceted course format within a “standard” learning management system (i.e., one that was built to support traditional course designs) proved to be both limiting for instructors and confusing for students. We have designed a new learning management system, GradeCraft, to support the unique requirements of game-inspired courses. In this Working Example we document that process, detailing some of the challenges that we have faced, along with issues we have yet to address.

Seed

Tell us about your idea or project. What’s your vision?

GradeCraft is a game-inspired learning management system. We believe that gameful courses can create more engaging classrooms, and we want to make it possible for any instructor interested in running a course like this to have a playful, intuitive space to do that. We are also dedicated to displaying real-time learning analytics information (e.g., patterns of system use and comparisons of assignment performance outcomes), to help teachers track the administrative workflow within their course, and facilitate students’ ability to make informed choices about how they can achieve success.

What problem are you trying to solve and why does it matter?

GradeCraft grew out of a distinct classroom need - we wanted to implement a gameful course design that included having students select their own coursework from a variety of options, earn badges that recognize mastery of skills and course content, and work together as teams to accomplish big goals. Using our traditional learning management system (LMS) proved so frustrating that it detracted from the course experience for students, and created a significant management burden for the teaching team. In one course we are aware of, the teaching team had to use 300 spreadsheets to track individual students’ assignment weighting decisions and calculate final

grades. Our goal is to make it possible for instructors to implement gameful designs they could not otherwise have done without investing significant management time, and to design the supporting feature based on the latest research regarding what mechanics and displays are effective at supporting student autonomy and engagement.

What history or context should we know about?

We have begun our work at the university level, growing one class at a time in our implementation. We are interested in expanding to the K-12 space but want to make sure that we have fully assessed the differences in what K-12 classrooms will need from this type of system. We need to have more conversations with teachers and administrators before we will be ready to implement GradeCraft within that context.

What are your goals and how will you know if you've achieved them?

Our initial goal was straightforward: provide students with an interface that would display how they were doing within a gameful course, and aid them in planning their future work choices. We have accomplished this initial goal, but continue to work to improve those two core functions. Our next goals are to further support personalization strategies (for instance, allowing students to declare which assignments they would like to be receive further information about and when). We are also building a dynamic 'unlock' system that allows instructors to establish combinations of academic achievements and system behaviors that open up new opportunities, establish ways for students to better recognize and support each other's work, and build assessment tools that support faster and more effective feedback.

Who will your work impact? What do you know about them?

We have a number of different audiences that we are working to build for:

- Instructors who are already familiar with gameful course designs, often having run gameful courses via existing technologies (and sheer force of will!), have been our initial focus in trying to get the system adopted. As leaders in the space, they have been willing to take risks and push the boundaries of what has been done—and often requested that we build complex new features.
- Instructors who are interested in running a gameful course but have hesitated given the management tasks involved or because they do not know where to begin. We are hopeful that when we start to work with instructors in this category we will be able to offer them two things: first, recommendations as to best practices to structure a successful gameful course, and second a feature-rich, engaging system that does the heavy lifting in regards to the gameful aspects of course management.

What challenges might pop up?

One of our biggest challenges has been sorting out whether we want to develop features that are considered 'core' for a typical LMS (e.g., forums, chat tools, and resource utilities), or whether we should focus on building out a uniquely gameful feature set. We are trying to create a cohesive, engaging student experience, and we want to make things as manageable as possible for teaching teams. One way to address this goal would be to build all the 'core' tools our teachers want to use in these classes, establishing a single platform to manage the comprehensive course. From a pragmatic standpoint, however, that is not an efficient use of time—doing so would only serve to duplicate the quality work that has already been done in the community (e.g. Piazza, LectureTools, etc.). Moreover, it prevents us from focusing on the development of gameful features we believe to be truly novel and exciting. Determining the appropriate scope here has taken significantly more time than anticipated. The solution seems to lie in a combination of leveraging tools built according to the Learning Tools Interoperability (LTI) specification, developing selected features if their inclusion in the app can offer both analytics and gameful features to be built on top of them, and expecting that instructors will employ multiple applications that students will have to manage.

Much of what is engaging about good video game design is the plethora of immediate and immersive feedback on one's actions; we are not (and do not wish to be) automated in our assessment of student work, creating a break in the rapid feedback loop where a teaching team must expend effort to provide students with quality feedback. One example of how gameful strategies can complicate this that we have seen play out involved students being able to earn a badge that allowed them to resubmit a particular paper. A large number of students were able to successfully earn this badge and, assured of their ability to resubmit for a better grade, submitted a lower-than-usual-quality paper as their first submission. Reduced risk? Check! Successful strategy? Check! Taxing and frustrating for the teaching team? Check... We have an open question of how we should go about balancing reduced risk and unique pathways with the time and effort limitations of our instructional staff.

How can our community support you? (expertise, resources, etc.)

Feedback! We would love to hear what aspects of games teachers want to be able to incorporate into their course designs, and how we can do more to support these uniquely challenging endeavors.

Tell us about the team you have assembled or hope to assemble.

Barry Fishman is a Professor of Learning Technologies in the University of Michigan School of Information and School of Education. His research focuses on video games as model learning environments, the use of technology to support teacher learning, standards-based systemic school reform, and the role of educational leaders in fostering classroom-level reform involving technology. He was a long-serving Associate Editor of *The Journal of the Learning Sciences*, and served as a co-author of the Obama Administration's 2010 U.S. National Educational Technology Plan. Barry received his A.B. from Brown University in English and American Literature in 1989, his M.S. from Indiana University in Instructional Systems Technology in 1992, and his Ph.D. in Learning Sciences from Northwestern University in 1996.

Stephen Aguilar is a doctoral student in the Combined Program in Education and Psychology at the University of Michigan and is interested in understanding how game-inspired pedagogies and learning environment designs can serve to foster adaptive student outcomes (e.g., increase student engagement with course content; provide a sense of agency and autonomy over course experience; and promote adaptive academic identities). He is also interested in how Learning Analytics innovations mediate and support the above processes.

Stephen first became interested in how technology can be used in the classroom during his time as a Teach For America corps member, where he taught middle school history and science in East Palo Alto, California. Prior to attending the University of Michigan he worked as an assessment specialist for a charter management organization based in Los Angeles, California. Stephen is a Rackham Merit Fellow, and holds a Bachelors of Arts degree in Philosophy and Psychology from Georgetown University as well as a Masters in the Humanities from the University of Chicago.

Michelle Carr is a designer and animator interested in how social media influences education and learning. She previously worked with Design for America to implement an online platform that helps undergraduate students engage with design and civic innovation. Michelle received her B.S. in Brain, Behavior, and Cognitive Science from the University of Michigan, and her M.A. in Learning Sciences from Northwestern University.

Michelle Fiesta is a master's student at the School of Information specializing in Human Computer Interaction at the University of Michigan. She previously attended the University of Missouri, graduating with B.A.s in Psychology and Anthropology. Michelle is interested in how gamified learning can affect student motivation to complete tasks, and how this ultimately affects education outcomes.

Adam Levick is specializing in Human Computer Interaction and Social Computing at the University of Michigan School of Information. He is interested in how incentives can be integrated into educational technologies to increase student motivation and learning. Adam works on development, design, and text analysis research within GradeCraft. He received his B.S in Environmental Science and Asian Studies at the University of Michigan.

Lauren Rocco Green is a Master's student specializing in Digital Media and Education at the University of Michigan's School of Education. Lauren is interested in education access and the creation of project-based, situated learning environments. Lauren has previously worked as an educator in both formal and informal education settings, an outdoor guide and a carpenter in the Antarctic. Lauren received her undergraduate degree from Dartmouth College in Government with an informal concentration in Computer Science.

Sara Molnar is a Master's student specializing in Digital Media and Education at the University of Michigan's School of Education. Sara is interested in learner autonomy, motivation, and self-regulation in game-inspired learning environments. Sara has previously worked as a technology coordinator and Media Arts teacher at an urban high school in Boston, MA. Sara received her undergraduate degree from Michigan State University in Media Arts and Technology, accompanied by a Philosophy minor as well as film and documentary studies specializations.

Caitlin Holman is a doctoral student at the University of Michigan School of Information. Her work focuses on the use of technology to support gameful coursework, and the impact of both game mechanics and learning analytics displays on student motivation and achievement. She received a B.A. in International Affairs from the University of Maine, and an M.S.I. from the University of Michigan School of Information.

Sprout

Tell us about your process and how your idea is evolving throughout the project.

We have grown organically, adding features in response to specific instructor requests and classroom needs. At the beginning, our goal was to build the grade predictor and a tool to award badges—just those two elements! But in order to have the information to power the grade predictor, we had to tell the system everything about the assignment structure; in order to tell the student the most up-to-date information about their progress, we needed the system to know everything about their grades. These requirements meant that we had to become the core assignment tool, and a full-fledged gradebook.

One of our most complex features, individual assignment weighting, has been the result of our collaboration with Professor Mika LaVaquer-Manty, an incredibly innovative professor in the University of Michigan Department of Political Science. He wanted a system that would allow students to specify how much assignments would be valued towards their grade, as well as a way for students to self-award points for certain types of assignments (used for self-reported attendance in a large lecture class). These two features have helped us to consider how (both within the course design, and as a technical challenge) students should be able to interact with their grade.

Asking students to take these actions unmediated by any authority figure enhances their autonomy within the course. It also increases the potential for mistakes – students may make choices that are not ideal or do not work in the manner in which they expect. That concern reemphasizes the importance of building a system that reflects their progress back to them, with the hope that they will be able to recover from any issues.

What interesting patterns or insights have you discovered?

There is not just one type of gameful course! Within the four courses we have worked with, we have observed three distinct patterns: our first course fits a ‘platformer’ game model, having a fun leveling system, using badges to recognize achievement (but not contribute to the course grade), and offering a selection of paths through which students can engage with the course material. Our political science course parallels a strategy game, requiring students to assess their skillset, and forecast which type of work will lead to the best outcome for them. Our newest course, Professor Cliff Lampe’s Intro to Information Science, plays out as an RPG, with students doing work in ‘Houses’ that contributes directly to their grade, completing quests that encourage skill development, and using leaderboards to assess competency and fuel competition.

Have your initial concepts/designs changed? Why have they changed? Show us how they’re being refined and iterated.

Aesthetically we have always tried to incorporate a playful approach, using a bright color scheme and whimsical design elements to inspire a platform-game type experience. There is so much information to convey within these displays, we worry about the threat of viewer overload (not to mention the performance issues it causes!). We are currently doing user-testing to try to whittle the displays down farther, and ensure that we are highlighting only the most relevant information.

We have been through three distinct design iterations so far.

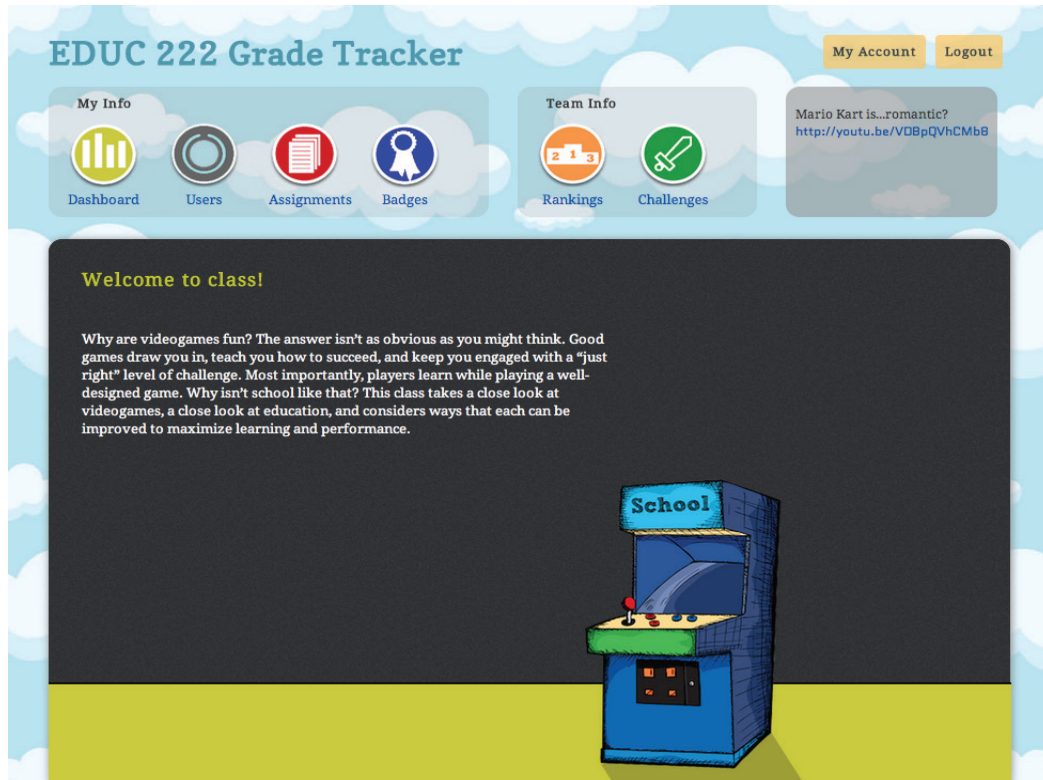


Figure 1: GradeCraft v.1 Design

The initial round was all custom CSS (Figure 1) with no responsive (the ability for a site to respond dynamically so as to properly in web-browsers, tablet devices, and phones) elements. We decided to move to a CSS framework to be able to leverage of some of the fantastic work going on in the open source community and improve our development workflow.

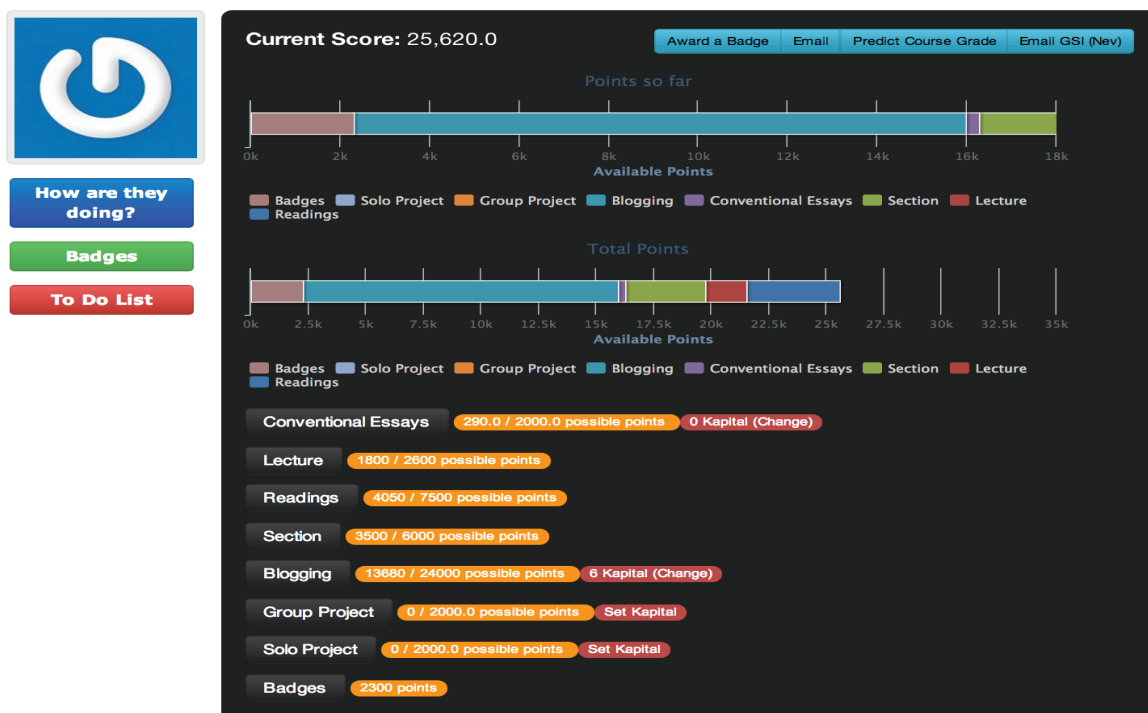


Figure 2: GradeCraft v.2 Design

We used Twitter Bootstrap in our second round of design (Figure 2), which was a huge step forward, but we never quite managed to customize it enough that it felt like we a unique design.

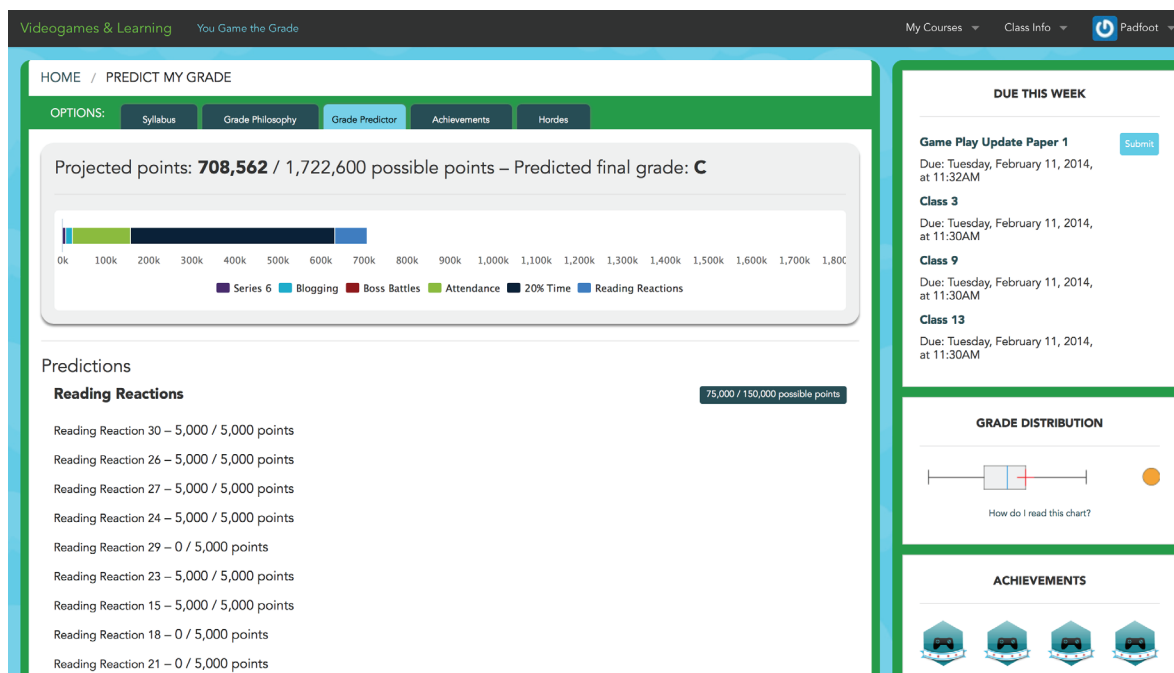


Figure 3: GradeCraft v.3 Design

Recently we have done a comprehensive redesign (Figure 3) using Zurb's Foundation framework. This has had a positive effect on the codebase itself, on our mobile presentation, and on our ability to build out new features rapidly.

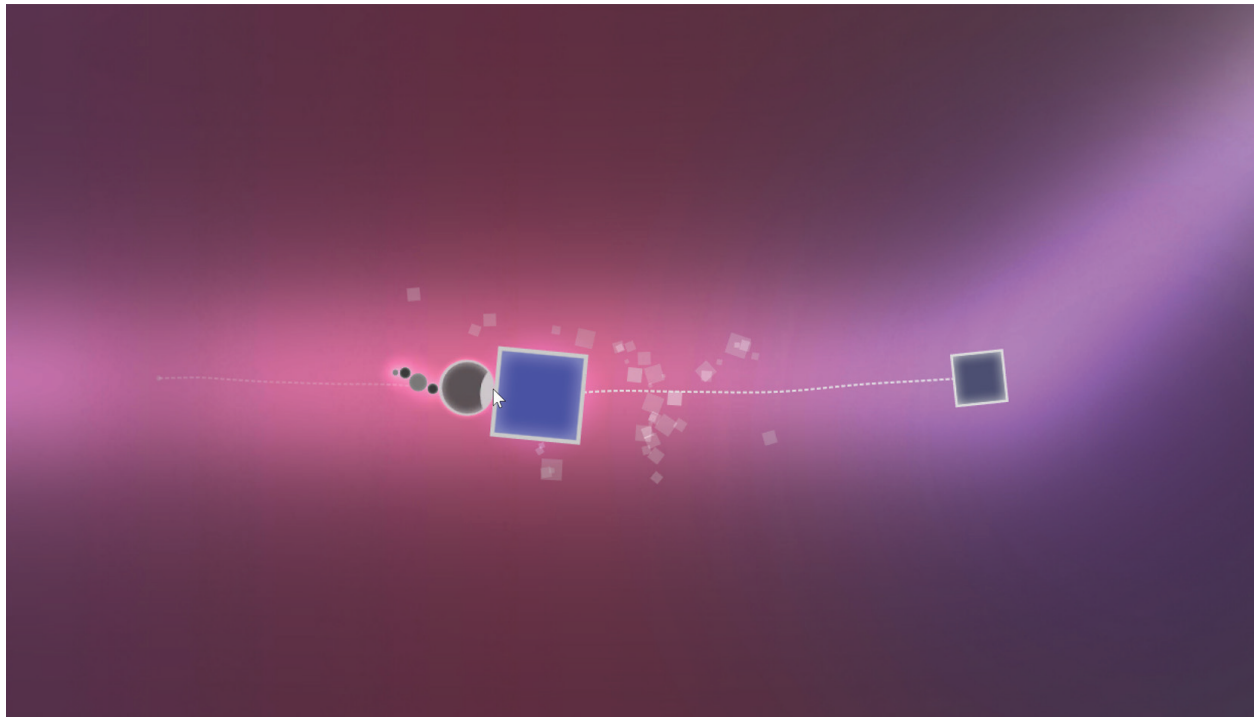
Long term we want to intend to build out several themes that reflect the different game patterns we see, and allow instructor to choose which best represents the experience they want their students to have. We also want to explore allowing students to select between certain visual design elements themselves, to explore how that agency impacts their course experience.

How will you make sure that this thing you're creating will be adopted by your audience?

Our approach is that if we focus on building a beautiful, engaging tool, that includes the features that teachers who want to run a gameful course need, adoption will take care of itself. To make sure that we are doing that, we continue to have in-depth conversations and brainstorming sessions regarding the future with our course partners, so that we can be sure that we are actually building the features that are needed. We are also putting together a process through which we will run regular focus groups, as well as one-on-one user testing, to ensure that the system is as simple and usable as possible.

The Creative Design of Physical Rehabilitation Games

Niels Quinten, University of Hasselt
Steven Malliet, University of Antwerp
Karin Coninx, University of Hasselt



Example URL: <http://www.workingexamples.org/example/show/638>

This working example describes a research project on digital games which assist stroke survivors in learning once more the physical abilities they lost during a stroke (e.g. drinking from a glass). Specifically, we aim to create a more engaging learning experience adapted to the needs and disabilities of stroke patients. Our focus lies on the creative design of these games.

Seed

Tell us about your idea or project. What's your vision?

In the current project the learning needs of stroke survivors are used as inspiration for designing new forms of gameplay in physical rehabilitation games. Learning procedures (e.g. goals, exercises or trajectories) and learner disabilities (e.g. bad sight or reduced dexterity) define the borders within which the instructional game designer operates, and can therefore be considered as creative design elements. As such we believe that the characteristics of the learning process should influence the look and feel of rehabilitation games. We explore new ideas, techniques, and methods for creating rehabilitation games, inspired by learning procedures and learner disabilities.

What problem are you trying to solve and why does it matter?

The project revolves around stroke rehabilitation, whereby patients are required to relearn daily, physical activities such as drinking from a glass or driving a car. After having suffered a stroke many people become disabled and lose their independent lifestyle. The fact that they consequently have to rely on caretakers severely impacts their quality of life (Choi-Kwon et al., 2006). However, they can regain a full or partially independent lifestyle by relearning these activities through stroke rehabilitation (Langhorne, Coupar, & Pollock, 2009).

The specific problem we intend to address is the gap in creative design knowledge on developing games that incorporate rehabilitation therapy. Digital games have been put forward as valuable additions to existing rehabilitation programs that can increase the motivation of patients (Garcia Marin, Navarro, & Lawrence, 2011). However, little design knowledge is available on how to create such games because most research has thus far addressed other issues such as technology and effectiveness (Quinten & Malliet, 2011). Consequently, we want to explore the creative design possibilities and limitations of digital games and rehabilitation, in order to create a more engaging learning experience for stroke patients.

What are your goals and how will you know if you've achieved them?

There are two overall goals in the current project:

- 1 We want to expand the practical vocabulary of the rehabilitation game designer, enabling her to combine game design and rehabilitation issues more effectively and create a more engaging learning experience for stroke patients.
- 2 We want to highlight the role of creative design in the development of rehabilitation games.

We will know if we have achieved these goals if:

- 1 We have created design guidelines, best practices or practical examples which adequately assist the game designer in creating rehabilitation games.
- 2 We can provide examples where creative design solutions improve the design quality of rehabilitation games.

Who will your work impact? What do you know about them?

Our target audience consists of people who have suffered from a stroke and need upper-limb rehabilitation. They can have physical, cognitive and/or emotional impairments due to brain damage. Physical impairments include loss of dexterity, muscle weakness, spasticity (Ada & Canning, 2005), and balancing problems (Tyson et al., 2006). Cognitive impairments can include visual difficulties (Rowe et al., 2009), reduced memory and slower processing speed (Zinn, et al., 2007), as well as language and attention problems (Tatemichi et al., 1994). Finally, stroke patients may experience emotional problems such as a lack of confidence and social isolation (Salter et al., 2008).

Because the target audience is defined solely on the basis of their disease, a wide range of demographic characteristics are represented. Stroke can occur at any age but the prevalence increases with age (e.g. 75% aged 65+)(Stroke Association, 2013). Also, both women and men, and people from different ethnicities are affected (Stroke Association, 2013). However, there are several elements that increase the risk of a stroke, including smoking/Tabaco use, physical inactivity, high blood pressure, and diabetes mellitus (The American Heart Association, 2011).

What challenges might pop up?

Several challenges might present themselves in this project. First, the cognitive and physical disabilities of the patients influence their ability to play traditional games (Rand, Kizony & Weiss, 2004). For example, a person with a reduced dexterity of the hand might not be able to operate a traditional computer mouse. Therefore, alternative types of input and output should be addressed. Second, as most of the patients are of older age, their technological literacy might be low. Consequently, our end result should be easy to use and to understand. Finally, the demographic diversity of the target audience makes it difficult to create a themed game experience. For instance, one patient might like golf while another might dislike sports altogether. Certainly, more challenges will arise as the project progresses.

How does this work relate to what others are doing in the field?

Current research on physical rehabilitation games mainly addresses issues of technology and effectiveness (Quinten & Malliet, 2011). We want to complement this by adopting a creative design perspective. As such we hope to create more motivating forms of game play which integrate knowledge of physical rehabilitation and game play. Related examples include the works of Burke et al. (2009), Annema et al. (2010) and Alankus et al. (2010), we believe we can extend this research by exploring more in-depth the creative design aspects and process of rehabilitation games.

How can our community support you? (expertise, resources, etc.)

There are more games which teach traditional cognitive skills than physical skills. We believe that some of the knowledge of cognitive skill based games could also apply to physical skill based games. For example, the way in which to motivate a player to participate in multiple learning sessions might be similar in both types of games. Other Working Example members which explore cognitive learning games are invited to comment on our project. Perhaps, an interesting discussion may arise on the similarities and differences between cognitive and physical learning games.

Sprout

Tell us about your process and how your idea is evolving throughout the project.

Our initial intention was to simply combine stroke rehabilitation and digital game play. However, while designing an early prototype, it became clear that the term 'combine' is too vague: it does not define a clear design approach or a concrete goal. For example, it is not self-evident to combine the time-schedule of a rehabilitation therapy with a game's mechanics, and afterwards validate this as successful or not. Yet, such ambiguity is common in creative design research where problems are usually ill-defined and where there often exists no uniform method to find solutions (Cross, 1982; Buchanan, 1992). As a result, we adjusted our initial research goal in aiming to create an underlying understanding (Dorst & Cross, 2001; Cross, 2004; Stolterman, 2008) of how stroke rehabilitation and game play relate to one another.

Overall, our research process (based on the principles of research-through-design [Frayling, 1993]) is not evolving in a linear fashion from point A to point B, but is rather iteratively going forward and backward again (Kruger & Cross, 2006). We cyclically discover the requirements, opportunities and limitations (Ho, 2001) of rehabilitation and games and apply these in the creative process. For example, in a first stage we developed a prototype that did not meet the requirement of engaging game play. Although the main concept was abandoned during later iterations, nevertheless we extracted valuable knowledge from the design, which was used as inspiration later on. This allowed us to practically explore the design of rehabilitation games from the start without being restricted to earlier concepts. In the development of a second prototype we gradually destroyed the player experience by leaving out and transforming game elements. Although this left us with a highly minimalistic player experience, this proved valuable because it enabled us to discern unimportant game elements. This was useful as not all patients can adequately process a game containing many game elements. In conclusion, this project can be described as messy on a short term basis, but steadily progressive a the long term.

What interesting patterns or insights have you discovered?

An interesting insight we have gained is that the use of general game conventions is not essential to the development of rehabilitation games. We can create custom conventions that are more strongly attuned to the needs of the rehabilitation therapy. Popular contemporary games such as Call of Duty: Modern Warfare 2 (Infinity Ward, 2009) or BioShock Infinite (Irrational Games, 2013) have helped establish the impression that a good game needs to be big, visually realistic, have a traditional game narrative, etc. The current project aligns to the indie game movement (cf. Independent Games Festival and the Independent Games Summit) which attempts to break established conventions. Many indie game designers create their own conventions through experimentation. By taking inspiration from this approach, we too experimented with the conventions of games and were flexible in integrating physical learning demands into the design of our game. For instance, by creating an abstract game world we could easily modify the direction and paths of a physical exercise, because there exists no up or down, left or right in the abstract world. Of course, creating new conventions is hard work and has no guaranteed results. However, as the field of rehabilitation games is relatively new, experimentation may provide appropriate alternatives to pure entertainment game conventions.

What are some of your initial concepts or designs? We'd love to see them.

A short clip of the current game play can be found on the following link (<http://www.nickgeboers.com/AbstractGameplayTrailerShort.mp4>) (the quality isn't great, but right-click and "save as" will give the best quality). The game is played with a HapticMaster input device as is seen in the picture below. This device lets the player move the screen cursor by moving her arm in three dimensions (x, y, z) within a range of approximately 40cm (1.3ft). The dashed lines in the game world

indicate the movement path the player has to follow in real life. By adjusting the sensitivity of the input device, the real life movements can be made smaller or bigger while the game world stays the same. As such, the patient is encouraged to perform physical movements, which is the basis of the rehabilitation therapy.

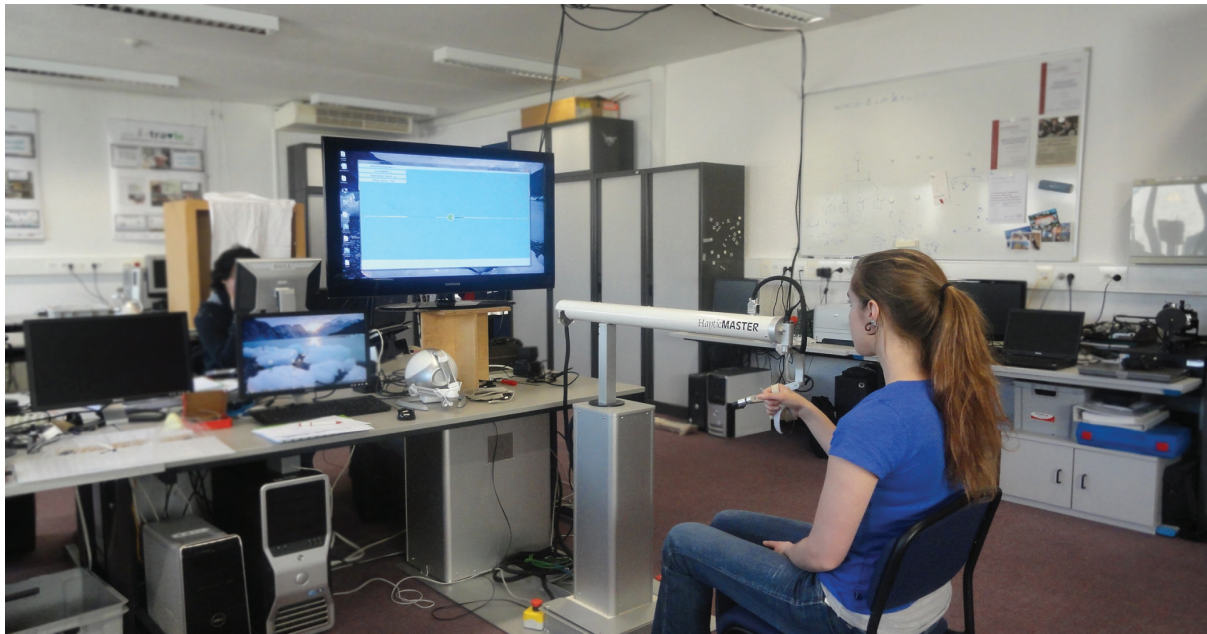


Figure 1: An example of how a player operates the game with the HapticMaster input device.
(<http://www.workingexamples.org/uploads/Image/712>)

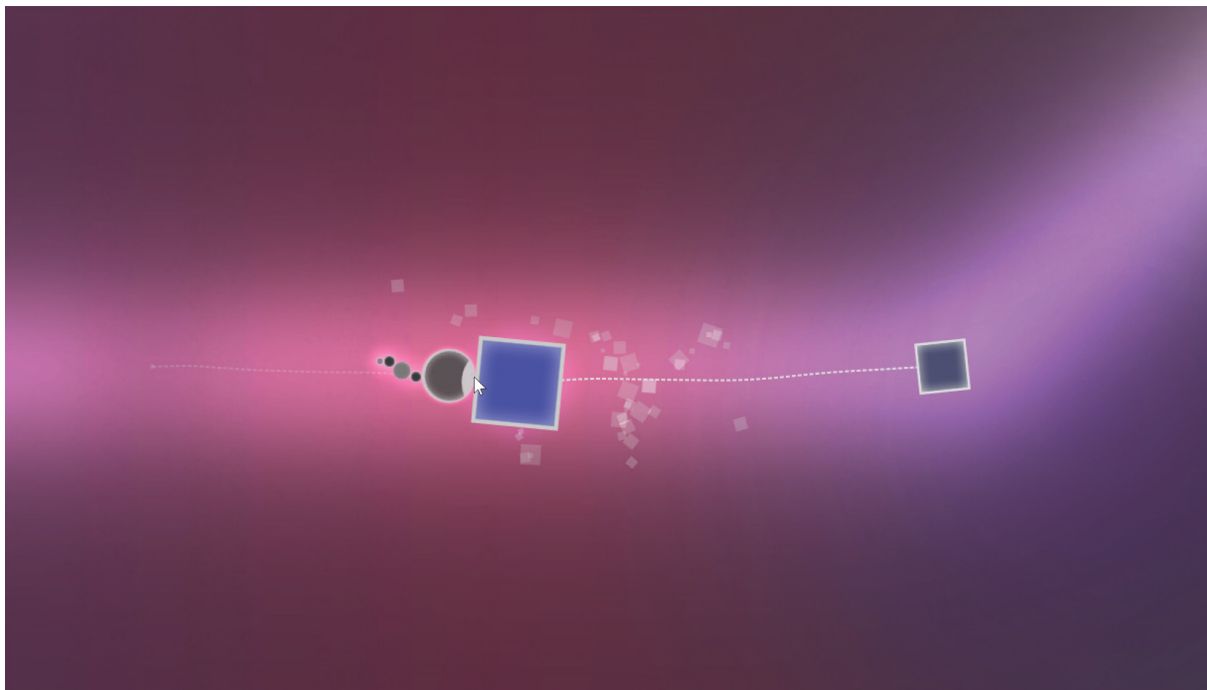


Figure 2: A screenshot of the current game play.
(<http://www.workingexamples.org/uploads/Image/594>)

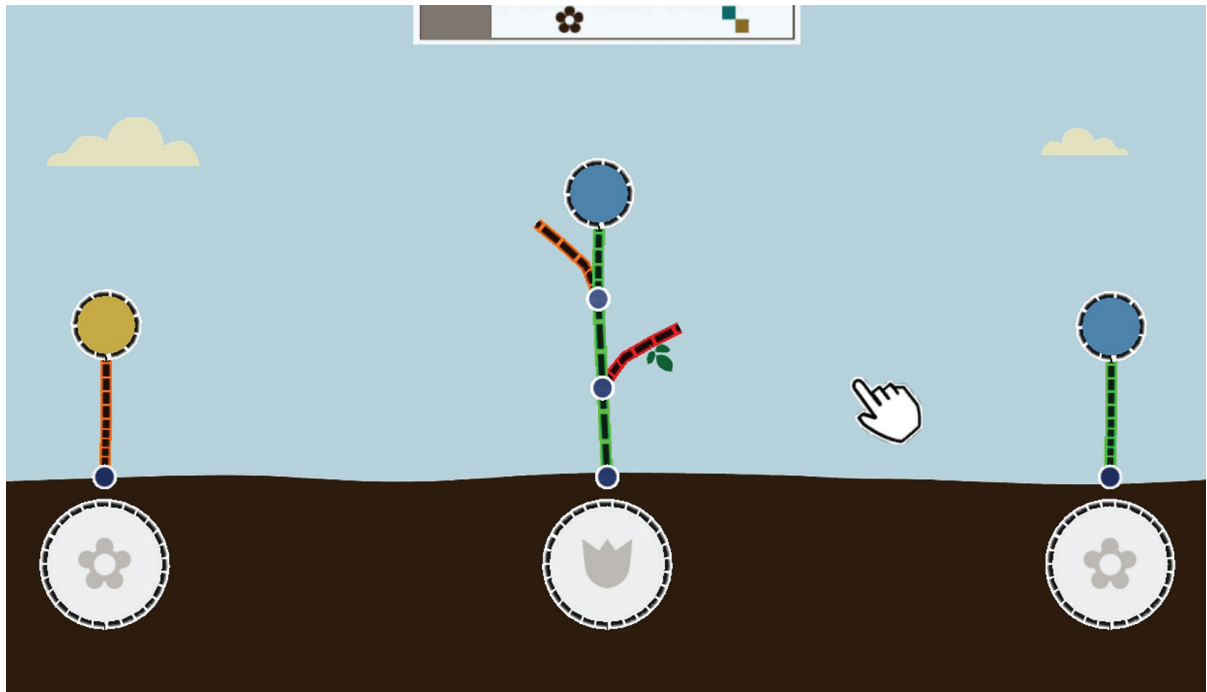


Figure 3: A screenshot of the first prototype.
(<http://www.workingexamples.org/uploads/Image/595>)

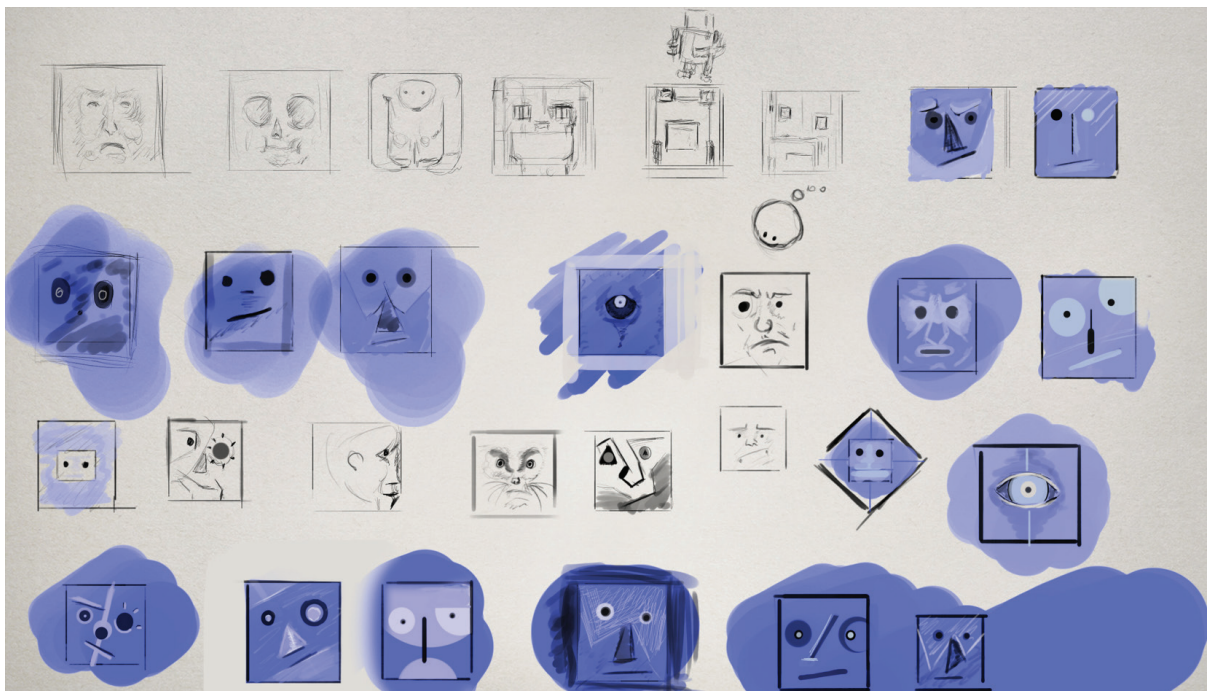


Figure 4: A series of character design experiments combining abstraction and figuration.
(<http://www.workingexamples.org/uploads/Image/596>)

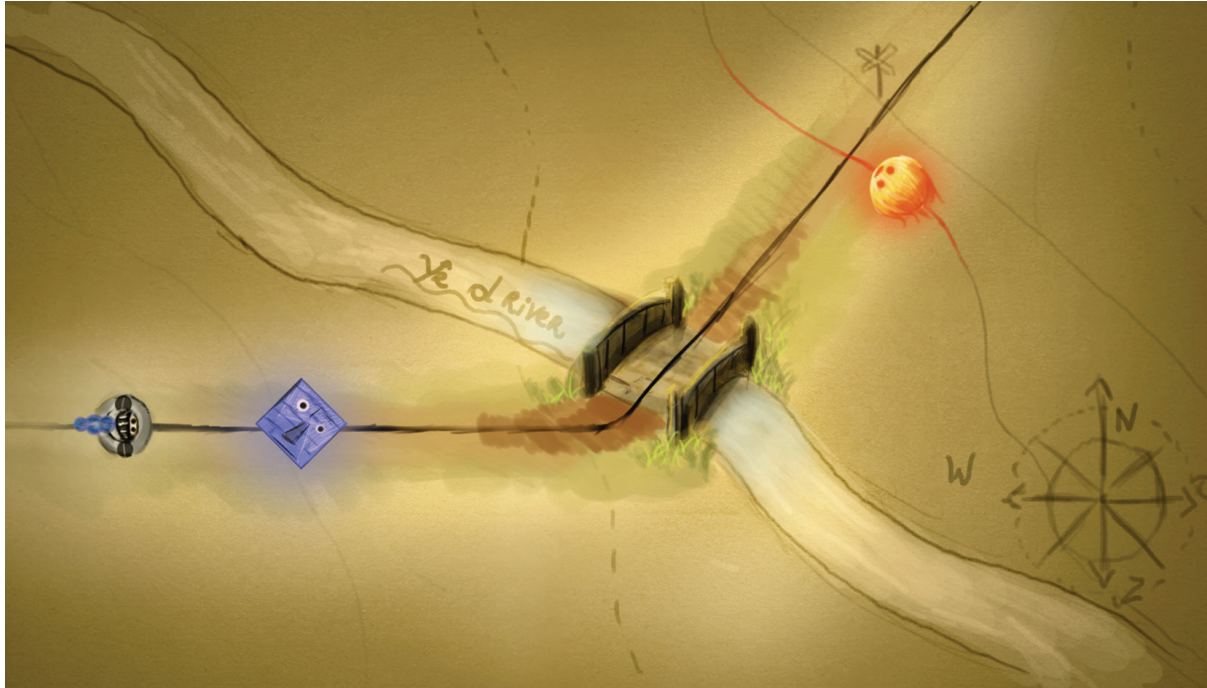


Figure 5: A visualization of the transformation between figuration and abstraction in the game's narrative.
 (<http://www.workingexamples.org/uploads/Image/597>)

How will you make sure that this thing you're creating will be adopted by your audience?

At two points during the development phase, rehabilitation therapists played the game and, afterwards, indicated where improvements could be made to facilitate a better rehabilitation for the patients. Furthermore, we have performed playtests with eight patients in a local rehabilitation center. In these tests, we included issues on how they handled the game both on a cognitive level (can they understand the concept) as well as on a physical level (can they operate the game). Furthermore, questionnaires on the level of interest of the patients were also included. When the results are analyzed, we hope to learn how the game can be better adjusted to the needs of the target audience.

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For the Records – Learning About Mental Illness

Doris Rusch, Depaul University
Anuradha Rana, Depaul University



Example URL: <http://www.workingexamples.org/example/show/637>

For the Records is an interactive documentary about mental health, particularly OCD, ADD, eating and bipolar disorder. Including short films, interviews, photo essays and games, it aims to increase understanding of these disorders. People with lived experience of the represented mental health issues have been actively involved in the conceptualization and design of the project. For the records is an interdisciplinary effort bringing together DePaul's cinema and game development program as well as the School of Nursing. An intended application area of this project is mental health education.

Seed

The Vision

"For the Records" is an interactive documentary on four young adults who live with mental health issues such as Attention Deficit Disorder (ADD), Bi-polar Disorder, Eating Disorder (Anorexia Nervosa) and Obsessive Compulsive Disorder (OCD). It includes interviews, short films, photo-essays, and experiential games, embedded in a website that affords ludic exploration. The various media components create a coherent whole, provide context to each other and illuminate complementary aspects of what it is like to live with mental health issues.

"For the Record" leverages the potential of an interactive format and playful engagement to create phenomenological authentic possibility spaces that shift the mode of reception from mere "witnessing" to "embodied experience." To ensure experiential accuracy, our four subjects have been strongly involved in the creative and production process, took leading roles on the game development teams, and participated in the films.

We consider "For The Records" as a prototype for a much larger project that covers a wider range of mental health issues, builds community and is used widely in various contexts, including Universities, Counseling Centers and Youth Centers. The games we have created for this project are already being used in the classroom as instructional tools for nursing and medical students. We want to explore more application areas of this project for medical education and health communication. To better understand how we need to design for different purposes and audiences, we have a user study with 110 participants set up and ready to go that investigates design principles of games for mental health, their impact on players and potential therapeutic value.

The Problem We Are Trying To Solve And Why It Matters

“For the Records” addresses inadequate understanding of mental illness as one of its main issues. “Understanding” in this sense relates to comprehending the fullness of experience, not merely the cognitive understanding of symptoms or physio-psychological mechanisms. Lack of experiential understanding may contribute to stigma and often burdens relationships between people with mental health issues and their social environment. This can complicate the already difficult task of constructively dealing with such disorders, leading to feelings of helplessness, frustration and anger on the side of friends, family and providers of people struggling with mental illness, and fueling the experience of stigmatization, isolation and disconnectedness on the side of the afflicted.

“For the Records” hopes to provide a space for “shared experiences” in order to increase understanding, promote support and constructive relationships, and alleviate stigma.

Sprout

Our Process And How The Idea Evolved Throughout The Project

For the Records is a project conceived by game designer Doris C. Rusch and documentary filmmaker Anuradha Rana. The goal is to create an interactive, transmedia documentary that provides an inside view into the lived experience of Obsessive Compulsive Disorder (OCD), Attention Deficit Disorder (ADD), Eating Disorder (particularly anorexia nervosa) and Bipolar Disorder. We decided to use different media (film, interviews, photo essays, soundscapes, written stories and interactive experiences / games – all embedded in one website and grouped into topic areas) to provide different entry points for different audiences and to leverage the strengths of each medium to get at another aspect of the lived experience.

We did not arrive at this approach directly. We initially focused on creating a support platform that could aid in community building. During this research process, we realized that one of the major obstacles in creating a supportive community and providing the resources that could help those facing mental health issues was a lack of empathy and understanding from those who weren't. This also contributed to the stigma surrounding people with mental health disorders and is a potential cause of the friction between the afflicted, their friends and family, society at large and even sometimes health care providers. This led us to question how we could use the specific characteristics of different media, particularly the benefits of games and the embodied experiences they provide, to give people with mental health problems a voice? How could we create something that captured what it feels like?

It soon became clear that we had to work closely with people who had lived experience and involve them actively into the conceptualization and design process of all media pieces. Anything else would have been disempowering and overreaching. We started with contacting NAMI, who generously allowed us to conduct interviews during their annual NAMI Walk last Fall, and drawing on our personal network. We were able to get five individuals with lived experience of mental health concerns involved who lived in Chicago and were able to interact with the productions on an ongoing basis. The fact that these individuals could serve as our subject matter experts is one of the reasons that we chose to focus on OCD, ADD, bipolar and eating disorder, besides the pervasiveness of these issues in a university setting.

To create the various media, we split into a game development and a film group. The games group was further divided into four teams, each with 3-8 students and DePaul alumni. The film group similarly formed four teams, each responsible for the production of one film and overlapping to conduct interviews with people interested in sharing their experiences, recording first-person narratives, filming ‘vox-pops’ (street interviews) and capturing visual moments that could illustrate a feeling expressed in a conversation.

The idea was that each topic area (ADD, OCD etc.) should be centered around one person's lived experience and include an interview, a short film or photo essay and a game sequence. Salient aspects of the individual's lived experiences should become motifs that remained consistent across media. Each piece should be connected to the others of one topic area, providing context and complementary perspectives. For OCD, the main motif was compulsive ritual performance. Our ADD pieces focus on the issue of self-worth and doubt that accompany the necessity for medication to focus. Eating Disorder centers on the body as the target of perfection, but also the source of healing (through dance!). Our approach to bipolar disorder concentrates on feelings of alienation from self and others in both manic and depressive state.

Interesting Patterns And Insights We Discovered Along The Way

Metaphorical Game Design and Game Comprehension

There is a strong, metaphorical component to all the media pieces we created to capture the experience of mental health issues. We are trying to make inner processes visible and tangible and since inner processes are abstract (i.e. they cannot be directly observed or delineated from a physical reality), metaphors are a great way to make them concrete. We follow Johnson and Lakoff's definition of metaphor: "The essence of metaphor is understanding and experiencing one kind of thing in terms of another." (1988, p. 5). While metaphors are powerful tools to communicate otherwise incommunicable concepts, they are not always easily understood. They might be the only way to represent what is going on "inside", but that does not mean that they do not require further explanation. One of our biggest challenges was and still is to find the right balance between staying true to the metaphors that arose from our conversations with people with lived experience and presenting these metaphors in a form that others can grasp them. There is evocative power in a subjective and artistic piece, but there is also the risk of it not being understood. We added quotes from our subject matter experts to clarify the motifs and meaning in the various media pieces. Perfection, the game on eating disorder, even includes a "what it means" page which spells out the metaphorical meaning of all its elements and facilitates interpretation of everyone's individual playthrough and interactions with these elements.

Abstraction and Patterns in Film Structures

Memory plays a big role in the structure of each film. The idea that our memories integrate so much more than actual events, coloring them with our emotions, subsequent experiences, and interpretations, allows for the films to be tools for reflection. The films use quotes excerpted from exhaustive interviews conducted with each of our experts. Depending on the style of the piece, these quotes appear as text, as a voiceover narration, or as a combination of both. In *Re-embodiment* (Eating Disorder), we made a conscious attempt to use snippets of conversations and/or brief snatches from interviews as opposed to complete thoughts or opinions. This structure lent itself to the idea of memory and thought, how that leads to acceptance and growth depicted through the pensiveness of the dance sequence. In *Ritual* (OCD), we chose to focus on one ritual, combining live action with animation, to linearly narrate one specific memory about trying to stay 'clean'. The abstraction came in the form of creating a silhouette of the character, removing their face, and adding animated 'germs' in order to take the experience from the personal to the relatable. Similarly *The Lost Month* (ADD) uses animation to depict the work that starts to follow our character and the pills he refuses to take, consequently shutting himself off from the world for an entire month.

Patterns in Experiential Structures

In terms of game design, one of the most interesting insights from this (and previous mental health game) projects is that there seem to be distinct experiential structures associated with different kinds of mental health issues. ADD, Depression and bipolar disorder lend themselves to be modeled as "states". The game captures snapshots of the experiences. The game may model more than one state and there can be a pattern to the state changes (e.g. from manic to depressive to neutral and back to manic etc.), but this pattern is "hard coded" (states are timed and change when the timer is up) rather not modeled systemically. The experiences of OCD, eating disorder and addiction, however, seem to share a more systemic structure. To break out of the (broken) system, these games require a perspective change, a reinterpretation of behavior and the re-learning of behavior / adoption of new behaviors. Their shared experiential gestalt is one of addiction / compulsion.

The games that model states more directly impose a designer's perspective on the player, whereas the games modeling systems leave players more freedom in regard to how they want to play the game. E.g. FLUCTuation, the game on bipolar, evokes two distinct experiences in manic and depressive state and the game determines how long the player remains in each phase. Perfection, however, can be played in different ways. There is more room for exploration. Players never have to succumb to the eating disorder modeled in the game. If they take good care of their garden despite the game's prompts and suggestions, they can reach "Imperfection", the game's true win state. A player study we are about to conduct on all four games with patients, their friends and family and therapists intends to shed light on how different experiential structures impact the games' communicative potential and ability to effectively make a point.

Audience

Noteworthy are also the various responses to the media pieces from different audiences. The games, particularly, tend to polarize. Therapists (or those in training) seem to struggle to accept the lived experiences modeled in the games. In our informal playtests we observed frustration in this audience due to the fact that some games can-

not be won (how do you “win” depression or bipolar disorder?). Friends and family members as well as patients themselves showed more positive responses. To gain a better understanding of the games’ impact on different audiences we are going to conduct a user study with therapists, patients and friends and family members.

The short documentary webisodes, interviews and photo essays provide context for one another and also allow a ‘way in’ to the interactive game sequences for those who struggle with the idea of games vis-à-vis ‘mental health’. Beyond that, these particular pieces of media allow the audience to sit back for a moment and observe. They allow a passive interaction as opposed to the more active engagement immediately required by the game sequences. Viewers can navigate through the various media at their own pace, based on their own growing interest (or lack of it!) Links to resources and first person accounts fill in informational gaps. The website hosting all the media will also utilize excerpts from the interviews as transitional pieces, to create an emotional resonance to the overall piece, to capture moments that can unravel an individual experience and by sharing them, unlock the experience for others to empathize with.

Therapeutic potential

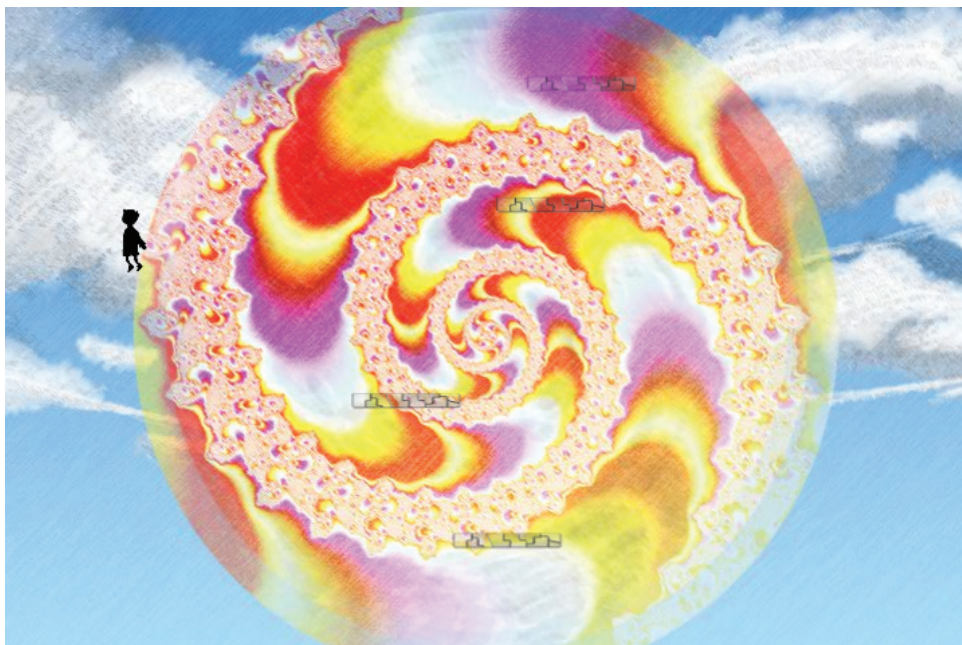
A particularly striking insight was the potential therapeutic value of being actively involved in the media creation process. The game as well as the film teams did not just draw on external subject matter experts to inform concepts and designs, but people with lived experience were also members of the film and development teams (some in leading creative positions). They reported that being able to express themselves with the goal of making their experiences more accessible to others had an empowering effect. This seems worthy of further exploration and would fit well with existing trends in expressive arts therapy.

Some Of Our Initial Concepts And Designs:

Games

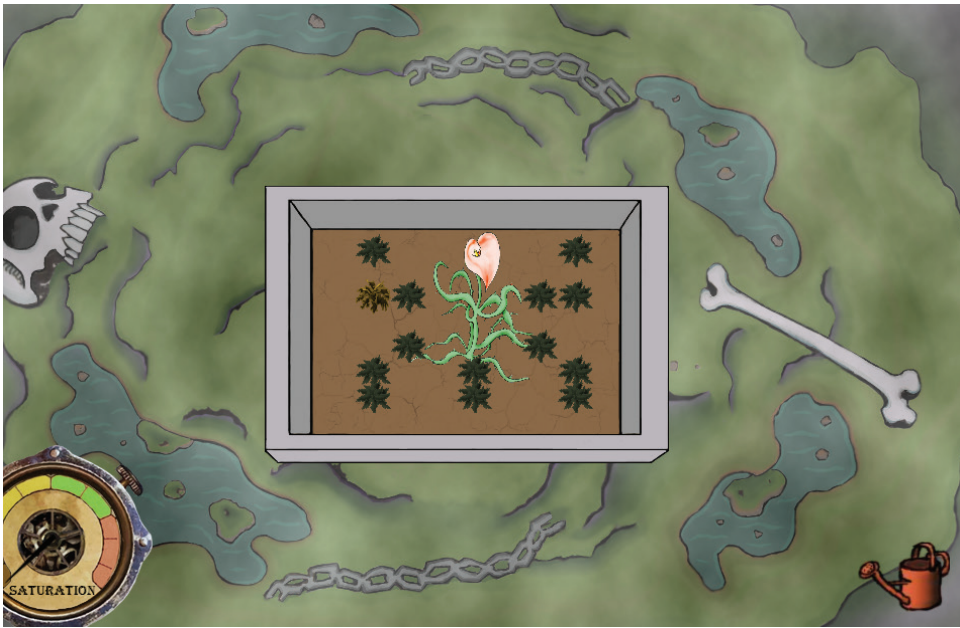
Fluctuation (BiPolar Disorder)

<http://fortherecords.org/fluctuation.html>



(<http://www.workingexamples.org/uploads/Image/583>)

Perfection (Eating Disorder)
<http://fortherecords.org/perfection.html>



(<http://www.workingexamples.org/uploads/Image/584>)

Into Darkness (OCD)
http://fortherecords.org/into_darkness.html



(<http://www.workingexamples.org/uploads/Image/585>)

The Lost Month (ADD)

(<http://www.workingexamples.org/uploads/Image/582>)



(<http://www.workingexamples.org/uploads/Image/587>)

Reembody (Eating Disorders)



(<http://www.workingexamples.org/uploads/Image/588>)

Reembody from Isthmus Films (<http://vimeo.com/isthmusfilms>) on Vimeo (<https://vimeo.com>).

Homeless (BiPolar Disorder)



(<http://www.workingexamples.org/uploads/Image/590>)

Depression from Isthmus Films (<http://vimeo.com/isthmusfilms>) on Vimeo (<https://vimeo.com>).

INTERVIEWS

Nami Excerpt 1 from Isthmus Films (<http://vimeo.com/isthmusfilms>) on Vimeo (<https://vimeo.com>).

Nami Walks Excerpt 2 from Isthmus Films (<http://vimeo.com/isthmusfilms>) on Vimeo (<https://vimeo.com>)

Iterations On Initial Concepts and Designs

Game design is by nature iterative and so all designs changed over time.

Perfection (game about eating disorder) had completely different imagery and metaphors in the beginning. The underlying structure remained quite consistent throughout the design process, but it took us a while to arrive at the garden metaphor. In the beginning, the game was set in a sterile science lab and as the guardian of the lab you had to prevent contamination. This metaphor was not rich enough to sustain all the necessary elements. The garden as multi-dimensional gestalt (with its weeds and worms, the need to be watered and the flower as object of idealization etc.) had more in common with the body and body image to allow for a more coherent design. Towards the end of the project we redid almost all art assets to emphasize the changes in the garden and make it clear that there is an alternative ending to the Perfection ending.

FLUCtuation (game about bipolar disorder) underwent several iterations to get the game “feel” right. The jumping mechanic in manic phase had to spiral out of control rather than be uncontrollable from the start. Manic phase had to start as an exuberant and joyful experience. Depressive phase was fine tuned to convey the emptiness and isolation of depression. We also had to redesign the “depth meter” several times in depression phase, but it is still such an idiosyncratic element that player’s do not understand its meaning without explanation. The “depth meter” shows the player’s progress towards the surface (at least initially). It soon becomes unreliable. Its purpose was to communicate the desire to know how long the depression phase will last, and the impossibility of predicting it.

It’s for the Best (game about ADD) focused strongly on getting the core mechanic right: the pacing of the assignments that flutter onto the screen and the effect of pressing the pill. Playtests revealed that there had to be a stronger sense of negative consequence when you didn’t take the pill. We thus let unfinished assignments clutter up the screen and grow into heaps in the background, to evoke the experience of being progressively overwhelmed. To avoid confusion about the game’s message (it is not against medication, but about what it feels like if you are

told by your parents that you have to take it), a video epilogue was created in which the designer explains the game's personal background. "It's for the Best" is probably the most straightforward of the four games, which can be attributed to the fact that the game already existed as an analogue prototype (produced in a game design class) long before development of the digital version was even in planning.

The process of creating each film roughly ran the same broad course. During our initial research, we sent out emails to mailing lists and people who could help recruit subjects with lived experience. We reached out to organizations like NAMI (National Alliance for Mental Illness), Chicago Hearing Voices, Websites such as 'CaptainAwkward', Dean of Students, the Counseling Center, and the School of Nursing at DePaul University, to spread the word about the transmedia project, and talked to everyone we could think of, including faculty at other universities in and beyond Chicago.

We conducted video, audio, Skype, and written interviews with people in Chicago and across the US during late Fall, 2013. Word of mouth helped a lot as well, as after the initial push of announcing the project, people reached out to us and spoke of their experiences. All of these interviews helped propel the documentary shorts in a general narrative direction and helped us then narrow our focus to specific incidents from peoples' lives for each piece. This was different from the original outlook for the project, but ultimately felt more 'true' to the stories we were about to tell.

For instance, we had initially planned to focus more heavily on 'groupthink'. We wanted to conduct numerous interviews and find the patterns that flowed through each of them, find a narrative that emerged organically and use that as the core for the films. We hoped to create short pieces that represented the thoughts and feelings of more than one person. This changed quite drastically to focusing on individuals, allowing their experience to form the core of each piece and use the individual films as one little piece of a larger puzzle. So while the format changed, the intention remained the same. Production for each of the first three pieces was completed in 2013, with the fourth piece currently in production. Post-production on all pieces will be completed by the end of July 2014.

Ritual (OCD): Ritual explores the idea of cleansing or healing rituals that permeate the life of an individual experiencing OCD. It follows a faceless character as they enter their home, only to see themselves as germ-ridden interlopers in a pure space. Over the course of the three minute film which features live action and animation, the character leaves behind germs, like Ritual, on everything they touch until they take a shower, their ritual, and are cleansed physically. However, all it takes is a phonecall from the outside world to start the cycle again, unless our character can overcome the need for the ritual.

The Lost Month (ADD): Through a first person narrative, *The Lost Month* uses live action and animated transitions to explore the emotional state of being with, and without, medication. "You learn how to learn," stresses our main character, but with a diagnosis of ADD, one takes a pill to learn. The film addresses the loss of self and identity that comes after being on medication for the majority of one's life.

Re-embody (Eating Disorder): Using dance as a metaphor, Re-embody explores the progression of healing as a body discovers that it holds the unconscious secrets to rebirth, housed in physical memories that surface when the mind can be stilled. The experiential game, Perfection, and quotes from the content expert's interview, provide context to this short film, and help us empathize with the challenges faced by an individual with an eating disorder as they seek to overcome it.

Homeless (BiPolar Disorder): is a photo essay that explores depression, a manifestation of BiPolar Disorder. Audio narration of person living with depression is juxtaposed with black and white photos of people on the street with their backs turned towards the camera. "My father believed that anybody seeking therapy was inherently weak." The piece addresses the stigma that is attached to mental illness and the lack of understanding that surrounds it.

How We Aim To Reach Our Audience And Promote Adoption Of "For The Records"

So far, we have been focusing on the DePaul University community as our testbed. We have the support of Counseling Services and Dean of Students office. We are about to negotiate the use of the interactive documentary as part of freshmen orientation and similar events.

A very exciting development is that DePaul's School of Nursing is very interested in "For the Records". There are already four faculty members who are using it in the classroom, to start discussion with nursing students about mental illness. The value of our approach to educators is that other than a textbook, the different media pieces are subjective expressions of what living with a mental illness is like. The games particularly enable a deep, experiential understanding, which is often lacking in mental health education.

We regard the current interactive documentary as a prototype. Our goal is to test its use and impact in the DePaul community and beyond while acquiring funding to do it all over again, covering a broader range of mental health issues and identifying a strategy for broader dissemination. We are further in the process of conducting a bigger user study right (Summer and Fall 2014) now at DePaul University focusing on mental health care providers and patients. The goal is to investigate potential application areas of the project in therapy settings as well as the project's resonance and usefulness as a communication tool for people with lived experience.

Scaling The Project For Impact

When we first started talking about "For the Records", we saw it as the beginning of a movement. Our goal is to cover a broader range of "unusual" human experiences (not just the four topics we are covering right now!), give more people a voice to express themselves and get more institutions and universities involved in the production and dissemination of content. We hope to broadly increase understanding of mental health concerns, foster dialogue and alleviate stigma and to build community in the process by adding a way for people to post their own stories, videos, games, comics, sound pieces.

Note: This work was submitted as a Working Example paper, so we are publishing it as such, although the conference presentation was a Well Played session.

Workshops

Building a Better Donkey: A Game-Based Layered Learning Approach to Veterinary Medical Education

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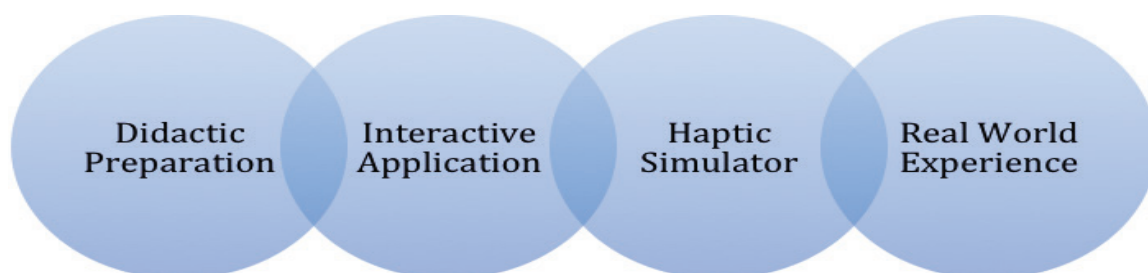
Building A Better Donkey

Teaching veterinary students the practice of anesthesia is fraught with many of the same concerns associated with teaching medical students, certified registered nurse anesthetists, and anesthesia residents. In fact, some would argue that teaching general anesthesia skills to veterinary students is even more daunting than introducing such skills to clinicians that will eventually take care of human patients, because the veterinarian is expected to enter practice with a much broader breadth of skills and often works in solo practice settings.

Theory

This project advanced along two parallel tracks, which included the development of a manikin-based donkey simulator, SimDonkey and a game-based mobile application, iDonkey.

In this way a layered learning approach is used to reinforce didactic components of the curriculum, while simultaneously providing authentic situated learning opportunities to move students towards eventual clinical practice and competency. The layered learning model, Figure 1, illustrates how a multi-medium approach scaffolds educational activities while preparing clinicians for real world experiences.



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Figure 1: Layered Learning Model

The layered learning model recognizes the importance and relevance of traditional facets of education. Students must take time to prepare themselves for more interactive components of the educational process, whether those processes take place in a classroom, digital environment, laboratory, or in the real world. In the layered learning model students still engage traditional didactic preparation, such as reading assignments. However, this didactic preparation prepares students for and overlaps with interactive situated learning activities that represent and portray clinical practice.

For the purposes of this paper, digital games and simulations represent interactive applications found within the layered learning model. Students continue to develop content and process knowledge through game-play, which in turn prepares them for supervised learning opportunities with physical simulators existing in created spaces (Bauman, 2007; Bauman 2010). Created spaces represent and replicate various aspects of actual clinical set-

tings. Student experiences with physical or haptic simulators in created spaces unfold as designed experiences (Squire, 2006). Designed experiences taking place in environments that produce sufficient fidelity to allow for the suspension of disbelief encourage learning to take place as performance (Bauman, 2007; Bauman 2010; Bauman, 2012; Bauman and Ralston-Berk, 2014). Learning that leverages digital interaction and interaction taking place with haptic simulators prepares students for supervised clinical education in actual clinical environments where students interact with real patients.

Mobile digital application: iDonkey

The mobile digital application developed for this project, iDonkey was developed in partnership with the Institute for Research and Clinical Strategy, Ross University School of Veterinary Medicine, and the Learning Games Network. The iDonkey mobile application introduces veterinary students to the process of large animal anesthesia. The application objectives were derived from and map back to the existing curriculum. The iDonkey application was designed to meet challenges and gaps found within the existing curriculum. iDonkey strives to prepare students for actual high stakes live animal laboratory experiences related to the safe delivery of anesthesia in the preoperative or surgical environment.

Introducing games into the curriculum must be seen as value added in terms of return on investment. The iDonkey application is intended to provide an orientation to and preparation for a live animal laboratory experience. Live animal laboratory experiences are expensive to facilitate. Further, they pose inherent risk to laboratory animals and students who are unaccustomed to working with large animals. By providing an interactive simulation or game to orient students to the live animal laboratory solves several challenges and gaps in clinical veterinary education. Students arrive to live animal clinical laboratories with more experience on which to draw from. Further, the game experience allows for an interactive orientation to the laboratory in terms of animal and clinician safety, as well as a lesson plan orientation to drive the depth of the learning that is taking place. Games should be seen as integrative rather than additive and provide situated supplemental opportunities that are seen to have intrinsic value for learners (Bauman and Ralston-Berg, 2014; Deterding, Dixon, Khalid, and Lennart, 2011).

Game Design

The current iteration of iDonkey focuses on one particular practice case involving a donkey with a leg laceration that must be sutured. In a fully 3D, photorealistic environment, the game guides students through the entire procedure of checking the animal's health, preparing the animal for surgery, sedating and inducing anesthesia the animal, and finally waking the animal and guiding it back to its feet.

Bringing the physical interactions of working with a large animal to a virtual environment involved replicating many of hands-on tests a student would use on a real patient. During the preoperative exam, a student is able to check pulse and capillary refill time, which are both important measures of health and faithfully recreated with appropriate visual feedback. In this case, pressing on the donkey's exposed gums turns that area white and slowly fades back to pink, allowing the player to measure the blood return time to gauge health. Similarly, clicking on accurate pulse points displays a visual indicator of what would be felt in the artery, again allowing the student to measure and record the pulse rate.

As the student progresses to the induction phase, drug knowledge begins to play a major role in the success of the procedure. Students must select the proper sedative and anesthetic agents, and be able to provide correct dosage in order to continue. Here, failure is caught immediately and corrected, indicating that a different medication or dosage should be used. Dosage specifically is corrected with proper proportions, helping the student become more familiar with the medications, and the math behind properly administering the medication.

Once the donkey is anesthetized, a set of randomized scenarios play out simulating either a "normal" case, or one where complications arise. The player is instructed to triage the situation accordingly, testing their knowledge of how a patient's vitals indicate their level of anesthesia. For the duration of the anesthesia, the player has the ability to watch a simulated monitor, check pulse and other indicators of health, and in turn adjust medications appropriately.

This iteration of the game finishes successfully on every play through, though future cases will include more severe consequences for incorrectly dosed medications and improper procedure. These simulations generally mimic real-world scenarios that the student is likely to encounter, and help prepare them for manikin based simulation and real patient interactions.

SimDonkey: The manikin-based simulator

To this end the SimDonkey project seeks to develop a donkey anesthesia simulator appropriate for pre-anesthesia assessment, induction of anesthesia and perioperative care. A donkey was chosen for the simulator medium because the affiliated veterinary school uses donkeys to teach large animal anesthesia. Just as simulation has become an important and viable option for teaching clinicians caring for humans, we believe the ethical concerns for animal patients and students caring for them are relevant in the context of veterinary medicine.

The SimDonkey was created by heavily modifying a second generation Laerdal SimMan and a life sized stuffed donkey toy. The Laerdal SimMan is a human manikin simulator used for clinical education in the human health sciences. In essence the stuffed donkey was stripped down to a steel frame and the SimMan was stripped down to component electronic and pneumatic modules (circuit boards, pneumatic distribution block, speakers, breathing, pulse and airway modules). These components were then mounted on the steel frame, and a plastic case was created to protect them and provide structure for the donkey's chest and abdomen. The heart and lung sound speakers were located in anatomically correct position on the outside of the case and the airway was mounted and extended using simulated bowel. The donkey was then recovered with fur and stuffed.

This initial design process however presented two primary technological challenges for several of the donkeys "physiological" systems.

Cardiac/Electrical

Challenge

To accommodate the retrofit of the electrical and pneumatic components into the donkey model; the vast majority of the physical mounting and electrical housing components were removed. This created two related issues first remounting the components without their intended physical support structures and second, "re-housing" the electrical components to protect them from contact with moisture, dirt, or the stuffing used to fill the donkey model.

Solution

The components of the simulator could be broken down into 2 main categories: central control (the computer main board, pneumatic control and pneumatic distribution block) and peripheral accessories (electronic pulse motors, touch sensors, speakers, EKG/Defib cables). The central components were hung along the upper steel spine of the model donkey using a series of zip ties, and the original mounting hardware. These were then rehoused in an internal plastic case.

The case was custom built using construction silicone to bond the upper edge of two plastic flowerpots together to make a closed "egg". The "egg" was then sectioned into 3 pieces (right side, left side, and upper spine). The upper plastic spine section was mounted onto the upper spine of the steel frame using zip ties. The right and left sides were then mounted to the spine creating an articulating joint at each side. The bottom of the right and left section were then joined together with Velcro and a sheet of vinyl plastic, cut from an industrial shower curtain, to create an expanding collapsible joint between the right and left side. The entire case was then cover in additional vinyl sheeting to prevent the cotton-poly stuffing from contacting the electrical components.

Several holes were cut into the case to allow wires from the peripheral accessories to be connected to the main computer board. The cabling was run through flexible electrical conduit and the conduit was mounted sealed on the inside of the outside of the case to maintain the "stuffing proof" seal.

The electrical conduit was run mounted the steel structure of the model. The corresponding peripheral accessory (pulse point, touch sensor, speaker) was mounted in anatomically appropriate locations with Velcro or zip ties using the steel frame or conduit as a mounting surface.

Respiratory/Pneumatic

Challenge

The standard pneumatic breathing apparatus from the human manikin is designed to operate while the manikin is in a supine position. The pneumatic control system uses a combination of air pressure and gravity to inflate and deflate a plastic air bladder. This causes a chest plate move up and down. While this design is effective to recreate the physical appearance of human respiration it presented several challenges when applied to the equine model. First and for most, the physical motion of human respiration is vastly different from that of equine respiration. The

human chest moves primarily up and down with limited lateral expansion during inspiration. The equine chest however expands almost entirely laterally with extremely limited up and down movement. Secondly, the SimDoney was designed to be operated with the donkey model was standing or lying on its side, additionally to accommodate the shape and size of the equine model the human chest plate was totally removed. This meant we could not use gravity and the chest plate to compress and deflate the bladder.

Solution

The lung bladder and pneumatic tubing supplying it were removed and replaced with a “Y” connector, two new supply lines, and air bladders that had been removed from the human manikin but would not be used in the equine model (the pneumothorax bladders). These were then placed between a series of three plastic electrical boxes fastened together with elastic bands. The two exterior boxes were then mounted transversely to the bottom section of the plastic case, and the center box was mounted to the steel frame.

When the bladders are inflated the exterior electrical boxes are pushed away from the center section, causing the side of the case to move outwards. Once the bladders are fully inflated the pneumatic control stops the air supply and the force of the elastic bands causes the bladders to deflate and the sides of the case move inwards.

Alpha Build Results and Moving Forward:

The completed simulator underwent beta testing by faculty at a veterinary school. Some modifications were recommended and have been included in the ongoing build and design of the Beta simulator.

The first and foremost criticism of the alpha SimDonkey was that it was far too small. The initial donkey build was based on a “life-sized” toy donkey. Ultimately it proved to be several times too small. This resulted in several of the pulse points and physiological features being anatomically incorrect and/or difficult to appropriately assess.

As a result the beta version of the donkey has been scratch built on a custom designed steel frame comprised of ½” and ¼” rigid and flexible gas pipe that has been reinforced with semi rigid PEX plastic piping.

A related but secondary criticism was that the simulated gut and human manikin jaw that were used to create the airway in the initial model were anatomically and functionally inappropriate. To correct this, the skull, jaw and airway of the beta build are based on a molded replica of an equine skull with teeth. However, a replica donkey skull was not available. Custom building a molded replica donkey skull was cost prohibitive and using a real skull presented ethical, health, and safety concerns. As a result a replica zebra skull was used as a proxy model. While there are subtle differences in the skulls of donkeys and zebras the size and functional differences are minimal. The new soft tissues of the airway are currently being designed and will be scratch built using commercially available moldable silicone and medical imaging as a reference.

The design plans from the initial build will otherwise remain identical to the initial build with the exception of scaling for the new size.

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Playtesting Games: Iterating Failures to Success

Mark Chen, Pepperdine University

Ellen Jameson, Filament Games

Marshall Behringer, Filament Games

Numerous designers of games in progress including teams from Cadre 19 of the EDLT program at Pepperdine University

Game Design as Scaffold into Learning through Failure

We often cite games as good for learning because they provide safe environments for players to explore their rule systems through trial and error—I.E. testing certain actions based on incremental mental models of how the games work and further incrementing those models through reflecting on failure. Yet, even though we know learning through failure is often the best way to learn, it can be difficult to think about structuring our learning environments (such as K12 classrooms) to include safe spaces for failure. As it happens, the perfect scaffold from game systems to classroom systems could be a design experience since it is common in design (and engineering) to iterate incremental changes for a final product. Indeed, usually the first prototypes, alpha builds, and drafts of our work start off truly sucking. It's only through collecting, synthesizing, reflecting, and acting on feedback—from trying the mechanics of the system, from peer reviewers, from playtesters—that our work improves. This process of incremental progress through design iterations can mirror the exploration process in games.

Workshop Logistics

This workshop provided hands-on experience with game design's playtesting cycle (cf. Fullerton, 2014). Participant-players playtested tabletop and digital games in progress, providing valuable feedback to participant-designers while also learning and reflecting on the playtesting process (see Figure 1).



Figure 1: Initial stages. Each game had its own table similar to a roundtable session.

To fit in the one-hour format, the workshop consisted of two 30-minute playtesting cycles, each including time for playing (20-25 min) and time for feedback (5-10 min). At the very end, the workshop organizers attempted a full-room debrief, but players were too engaged in their games and wanted to keep going rather than break out of their groups.

Part of the original plan was to allow for games of varying durations within the workshop schedule. We guessed that there would be certain groups that cycled through more than two iterations and groups that would want to eat up the whole session time. While this did happen with a couple of groups, surprisingly, a majority of the gaming experiences did only take half an hour and were able to host two sequential playtest groups.



Figure 2: One of the games (Science, It's Elementary!) in progress with a designer (foreground, left) using the provided handout.

The workshop organizers prepared a 2-page handout for design teams to use as their games were played (see Figure 2). This included space for notes from in-game observation and then sets of in-game and post-game questions, culled from Fullerton (2014, pp. 295). One participant-designer came alone, so we assigned one of the workshop organizers to take notes for her while she led players through her game. Also, one group created an online survey for participants to take after playing. It worked extremely well, and future playtesting workshops will incorporate this officially.

Featured Games

The games that were tested came from multiple sources (see Table 1). Some were tabletop games under development during the Games, Simulations, and Virtual Worlds for Learning course in Pepperdine University's Doctorate in Learning Technologies program. The GLS conference bisected the course term, providing the perfect opportunity for students of the course to test out their in-progress games for learning. Other games included some featured in the Educational Game Arcade and/or other in-development games by the same designers.

The workshop organizers invited teams that were working on issues with learning goals (rather than basic user interface issues) and that could be explored in just a short amount of time. Designers were also encouraged to welcome moments of frustration and failure with their games. Some groups were apprehensive since this was the first time their games were shared with the public, but this feeling quickly dissipated once players and designers got "stuck in" with the work of seeking improvements.

Game name	Author/Affiliation	Genre	Digital?	Time to play	# of players
Cognitive Overlord	Pepperdine	Metacognitive skills	N	30 min, 2 sessions	2 - 4
Knowledge Tree	Pepperdine	Math and logic	N	30 min, 2 sessions	3 - 6
Research Ninja	Pepperdine	Internet research skills	N	30 min, 2 sessions	2 - 6
Perspectives	Pepperdine	Social-Emotional	N	30 min, 2 sessions	4 - 6
Science, It's Elementary!	Pepperdine	Science	N	50 min, 1 session	2 - 5
Go Extinct!	Ariel Marcy, STEAM Galaxy Studios	Science	N	30 min, 2 sessions	3 - 6
MicroRangers	Barry Joseph, AMNH	AR Mobile Game	Y	30 min, 1 sessions	1 or team
Down With Food	Chris Berizko, UCI	Science - digestive system	Y	15 min, ~4 sessions	1
Dreamkindlers	Gabriel Recchia, UM	Social-Emotional Health	N	15 min, ~4 sessions	2
Gaming Manifesto	Barry Joseph, AMNH	Infographic for the future	Y	30 min, 1 sessions	3 - 6
We've Got Issues	Several (O'Donnell), MSU	Card Game	N	15 min	4 - 7

Table 1: The list of games, designers, and game details featured in the workshop.

Conclusion

By the end of the workshop, both participant-players and participant-designers gained experience with the process of rapid playtesting iterations. Other, slower forms of playtesting afford other kinds of feedback, but this rapid format gave us a more manageable chunk/concept/process that we could think about incorporating into our other learning experiences. Plus, it gave invaluable insight for our participant-designers as they sought to improve their games, **and** it was a lot of fun!

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The Metagame: Discuss and Design

Sean Duncan, Learning Sciences Program, Indiana University
Colleen Macklin, Parsons the New School for Design
John Sharp, Parsons the New School for Design

Playing With Culture

The Metagame (Local No. 12, 2013) is a new series of games and associated card deck designed to provoke discussions of culture and play. Designed by Colleen Macklin, John Sharp, and Eric Zimmerman (also known as Local No. 12), the *Metagame* consists of a deck of 250 cards representing cultural artifacts ranging from *Citizen Kane* to the *iPhone* to the *Big Mac* to *Pride and Prejudice*, along with a series of comparison cards that include questions to provoke discussion between players (e.g., “Which better represents America?” or “Which will save the world?”). Originally designed as a massively-multiplayer conference game to provoke discussions of videogame culture and design, the new version of the *Metagame* tackles a much wider palette of human experience. The new *Metagame* cuts a wide swath across culture and fosters discussion as a form of playful interaction.

We see the latest version of the *Metagame* as an avenue for educators to engage with the idea of using discussion and argumentation as central game mechanics, while also providing a game design toolkit that allows anyone to create their own game that engages with art, architecture, music, food, fonts, games, and many other meaningful parts of our everyday lives. We seek to provide players, researchers, and educators with the experience of playing *and* designing using the *Metagame*, exploring new avenues to provoke, discuss, and instruct about culture.

Discussing and Designing

In this workshop, we wish to provide the Games+Learning+Society community an opportunity to explore playing with culture through this new *Metagame*, as well as promoting the goal that anyone can develop their own games toward educational aims, regardless of technological prowess and access to digital gaming hardware. Through experience with multiple forms of play and design with the *Metagame*'s cards, attendees will be encouraged to consider instructional applications of the *Metagame*, to critique forms of instruction and play within the game, and to use design practices with the *Metagame* as a means of kickstarting their own game design skills.

Questions and topics we will address include:

- What impact might the broadening of the game's scope to a wider variety of cultural artifacts have for everyday classroom use?
- How might different academic disciplines approach the use of something like the *Metagame* in a variety of classroom settings?
- How can a teacher best modify the *Metagame* to help students develop gaming literacies and game design competencies?
- How can the *Metagame* best be used as a *game design toolkit*, for exploration by education scholars, practitioners, and researchers?

This interactive workshop will include illustration of play with the *Metagame* and discussions of its use in instructional contexts, but will primarily provide space for educators to determine *their own uses of the game*. Macklin and Sharp, two of the three creators of the *Metagame*, will run the workshop, and Duncan will assist, relating experiences using the *Metagame* in both undergraduate game design instruction and graduate level educational research instructional contexts. For this hour-long session, we propose the following schedule of activities:

Playing the *Metagame* (10 minutes)

We will begin with a brief introduction to the basics of the *Metagame*, its history, and the value of using non-digital games in the classroom. Volunteers drawn from the workshop attendees will play pre-designed game variants using the *Metagame* in order to help them become familiar with the way the game works, as well as to get a sense of its flexibility for teaching and design.

Teaching With the *Metagame* (10 minutes)

The workshop organizers will discuss experiences using the *Metagame* in the classroom, and their pedagogical goals and techniques. We will focus on the ways the *Metagame* might be used differently with different ages, types, and goals of learners, as well as across different disciplines (e.g., art, language arts, history, education, and game design).

Make a New *Metagame* (20 minutes)

Workshop attendees will work in groups organized around educational disciplines to design new *Metagame* variants for use in the classroom, using the new *Metagame* deck of 250 culture cards and comparison cards. Groups can change and refine any aspect of the game: content, number of players, how arguments are presented, how judging occurs, context for play, and so on. To spice things up, optional design constraints (“diversifiers”) will be provided to participants, and additional tabletop game design materials (e.g., dice, index cards, tokens, Sharpies) will be provided in order to encourage new conceptions of *Metagame* play for the presumably many disciplinary contexts represented in the room.

Playtesting a New *Metagame* (10 minutes)

Each group will playtest their *Metagame* variants with other attendees in order to assess their games’ effectiveness and to refine their game designs. Attendees will critique each others’ *Metagame* variants, while also thinking critically about the affordances of and the potential limitations of the *Metagame* itself for the instructional or research challenges they face.

Discussing the New *Metagames* (10 minutes)

We will wrap up the workshop with an open discussion of attendee game designs with the workshop organizers and workshop attendees. What worked well, what didn’t? Why? We will conclude by collecting the new *Metagame* variations designed by attendees with the goal of making new variants available as a resource online for educators and researchers interested in designing further educational *Metagame* variants.

Discussing and Designing

Throughout the course of this workshop, attendees will have the opportunity to engage in a hands-on workshop experience in which their interests and expertise will be brought to bear through the play and design of games for learning. Additionally, the workshop will give attendees the opportunity to provide the game’s designers with direct feedback on how the *Metagame* could further be revised to better apply to specific instructional contexts.

Could the *Metagame* become part of the arsenal of 21st century learning tools as ubiquitous and versatile as a standard deck of playing cards in playful contexts and as essential as a textbook in learning environments? It would certainly be surprising if it did, with its quaint 18th century form as a simple deck of cards. However, a flexible and easily modifiable platform that asks us to reflect on the meaning and significance of our cultural world with one another seems to have special relevance in today’s increasingly mediated moments, and provides an interesting counterpoint to many of the dominant, technology-heavy approaches to games and learning. The organizers wish to emphasize playful approaches to learning regardless of the game system’s implementation in silicon or in paper.

By providing teachers with not just an educational technology to deliver content to their students, but a living, changeable, and eminently modifiable game deck, we hope to empower teachers to become game designers in their own right, and give them simple tools to develop games for learning that can better adapt to their needs. And, ultimately, we seek to provide Games+Learning+Society attendees with opportunities to both design games for learning as well as reflect on their experiences designing games for learning.

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From Gamified to Game-Inspired: Using Games in Higher Education Settings

Jeffrey B. Holmes, Arizona State University
Elisabeth Gee, Arizona State University
Sasha Barab, Arizona State University
Elizabeth Lawley, Rochester Institute of Technology
Anna Arici, Arizona State University
Adam Ingram-Goble, Arizona State University

For several years, the New Media Consortium's *New Horizons Report: Higher Education* (Johnson et al., 2014) has identified game-based learning as one significant trend potentially affecting higher education. The actual prevalence of game-based learning has been somewhat harder to document, complicated by the diversity of instructional strategies and models associated with games, from the use of entertainment-oriented games for academic purposes to the use of badges and other achievement systems to document learning. Using games in higher education settings involves particular issues, from gaining institutional and faculty support to meeting expectations for academic quality and content integrity (Epper, Derryberry, & Jackson, 2012). The types of content and forms of learning possible in higher education settings differ from other educational contexts. The GLS community has a breadth of experience in approaching these various issues; one goal of this workshop was to begin forming a formal structure for support and collaboration among higher education practitioners interested in game-based learning.

There are many approaches to using games in support of learning and teaching goals in higher education, yet often these approaches are not clearly differentiated or defined. For example, the authors of the NMS Horizon Report make a simple and broad distinction between the use of games and gamification; a central goal of this session was to illustrate more complex and nuanced variations in how games are being used or how games are inspiring innovations in higher education. This workshop was designed to briefly explicate several different conceptual models as well as ways of implementing game-based instruction at both the course/lesson level and the programmatic level. By engaging participants in comparing and contrasting how games or their features have been adopted and leveraged to enhance learning within the structural, organizational and cultural constraints of higher education, we hoped to collectively illuminate and evaluate some of the assumptions that underlie these models.

Format

This workshop consisted of three interrelated components: (a) *Theoretical Overview*, which provided a theoretical foundation and a shared vocabulary for looking at and critiquing game-based instruction, with a focus on what games do well and in support of what kind of learning/teaching goals, (b) *Models-in-Action*, a brief description of five examples of game-based instruction in action, including games as “texts” or exemplars of a particular issue, teaching a game-inspired curriculum, gamifying a program of study and learning outside of the classroom, and creating and using a specific game as part of teacher training, and (c) *Workshop*, small group roundtables in which the practitioners of the various models engaged participants in hands-on activities that demonstrated key elements of their approaches and promoted discussion of the model's application in other settings of interest.

Each roundtable group was asked to respond to a common set of questions (included below) intended to promote reflection about the goals of the model and the assumptions that underlie it. Attendees were invited to participate in an ongoing, informal conversation following the session, with the goal of contributing to a “conceptual roadmap” that will serve as the beginning of a shared resource for educators interested in game-based learning in higher education, and potentially a starting point for future workshops or conference sessions.

Example models

Adapting a Role-Playing Adventure Game Format to Structure Learning - Adam Ingram-Goble

This model focused on a game-based course that aimed to help students understand the relationship between technology and society through a series of Quest Arcs. In each Quest Arc, students took up a role (i.e. critical consumer, ethnographer, game designer, etc.) and went through thematic quests to develop the skills that are necessary for them to succeed in the boss battles (project assignments). Implications for stretching students' learning across different courses using this model were discussed, as well as illustrative examples of how conceptualizing a course this way played out.

Videogames and Digital Rhetorics: Using Games as a Lens of Study - Jeff Holmes

This model examined an upper-level undergraduate English course in which games were used both as a topic of study as well as a model for inquiry. Students explored concepts of rhetoric through examples in videogames as well as their collaborative play as a class using *World of Warcraft*; in this way, students had a practically grounded experience “playing” the topics they studied. Further, the course was designed using game-inspired teaching principles in which students collaboratively created knowledge and encountered a weekly goal-directed challenge which used the work they developed to confront a particular problem.

Just Press Play: A Game-Inspired Achievement System - Elizabeth Lawley

Just Press Play is an achievement system developed for undergraduate students in the RIT School of Interactive Games and Media. It was designed to recognize and reward student engagement in non-curricular activities—specifically activities that successful graduates of the program regularly cited as significant factors in their undergraduate experience. While Just Press Play is not a game per se, it was designed using a number of game mechanics and principles of motivation in games.

Quest2Teach: A Game-Infused Learning Environment - Anna Arici

Quest2Teach is a game-infused virtual learning environment and social-professional network for teacher preparation programs to bridge between students’ theoretical coursework and its application into the field. Pre-service teachers evolve their professional identity in a variety of narrative-based 3D scenarios. Game meters and other in-game analytics are fed back into a real-world professional network, leveraging gamified achievement layers to validate and extend their digital experiences into their real lives.

Journey Builder Platform: Creating Game-Infused Curriculum - Sasha Barab

This new journey builder platform is intended to support a wide range of formal and informal learning experiences, using missions and challenges that position participants to develop key dispositions as well as knowledge and skills. Quests from a pilot implementation in an undergraduate course on games and impact were used to illustrate the platform’s conceptual foundations in the learning sciences and specific features that leverage game-based methodologies.

Workshop findings and future steps

The workshop was designed as an opportunity for attendees to interact with the presenters and to share some of their own insights. Each presenter served as a conversation leader for a small group around their perspective, so that attendees could focus on a topic that most interested them. After working in small groups, we reconvened to share the observations each group developed. In this way, attendees got a chance to dive deeply into a perspective but also gained some insight from the other views which could influence their own practice.

To guide the deep/broad goals of the workshop, each group responded to the same set of questions using their particular perspective. This provided each of the groups a chance to critically engage problems and opportunities in higher education settings and then hear how the other perspectives addressed those same challenges. The guiding questions were:

1. What problem, challenge, or issue does this particular form of game-based learning (GBL) address?
For example, gamification techniques frequently are employed as a means of addressing the problem of students’ lack of motivation.
2. How does this form of GBL address these issues? What features or affordances are most effective?
For example, the capacity of digital games to allow players to take on new identities can be important to helping them adopt a new perspective.
3. What are some difficulties or uncertainties associated with this form of GBL?
For example, how do badges really differ from grades in motivating students or representing their learning?

Several common themes appeared from all of the groups. First, giving learners context-rich experiences is central to using games of all sorts (which is indeed a theme in much of the literature around games and learning). By context-rich experiences we mean that the tasks and learning goals occur in relevant and meaningful situations connected closely to the topic or concept at hand. For example, the Quest2Teach program tasks pre-service teachers with giving feedback to students; through the game interface, the pre-service teachers interact with virtual students “face-to-face” and play through various ways of interpreting student’s attitudes and providing meaningful feedback to them. The game embeds the learning goal (how to give good feedback) into a scenario that includes actions (interacting with students), explicitly related feedback (the student responses) and a narrative framework (a writing classroom) that will closely resemble the pre-service teachers’ experiences when they enter their own classrooms.

The groups also recognized that games are just one tool among many good teaching techniques, which is an important move away from viewing games as a kind of cure-all. These techniques include lecturing, discussion, supplemental readings, demonstrations and worked examples, peer mentoring and support, one-on-one and one-to-many feedback, and many other teaching strategies. Games may provide a channel for some of these techniques (a worked example of a physics problem, for example). However, there is still a critical place for a teacher in the classroom who leverages the features of games strategically and in support of the learning goals in conjunction with these other techniques.

Lastly, and most critically, a central problem of using games in higher education is that the goals and subject matter of many classes are often highly idiosyncratic, so identifying games or game-inspired techniques that are appropriate for use or adaptation across various subjects, levels, and institutions is especially difficult. There may be tremendous variation in the instruction, assessment methods, and objectives and standards used by different instructors and institutions even in similar subjects (say, algebra or biology). Using games in these settings presents unique challenges, and off-the-shelf or “canned” solutions may not be particularly effective. Developing methods for using games in these kinds of classrooms is an important facet of game-based learning and instruction in higher education settings that is often overlooked in larger discussions of GBL issues.

The ultimate goal of the workshop was to begin a conversation specifically addressing the unique characteristics of using games in pursuit of higher education teaching and learning goals. We intend to hold a higher education track of the Playful Learning Summit held during the 2015 GLS conference in order to further address these unique and compelling problems.

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Building a Foundation for Impactful Work – A Design Jam

Jolene Zywica, Working Examples - Carnegie Mellon University
Courtney Francis, Working Examples - Carnegie Mellon University
Anna Roberts, Working Examples - Carnegie Mellon University

Purpose and Goals

An important goal for this workshop was to make it personally meaningful and relevant to each attendee, so participants didn't poke at something we created or create a hypothetical solution to a random problem. Instead, it was an opportunity to think about and refine their own work.

We asked participants to come to the design jam with a promising idea or a project-in-progress and thoughts on how to make it a success. This workshop helped them to dig into their work strategically – using structured exercises that help grow ideas and games with impact. It was an opportunity to improve their ideas and create something engaging and valuable using tools that help them strategize, clarify, and integrate new perspectives.

Participants worked together to explore the environment around their projects and start to develop a better understanding of elements that will impact the success of their work. We facilitated activities that helped participants make small choices that addressed broader goals, reflect on what works and what doesn't work, and make connections between ideas, plans, and people (Davey, 2014). This helped people move their projects and ideas closer to having the intended impact and, in some cases, discover new ways of thinking about their work and its impact.

Our approach draws from design and business strategy, using proven methods that explore the audience they hope to engage and the problem that they're trying to solve. Our goals were to provide tools to help participants plan, strategize, think critically, and re-evaluate their own ideas, all for the sake of creating more valuable and effective games or gameful learning experiences. During the design jam, participants:

1. Thought purposefully about the problems being solved and why specific solutions matter
2. Developed more focused audience
3. Refined their goals
4. Gave and received feedback on ideas
5. Thought about their work from new perspectives, and
6. Developed a plan for taking ideas to the next stage

Through this experience, participants uncovered their project's unique path to success. The design jam used tools and best practices from human-centered design and business strategy to help participants think strategically about their work, gain empathy for their users and consider the broader ecosystem in which their projects live (Frog Design, 2013; IDEO, 2012).

The power of being strategic

Throughout the session we returned to an example from *Creative Confidence* (Kelley & Kelley, 2013) that showed the benefits of what we were demonstrating and how tools like the ones we provided can impact process. In the book, a design lead from G.E. Healthcare witnesses a child using an MRI machine that he spent years designing. The tiny patient and her parents were sad and stressed in the office – and in the time leading up to the visit - and the designer realized he hadn't properly designed the machine for the people using it. In an attempt to remedy the issue, he participated in a workshop at the Stanford d.school. The workshop used design strategy to clarify the problems he was solving in order to better serve his target audience. As a result of his work, the designer was able to create the "Adventure Series", of MRI machines. Young patients climbed aboard themed machines resembling amusement rides, which reduced the number of patients requiring sedation and drastically improved patient satisfaction. We used this example to demonstrate the power of being strategic.

During our GLS design jam, participants worked on their own projects; anything from a budding idea that hadn't yet been detailed out to a prototype. They participated in activities designed to develop and refine:

The Problem They're Addressing

Participants created problem statements and thought about what they know and don't know about the problem. They reflected on questions, including: What is the specific problem you're trying to solve? Why does this problem matter to the communities it affects? Why is your design/work a valuable solution to the problem? Some participants realized during the session that they didn't know what problem they were solving and hadn't given it much thought. While all of the projects did address a real problem, many of the participants began to view their work as a solution rather than just a cool idea. This change in perspective has important consequences for shaping what people create and who they create for. It was rewarding to see people begin to think of their work as innovative solutions for the first time.

Audience

Participants created stakeholder maps and learned how to develop profiles to define their specific audience, build empathy and better address questions, such as, Who are you trying to impact? What stakeholders are involved? What do these people need? Many participants debated who their target audience was and which primary stakeholders needed to be considered for the design. Some realized they weren't taking all the appropriate stakeholders into consideration.

Goals and Vision

Participants were given additional strategies and activities to complete later with colleagues and team members to define what they're trying to accomplish and how they'd know if they're successful.

The strategies and activities from the design jam are described in more detail at: <http://bit.ly/gls14jam>.

During the design jam, our team facilitated and asked questions to promote creativity and reflection. Examining the problem, audience and goals more closely helped participants to get more focused and ensured their work was addressing a real need or solving an important problem. Many participants left the session ready to hit the ground running, taking their idea to the next stage. Others left inspired after seeing how the strategies they learned were used by peers during the jam and by the G.E. designer to create a new MRI machine.

Who hosted the design jam?

Working Examples is a project based at the Entertainment Technology Center at Carnegie Mellon University. Our team supports designers, researchers and educators in the ed tech field. We've built an online knowledge sharing community, www.workingexamples.org, and host events and workshops to help people collaboratively create innovations for education. In our online community and during our workshops, we provide tools that help people reflect on and improve their work and openly share their process, as well as learn about other's work, discover new perspectives, and connect with diverse experts in the field.

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SHORT PAPERS

Showcase

Kung-Fu Kitchen: A Physical Therapy Game to Remedy the Negative Consequences of Spasticity

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Luc Geurts, KU Leuven, Campus Group T, Belgium
Jelle Husson, KU Leuven, Campus Group T, Belgium
Lieven Van den Audenaeren, KU Leuven, Campus Group T, Belgium
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Overview

Spasticity is a motor disorder defined by involuntary muscle contractions, resulting in uncoordinated gait, stiff body posture and shortening of range of limb movement. The first line treatment of spasticity is physical and occupational therapy, involving physical exercises that focus on stretching and strengthening of muscles. During the Theraplay project, we developed Kung-Fu Kitchen, a game that builds upon these physical exercises and aims to remedy the negative consequences of spasticity.

In order to design Kung-Fu Kitchen, we relied on a participatory design method, involving physical and occupational therapists from two special education schools, one clinic for Multiple Sclerosis patients, and one center for people with mental and physical impairments. Over a period of two years, we co-designed and developed game concepts and prototypes that were subsequently improved upon through an iterative development process and user tests (Vanden Abeele et al., 2012).

The Games

Kung-fu Kitchen includes the following games:

Catching Dishes

This mini game requires players to catch flying dishes at the edge of the screen and put them on a pile in the middle. The physical exercise focuses on the extension of the elbow and exorotation of the shoulder. As for the sensor technology, this is realized by a webcam in front of the patient. The tracking of hands is done via OpenCV's CAMSHIFT algorithm. The communication between OpenCV and Unity3d is done via a C++ plugin.

Serving Clients

This mini game requires players to hold drinks on a serving plate and bring them to the guests. The physical exercise relies on the extension of the elbow and the supination/pronation of the wrist/hand. As for the sensor technology, this is realized by a combination of the webcam and the acceleration sensors in the Wii remote.

Flying Dragons

This mini game requires players to fly a dragon, collecting feathers by steering the dragon to the left and right. The physical exercise relies on a transfer of weight and balancing of the center of gravity, strengthening muscles of the back. As for the sensor technology, this is realized by strain gauges inside the balance board.

Collecting Eggs

This mini game requires players to collect eggs by jumping from mountain tip to mountain top. The physical exercise allow for a triple flex (stretching of foot, knee and hip). This is realized by three Wii remotes with Wii Motionplus positioned on the foot, lower leg and thigh. Kalman filtering is used to estimate the orientation of the Wii remote from gyroscope and accelerometer. The Wii remote is addressed via the WiimoteLib. The connection between WiimoteLib and Unity3d is made via sockets.

Preparing Dishes

This mini game requires players to select ingredients from the side of the screen, and throw them in the cooking

pot in the middle. The physical exercise focuses on a rotation of the head in a horizontal plane and/or bending forward of the neck. As for the sensor technology, this is realized by the infrared camera of Wii remote, positioned on the head.

Therapy Assessment

Theraplay allows therapists to set difficulty levels separately for cognitive and physical challenges, accommodating for a variety of impairments. Additionally, an assessment module for the therapist allows for monitoring the patient's progress.

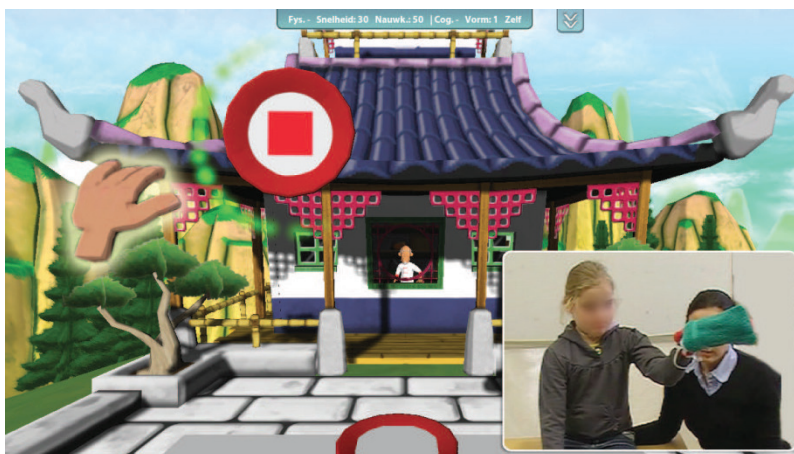


Figure 1: Picture of the Cathing Dishes game.

More information about the game can be found here: http://www.bobdeschutter.com/?page_id=1426. If the video does not work then please access it directly through this link: <http://bit.ly/1aFab5F>. (The video is in Dutch but there is gameplay footage near the end.)

Acknowledgements

Theraplay is a TETRA funded research project by IWT –Flanders (80135). We like to thank all participating therapists and children of Dominiek Savio, Gits, MS Centrum, Melsbroek, Windekind, Leuven and 't Balanske, Tielt-Winge, for their cooperation.

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Quest2Teach: Digitally Bridging Educational Theory to Practice

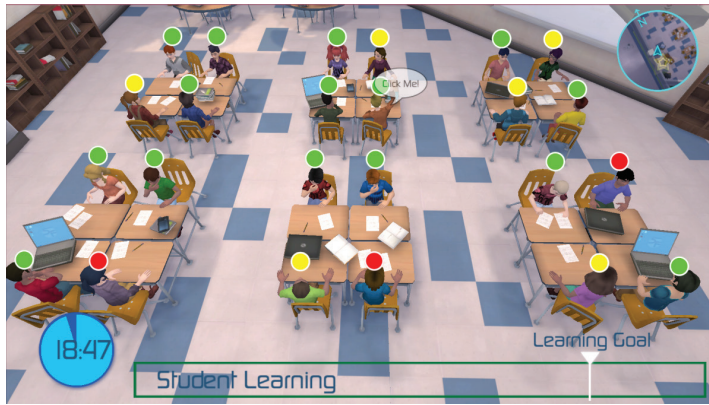
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The Quest2Teach Program

Quest2Teach is a game-infused virtual learning environment and social-professional network designed for teacher preparation programs to bridge between students' theoretical coursework and its application into the field, as well as PD for professional educators. Pre-service students and in-service teachers evolve their professional identity in a variety of narrative-based 3D role-playing scenarios, each with a particular theoretical focus such as Writers Workshop, Student Mentoring, Data-Driven Decision Making and other standards-based skills, guided by their instructor or facilitator, and embedded within a larger experience-based and game-based curricula. In these immersive worlds, players create their professional avatar (which they evolve over several semesters), play out roles, solve contextualized authentic problems, fail safely, see the impact of their individual decisions and trajectories, while gaining experience and fluency in these theories-in-action. Game meters and other in-game analytics are fed back into a real-world professional network, leveraging gamified achievement layers to validate and extend their digital experiences into their real lives, via this network of supportive network colleagues. Here, game achievements are translated into a social currency that is used to validate other players as they reflect, craft, and evolve their impact stories of how they are translating core learning concepts to the real world. In this way, we are leveraging bounded learning experiences and gamified achievement layers to achieve real-world professional growth and impact.





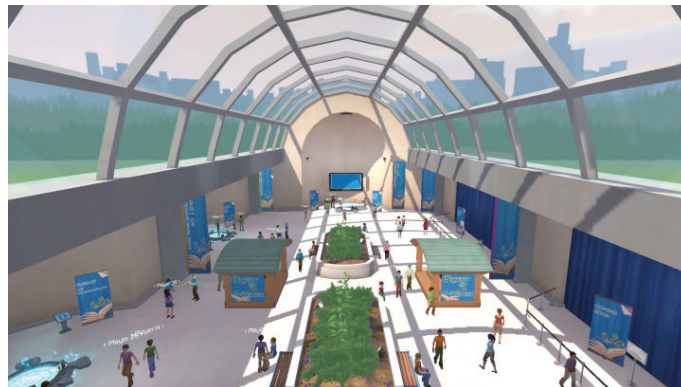
Our small 'g' games

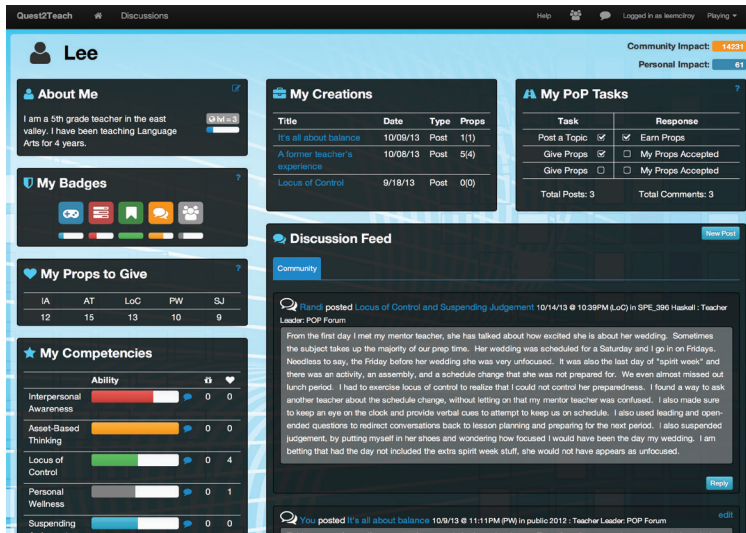
While only in its 2nd year and growing, Quest2Teach currently offers a suite of four 'small 'g' games' currently being used in courses at our Mary Lou Fulton Teachers College and other universities in our Q2T network. Small 'g' games are bounded and completable (in 3-4 hours) and what our teachers would call our 'video games'. The titles and subjects are listed below, and all are ready to scale to interested:

- **Pursuit of Professionalism** (Communications, leadership, interpersonal dynamics, and professionalism skills)
- **On the Write Track** (Student conferencing and mentoring in literacy and new media literacies)
- **Diving into Data** (Using data-driven decision making (from multiple sources, not just assessment) to inform educational practice and continually increase impact)
- **Project Based Approaches: At the Core** (Creating and implementing project-based unit plans to actively engage students)

Our big 'G' game

More important than any individual game title, is our big 'G' infrastructure, which is open-ended; a socio-professional network integrating small 'g' games into a larger infrastructure with student driven extensions, teacher smart-tools and modding, affinity spaces, a 3D multi-player hub, and a professional identity that evolves over semesters from in-game analytics, reflections, and real-world experiences. This network also links together multiple teachers colleges for collaboration across campuses and internationally with Q2T sister sites in Ireland, Italy, and Denmark.





Impact

Founded in a design-based research program, Q2T is theory-based and has been extensively studied and iterated over the past 4 semesters of classroom implementations with hundreds of pre-service teachers. Each study has resulted in significant learning and engagement gains, moreover, comparison studies and ethnographic methods show compelling results. Q2T students report shifting into a protagonist and active role in their learning, describing the 'skills they've gained', rather than the 'information they learned about'. There is also an interesting shift in their self-reported identity from that of a 'student' to a 'teacher' as they see themselves successfully engaging in these professional practices with their avatars as extensions of themselves. Students report higher levels of confidence in their teaching, having gained this virtual practice, and frequently voice appreciation of the ability to fail safely and try new approaches. Players also show stronger fluency in the language of education, including *how* to better engage with students, after experiencing these discourse nuances on a personal level with multiple linguistic models from which to choose.

Conclusion

In sum, these games and their extensions place the student as protagonist in an immersive classroom narrative, with scaffolded language and experiences, able to make authentic decisions, see their consequences played out, and gain fluency in those practices. The network infrastructure helps bridge these virtual experiences into the real world through reflection, extensions, transfer, and community, allowing students to craft and evolve their professional identity and impact over their entire Teachers College experience and their professional career.

Additional resources about Quest2Teach

Please visit the Q2T website to learn more about this program, as well as watch videos, and request a guest account to play through these games. www.quest2teach.org



Down with Food: An iPad Game About Digestion

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Nathan Petitti, University of California, Irvine
Neil Young, University of California, Irvine

Introduction

Down With Food is an in-development iPad game that addresses upper elementary school children's misconceptions about what happens to food after they eat. Children typically have a simplified understanding of digestion: food enters your mouth, goes down your throat, enters your stomach, and digestion is completed in a linear fashion. We address the complexities of the digestive system through a storybook narrative integrated with a series of mini-games and simulations that are each based on attempts to apply popular game mechanics to an educational context.

Though much effort has been put toward integrating game elements in educational spaces to improve learning, results have been disappointing (Wouters, Nimwegen, Oostendorp, & van der Spek, 2013). One reason for this unsuccessful hybrid is that designers have taken a "chocolate-covered broccoli" approach, in which the gaming element is a reward for completing the educational component. Our game is developed with the mindset that educational games need to be designed in a way that allows for the learning material to be delivered through the parts of the game that are most engaging (Habgood, Ainsworth, & Benford, 2005).

Game mechanics

Down With Food requires the player to be an active agent in facilitating the ingestion, digestion, and absorption processes. The player flips through storybook pages to learn about the various organs of the digestive system, such as the mouth, esophagus, stomach, small intestine, and large intestine. Within these pages are interactive mini-games or simulations that model the organ's biological functionality. Below we discuss in more detail the esophagus and small intestine games.

Esophagus

The esophagus game mimics the design of the popular rhythm games genre. Rhythm games are typically set to music and require the player to correctly simulate dancing, singing or playing an instrument along to the beat. This simulation usually requires the player to press buttons with precise timing, and rewards the player incrementally using points and/or ratings systems based on how well they were synchronized with the beat. The popularity of rhythm games stem from their ability to combine simplicity with increasingly complicated gameplay mechanisms that are relatively easy to learn but extremely difficult to master. This property of rhythm games gives them a very high replay value as players typically strive to obtain as perfect of a score as possible for each available level.

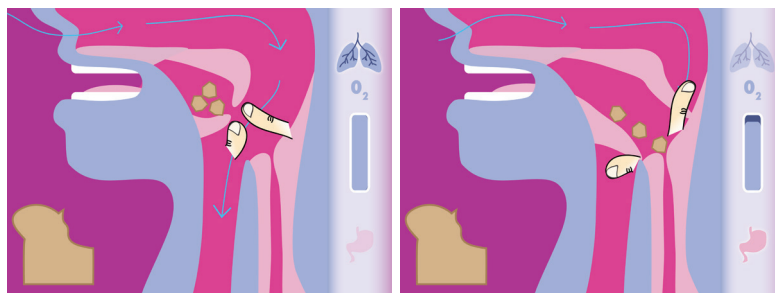


Figure 1: Opening the passageway to switch from breathing to swallowing.

In our esophagus game, the player must control the intake of food and air in a rhythmic fashion. The goal is to perfectly time actions to swallow food as it enters the body while also allowing the body to breathe in oxygen. The swallowing of food is controlled by using the thumb and forefinger to move apart the uvula and the epiglottis and

open the upper esophageal sphincter (see Figure 1). This motion also blocks the nasal passage and the trachea, briefly stopping the flow of oxygen to the lungs. The body switches from “breathe” to “swallow,” as indicated by the righthand column of the user interface (see Figure 2). The meter is an indicator of how much oxygen is in the body, and the player must pinch to close the passageway in time and switch back to breathing. When oxygen runs out, the body forcefully closes the opening and coughs out any food not in the esophagus.

Small Intestine

The small intestine game is presented in the style of the tower defense subgenre of real-time strategy games, in which a player typically places a variety of towers at several points on a game map. Computer-controlled enemy units, usually following a pre-determined path, attempt to infiltrate the player’s base by navigating past the defense system of towers. The goal is to successfully destroy all waves of enemy units before they are able to successfully infiltrate the player’s base. The tower defense subgenre has been popular for years, as these games combine intuitive simplicity with the opportunity for complex, multilevel strategy. Thus, they are easy to play but difficult to master, increasing replayability. Given the natural mapping of tower defense game mechanics to the processes that occur in the small intestine, we adapted the tower defense paradigm to illustrate the absorption processes in the small intestine.

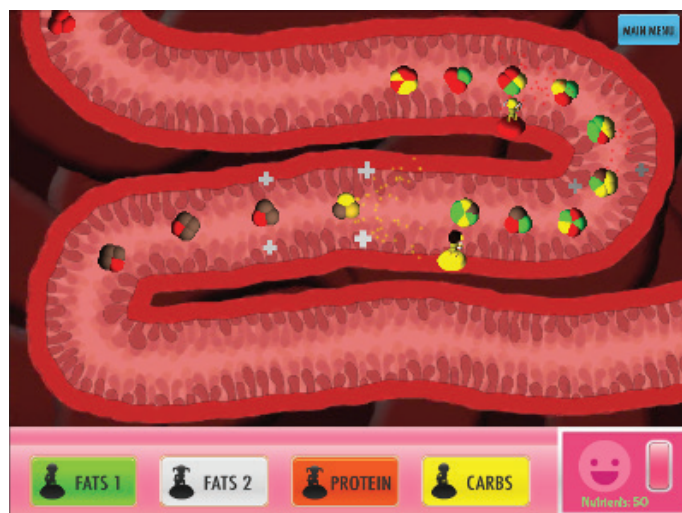


Figure 2: Towers release enzymes to bind to nutrients of incoming food.

In our small intestine game, players strategically place enzyme towers along the walls of the small intestine, to release enzymes at oncoming chyme, represented as multicolored food blobs (see Figure 2). The colors indicate the content of the food: carbohydrates (yellow), proteins (red), or fat (green and white). Fats in the body require two enzymes to be broken down. Each enzyme tower can release enzymes at food particles that contain their corresponding nutrient, indicated through color matching. For example, red enzyme towers can break down red food particles while yellow towers break down yellow food particles. The challenge is to place enzyme towers strategically so that as food blobs pass, the enzymes release to attach to the appropriate part of the food blob. If successful, the corresponding food particles will break down, releasing nutrients that are absorbed by the villi projections at the wall of the small intestine, to be released into the bloodstream.

Prototype in action

For the educational arcade, we present a prototype of a storybook integrated with games for the mouth, esophagus, and small intestine. This is available at <http://www.downwithfood.com/prototypes>.

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After the Storm: A Digital Literacy Game

Kathy Yu Burek, Classroom, Inc.
Anne Richards, Classroom, Inc.

The World of Work

Developed for struggling readers, Classroom Inc.'s *After the Storm* focuses on the aftermath of a major hurricane in the community of Port Douglas. Players take on the role of Editor-in-Chief of an online magazine. As students navigate through a day in the life of a working professional, they experience challenges related to how the storm has affected both their workplace and the community. Players must decide how best to respond to these challenges based on the information gathered during the game through informational texts such as press releases, official reports, emails, text messages, conversations with colleagues and much, much more.

The Game

The game presents students with a wide variety of reading and workplace experiences. Designed for use as a literacy program in various implementations, *After the Storm*, consists of 10 episodes of online game play, each representing a full day at work. Episodes can be played in any order, except for the first one, which provides context to the student's role and workplace. An episode spans 4 class periods and contains an overarching narrative them with mini-stories and goals specified for each class period. Offline activities include collaborative classroom projects and book-centered discussions.

Each episode contains three acts and a writing activity. Each act represents the beginning, middle and end of a workday while the writing activity is a culminating piece written by the player, as Editor-in-Chief. At the beginning of each act, players are directed towards their "To Do" list, which is pre-populated with goals and tasks for that part of the day. As the storyline is non-linear, players are self-directed and decide what tasks to complete first within certain limitations.

Standards were specifically chosen so that players will develop a strong foundation for success in reading comprehension and college and career readiness. The game addresses top-level 21st Century Skills as defined by The Partnership for 21st Century Skills (P21 Framework) and assesses the following six Grade 6 Common Core State Standards (CCSS) for reading informational text:

- RI 6.1. Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.
- RI 6.4. Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.
- RI 6.7. Integrate information presented in different media or format as well as in words to develop a coherent understanding of a topic or issue.
- RI 6.8. Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.
- W 6.1. Write arguments to support claims with clear reasons and relevant evidence.
- W 6.2. Write informative/explanatory texts to examine a topic and convey ideas, concepts and information through the selection, organization and analysis of relevant content.

Assessment

In each episode, players complete several embedded assessments or main reading activities (see Figure 1), where they read a variety of real-world documents, written at the 6th grade level, and perform specific CCSS related tasks such as choosing the best images or text for a blog post or citing evidence that supports various opinions or ideas.

Based on their initial performance in these main activities, players will be routed seamlessly in different ways:

- If performance is above the designated threshold, players will move to a more challenging activity written at a high 6th grade level and includes a higher level of critical thinking tasks.
- If performance is below the designated threshold, players will move to an easier and shorter activity that offers support to students on the CCSS skill assessed in the main activity. If players successfully complete

this activity, they are routed back to the main activity so they can try again.

- If student performance on the initial support activity is unsuccessful, players are routed to another much shorter support activity that incorporates more visual strategies and focuses on a particular foundational skill within the main activity standard. Players are then routed back to the main activity to try again.

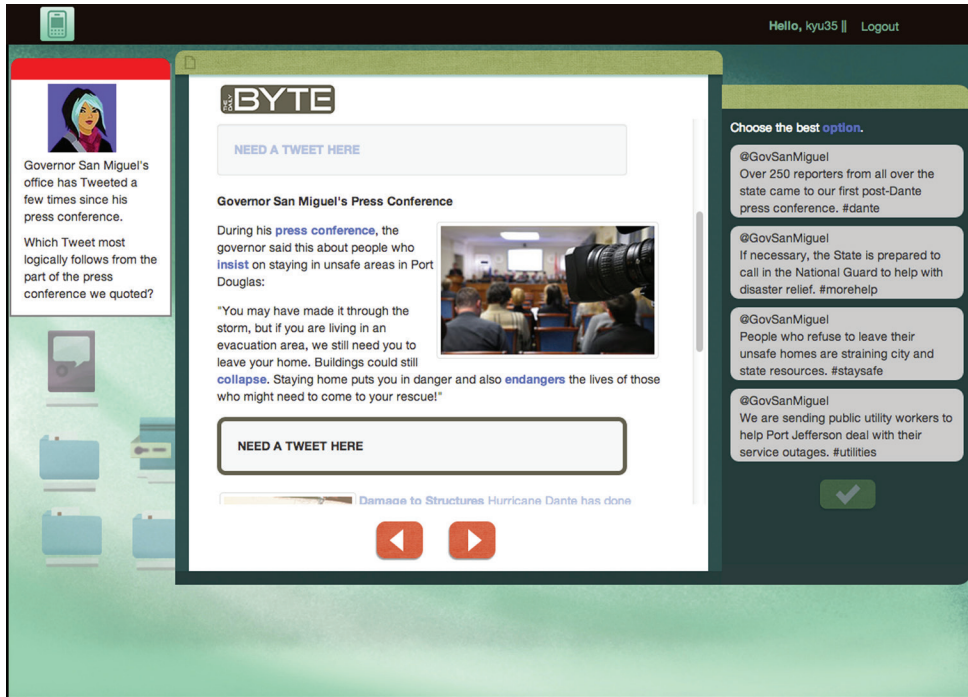


Figure 1: Main Reading (RI. 6.7) Activity

As decisions are made and tasks or activities completed, the game collects, assesses and responds to provide each player a different experience; however, all players complete the same main activities which are scored and data is sent to a teacher dashboard. Upon completion of each episode, players will complete a writing activity set in the game's environment. Teachers have access to writing activities in their dashboards and can assess them using a CCSS based rubric.

Teacher dashboards allow for account creation and management, show student progress on a variety of metrics such as performance on specific activities and by standard, and access to teacher resources. Teachers will use the dashboard information to determine next steps for his/her class or individual students and students can use the information to determine goals and individual progress.

Research and Results

An initial episode was developed and piloted in two New York City schools with about 90 students. Each school had one general education class and one integrated co-teaching (ICT) class that consists of both general education and special education students. Key findings that we have incorporated from this pilot include:

- Increased emphasis on student choice and control of their experience was popular and will be expanded moving forward.
- Based on the difficulty some students had understanding required interactions in activities, we are working with our developer to redesign some UI elements to make this more intuitive.
- Teachers provided feedback on dashboard reporting prototypes that we will use to redesign these screens before building them.

The Radix Endeavor

Susannah Gordon-Messer, Louisa Rosenheck, Angie Tung, Jody Clarke-Midura, Jason Haas, Eric Klopfer, Massachusetts Institute of Technology

The Radix Endeavor (radixendeavor.org) is an online multiplayer game designed to improve knowledge and engagement in high school math and science students. In a robust virtual world, players explain and solve problems by completing narrative driven quests to progress through the world. As they take on the roles of scientists and mathematicians in authentic situations, they develop inquiry, problem solving and critical thinking skills. Through a dashboard, the game allows teachers to monitor student progress as well as access resources that connect the gameplay to classroom instruction. Radix began a research pilot in February 2014 that continues through the end of the school year.

Game Experience

When you enter the game, you find yourself on an island in an Earth-like world with a technical and social situation similar to our 1400s (see Figure 1). The leader of the island is making arbitrary and greedy decisions that threaten the health of the island and its inhabitants. You come to join a group called The Curiosi who asks you to help find solutions to some of the island's worst problems, both environmental and societal. If you can figure out what is causing the problems, how the natural systems work, and which factors need to be changed, you may be able to improve the lives of the people and even save the island from destruction. An overview of the game's narrative and curriculum is presented at <http://youtu.be/1pYr3R3BTvU>.



Figure 1: Two of the regions on the island of Ysola, the forest and the marketplace.

One example of an adventure you have while exploring the world is when you learn that the leader of the island has decided to plant only extremely tall palunculus trees for cosmetic regions and is unconcerned that it may cause problems for local birds who use it as a food source. You learn that he believes the birds, within a few days, will simply grow longer necks to adjust. Your job is to collect historical evidence from all over the island to convince him that evolution takes place on a much larger time scale. In another area of the world, the Curiosi ask you to help them create plans to build a new city. To do this, you must find the architect of the old city, help her measure the ruins of her city and create a brand new set of scale maps that can be used in building a new city. The process of completing this project can be seen here: <http://youtu.be/kZLrFUTBjpA>. In both of these cases and many others in the game, you must determine for yourself what tools to use and how best to solve the problem.

Benefits of a Multiplayer World-based Game

In The Radix Endeavor game, players' avatars exist in a shared and persistent world. Players work together to understand how the world works, then use that knowledge to accomplish task-based goals. This MMO-like game structure has affordances that integrate well with inquiry based learning and scientific ways of thinking, creating a framework uniquely suited for STEM learning. Players will need to explore the virtual world and conduct their own

“experiments” to develop hypotheses about how the biological and mathematical systems function. They are able to collaborate with other players in the game to compare ideas and solve problems using scientific reasoning, while being motivated by the social and contextual nature of the in-game goals.

Curriculum

The game covers content from high school math and biology. In biology, topics covered include evolution, ecosystems, human body systems and genetics. A walkthrough of the genetics quest line can be found here: <http://youtu.be/7TgCrdOonyI>. In math, topics covered include algebra, geometry and statistics. The content is aligned with the Common Core standards in mathematics and Next Generation Science Standards. In addition, for both content areas, we are placing particular emphasis on including opportunities for students to develop key STEM practices and 21st century skills such as using models, analyzing data (see Figure 2) and communicating information.



Figure 2: The Data Library and Data Explorer tools used for analysis in both content areas.

Assessment and Teacher Tools

Innovative task-based assessments are embedded into the game for each topic area. The data logging system collects information on players’ actions and progress in the game. Through this we can gather information on players’ strategies and that can determine if learning objectives are met and whether potential misconceptions may be present. This information will be synthesized and displayed in real time on the teacher dashboard, a tool to help teachers monitor student progress and tailor their lessons to students’ needs. Additionally, using the dashboard, teachers can manage classes, assign quests and access bridge curriculum that includes learning standards, implementation recommendations and questions to connect game play to traditional classroom instruction.

Research

Between February and June 2014, Radix will be in a pilot research phase. During this time we will have thousands of students playing from across the United States. All teachers using the game will be asked to complete surveys to give us information about usage and implementation. A subset of the teachers will be using external pre and post assessments designed to measure learning gains associated with the game. Additionally, we will be doing classroom observations and student interviews in order to measure interest and engagement. This research will give us insight into the feasibility of implementing such games in a classroom setting, as well as the potential of game-based assessments in STEM courses.

Radix in the GLS Arcade

The Radix Endeavor is a living game and changes based on feedback from students and teachers. However, we are always interested in feedback from colleagues in the educational games community. In June of 2014, Radix will be finishing up the research pilot and we will be thinking about future directions for the game. We believe that GLS attendees will be able to provide us with valuable feedback both on the content of the game and well as suggestions for pathways to pursue in order to grow the game.

Sanctuary: Asymmetric Interfaces for STEM Learning

Jason Haas, Massachusetts Institute of Technology

SANCTUARY is a multiplayer game designed to encourage science learning for 10th grade math and biology students, attempting to promote greater public understanding of science and interest in Science, Technology, Engineering, and Mathematics (STEM) learning. The design descends in part from Elliot Aronson's work on the Jigsaw Classroom (2011). It requires a group task to be completed by students with a shared goal but with individual accountability (through specialized roles). The game is played by two co-located players on two tablet computers (iPads in this version). While both players are seeing the same simulated world, each player has a different set of tools with which to act in that world. The purpose is to elicit quality communication, arguments, coordination, and co-strategization (planning ahead for future turns) between participants. This is an advance over single-player or multiplayer learning game experiences, in which players are rarely required to verbally express and formalize their strategies during play. The project is also intended to provide a counter to a "one-size-fits-all" status quo in learning games.



Figure 1: (left) The biologist's interface. Figure 2: (right) the mathematician's interface.

My project is to question whether, by providing players with two points of view on a shared scientific problem via asymmetric interfaces, under the conditions of play, the challenges of epistemological pluralism can be made into a virtue for science learning, forcing quality communication, arguments, coordination, and co-strategization amongst participants. By provoking these behaviors, I expect that the game will overcome a chief challenge of experiential learning activities—the creation of tacit, unformalized experience and knowledge. To this end, I built *Sanctuary*, an ecological simulation with one biology-themed and one mathematics-themed interface for two players. By requiring players to express their beliefs about the game world to one another in language in order to be successful, the design of the game encourages players to formalize their intuitions and experiences. I believe this to be an advance over existing learning game experiences, in which players are rarely required to formalize their strategies. I see this as a naturalistic advance over other metacognitive interventions in which a play experience is literally halted in order to solicit formalized thoughts from players. If this approach is successful, then it may be applied further to an increasing range of epistemological frames and better science education. This has the potential to build cooperative, thriving learning communities with shared learning experiences.

References

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Game Arcade: Turn Up the Heat!

Michael S. Horn, Northwestern University
Amartya Banerjee, Northwestern University
Sarah D'Angelo, Northwestern University
Pei-Yi Kuo, Northwestern University
D. Harmon Pollock, Northwestern University
Reed Stevens, Northwestern University

Game play video: <http://bit.ly/1eUYIX1>

As a global society we face unprecedented challenges related to environmental sustainability. **Turn Up the Heat!** is a collaborative board game that provides families with a playful context for discussing household heating and cooling systems and tradeoffs related to energy, comfort, and money. Through a tablet computer interface, the game offers all players (children and adults) the opportunity to set a thermostat on their turns. By allowing families to see the immediate effects of temperature settings with both a manual and programmable thermostat interface (Figure 2), we confront usability issues and misconceptions around residential thermostat use. We also examine the role of board games as a *cultural form* through which to foster whole-family interaction and learning around sophisticated and potentially difficult concepts related to energy consumption.



Figure 1: Turn Up the Heat is a cooperative board game in which players make tradeoffs related to comfort, energy, money, and environmental sustainability.

The game is designed for 2-5 players ages eight and up, and it features a cooperative style of play, meaning that players must work together instead of against each other to beat the game. Turn Up the Heat! consists of both traditional and digital components, where players use a board, dice, cards, tokens in addition to a tablet computer app (Figure 1). The app acts as the central interface of play, enabling each player to simulate heating and cooling systems based on their temperature preferences, outdoor temperatures, thermostat settings, and home insulation levels (Figure 3).

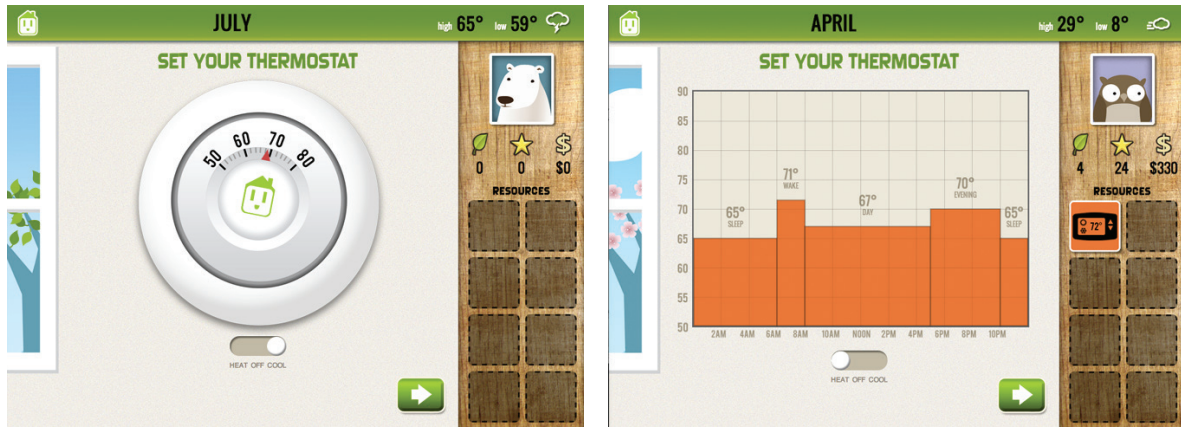


Figure 2: Players start the game with a manual thermostat (left) that can only set one temperature value per turn. Families can upgrade to an Internet thermostat (right) that allows players to set temperatures for four different time zones.

To win the game, players must survive for one full year without debt and earn at least 20 *Green Points* and 20 *Comfort Points*. After setting the thermostat, players have the option of using one of their *Resource Cards* to make it easier to earn points. Some resources (such as warm clothes, hot chocolate, and lemonade) can be used to expand an individual player's comfort zone, making it easier to earn *Comfort Points* while using less energy. Other resources (such as insulation, storm windows, and a programmable thermostat) cost money but make the game easier for all players through improving the home's infrastructure. At times, players may land on the spaces of special events on the board (such as power outage, broken window), where they are required to draw one of the *Event Cards*. *Event Cards* usually make the game more challenging, but they are not always negative.

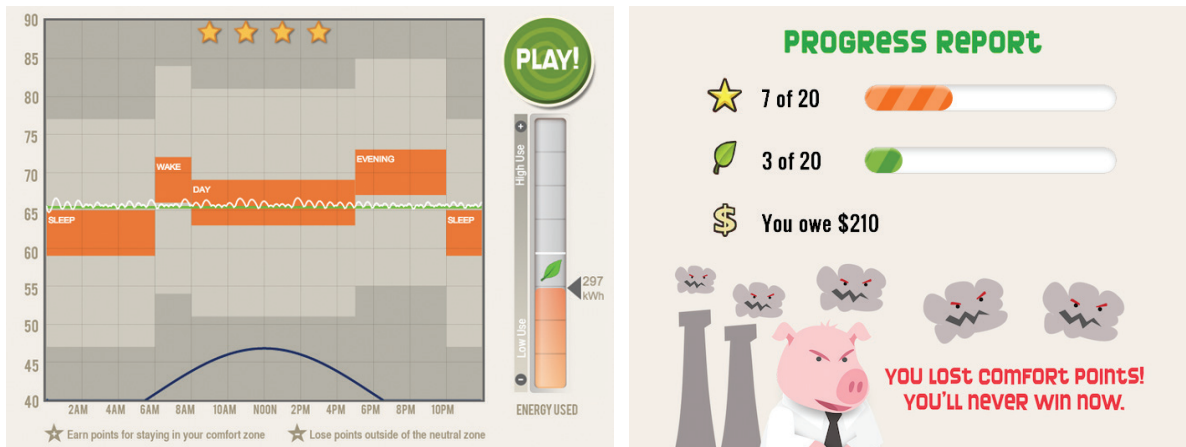


Figure 3: The simulation screen (left) shows each player the results on how their thermostat settings affect their comfort, bill and the environment. Following the simulation screen, each player gets a progress report (right) that summarizes the points they earn and the amount of the energy bill per turn.

Acknowledgements

Laurel Schrementi, Zeina Atrash Leong, Michael Greenberg, and Andreas Wadum also contributed to this work. Maisa Morin (maisamorin.com) was our graphic designer. This work was supported in part by the Institute for Sustainability and Energy at Northwestern (ISEN) and the National Science Foundation (grant IIS-1123574). Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Foundation.

Backyard Engineers: Bringing Efficient Design To a Water Balloon Fight

Ellen Jameson, Filament Games
Marshall Behringer, Filament Games
Gregg Sanderson, Filament Games
Chenya Chang, Filament Games
Dave Hoffman, Filament Games

Game Description

Backyard Engineers is a game about the engineering design process. In *Backyard Engineers*, players create catapults to launch water balloons and win battles in the great neighborhood balloon fight. Players will need different catapults to meet different challenges, and will have to balance design characteristics (like mobility, energy use, stability, and efficiency) with their goals as they try to build the best catapult for the job. After making design decisions, players can test their catapults and adjust their designs before joining the battle and laying siege to the backyard.

Using the Engineering Design Process

Players can experiment with the trade-offs between the design and materials used and stability, accuracy, range, and soaking area of their resulting water balloon catapult. They can try out each design in the field, making adjustments as desired, and when they are certain the design meets their goal, they can put it to the test and evaluate their results with respect to efficiency benchmarks (see Figure 1). This process can be repeated as players complete each level (see Figure 2).

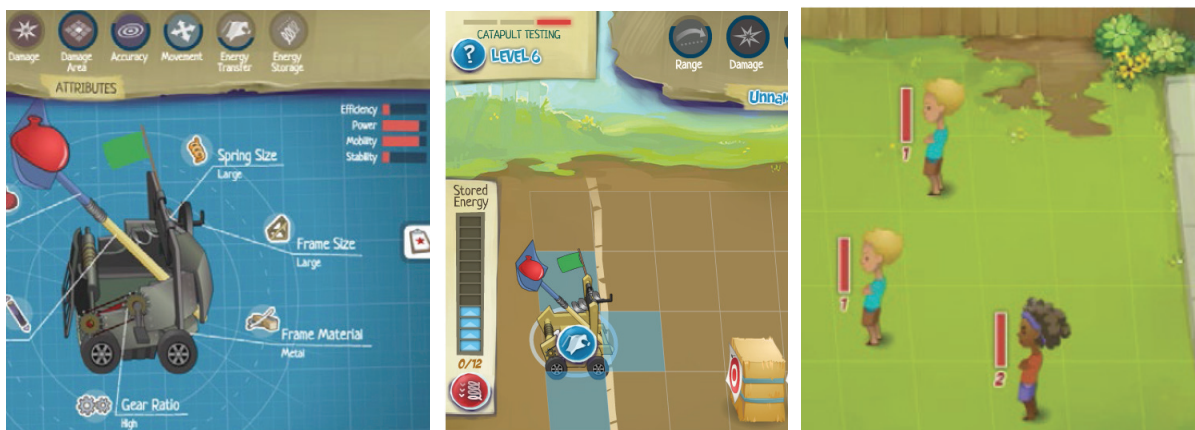


Figure 1: One round of catapult building, testing, and deployment

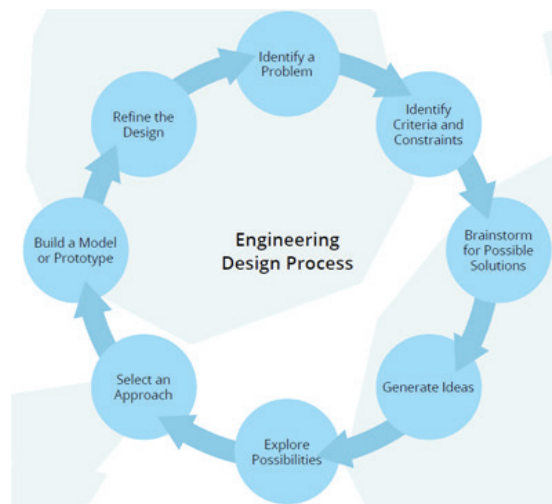


Figure 2: The engineering design process in *Backyard Engineers*

Learning Objectives

Students will be able to use the engineering design process to adapt and refine their catapult designs to meet their design goals efficiently.

Target Population

Backyard Engineers targets 6th - 8th grade students in classroom environments.

Next Generation Science Standards (2013)

MS-ETS1.A: Defining and delimiting engineering problems
MS-ETS1.B: Developing Possible Solutions
MS-ETS1.C: Optimizing the Design Solution
(NGSS Lead States, 2013)

Common Core State Standards

CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.ELA-Literacy.RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

(National Governors Association Center for Best Practices et al, Council of Chief State School Officers, 2010)

Development Process and Teacher Feedback

Backyard Engineers is a lean game, meaning that it targets a small number of learning objectives efficiently so that development resources can be conserved to allow the game to be iteratively refined through more cycles of development and feedback than a larger game could sustain. Filament developed this game through the AGILE process, in which each development cycle aims to produce a complete feature or set of features that can be evaluated. This game is part of a series of lean games targeting STEM standards that Filament developed in consultation with teachers during each development cycle.

Backyard Engineers Demo Video and Launch Page

A video demo of *Backyard Engineers* is available on the Filament Games website:

<https://www.filamentgames.com/fws2/products/backyard-engineer>

References

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common Core State Standards*. Washington, DC: National Governors Association Center for Best Practices, Council of Chief State School Officers

NGSS Lead States (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Acknowledgments

Filament Games would like to thank Curriculum Specialist Heather Wentler, and NSF Research Experience for Teachers (RET) Fellows Tammie Schrader, Cheney Middle School, Cheney, WA, and Kate Slabosky, Central Middle School, Columbus, IN, for their collaboration in the design and development of this game and game-based curriculum materials. Filament is also grateful for the playtesting and feedback from middle school science teachers in Bartholomew Consolidated School Corporation, Columbus, IN, whose efforts helped shape the game during development.

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Worlds Made to Order in *Planet Mechanic*

Ellen Jameson, Filament Games
Fiona Zimmer, Filament Games
Flash Kowaleski, Filament Games
Rachel Berkowitz, Filament Games
Alexander Cooney, Filament Games

Game Description

Planet Mechanic is a game about the Earth-Sun-Moon system. In *Planet Mechanic*, fickle aliens ask the player to modify their planet to produce a variety of climates, seasons, and tides (see Figure 1). To fill each request, the player modifies characteristics of the planet, including its orbital distance and speed, atmospheric density, rotation speed, tilt, and whether it has a moon. Interdependencies between planetary characteristics are front and center as players decide how to fill each order (see Figure 2).

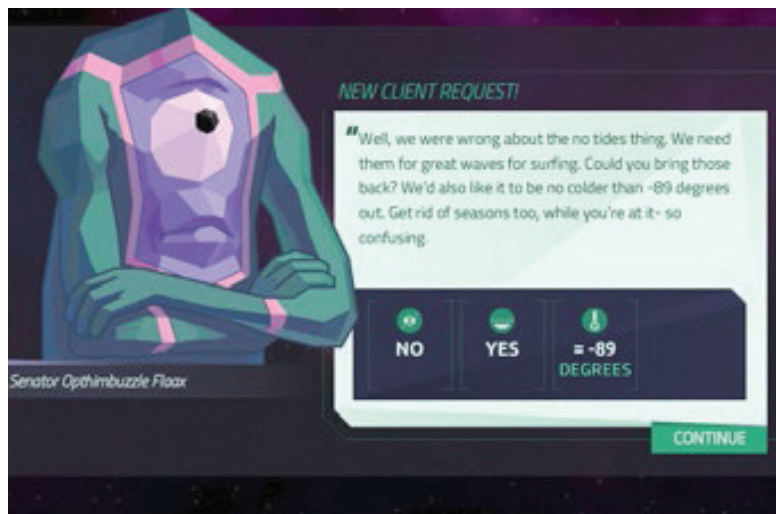


Figure 1: Order up! Eliminate seasons, and make sure it stays warmer than -89 degrees!



Figure 2: Change features of the planet and see how other features are affected

Learning Objectives

Students will be able to use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.

Target Population

Planet Mechanic targets 6th - 8th grade students in classroom environments.

Next Generation Science Standards (2013)

MS-ESS1-1: Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.

(NGSS Lead States, 2013)

Development Process and Teacher Feedback

Planet Mechanic is a lean game, meaning that it targets a small number of learning objectives efficiently so that development resources can be conserved to allow the game to be iteratively refined through more cycles of development and feedback than a larger game could sustain. Filament developed this game through the AGILE process, in which each development cycle aims to produce a complete feature or set of features that can be evaluated. This game is part of a series of lean games targeting STEM standards that Filament developed in consultation with teachers during each development cycle.

Planet Mechanic Demo Video and Launch Page

A video demo of *Planet Mechanic* is available on the Filament Games website:

<https://www.filamentgames.com/products/planet-mechanic>

References

NGSS Lead States (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

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Bongo Balance: Scaffolding Work with Chemical Equations

Ellen Jameson, Filament Games
Marshall Behringer, Filament Games
Ryan Baron, Filament Games

Game Description

In *Bongo Balance*, students learn techniques for balancing chemical equations as they balance fruit to feed fair portions to two hungry jungle animals. Players add and subtract groups of fruit in order to feed an equal amount of every type of fruit to each animal (see Figure 1). Some groupings are harder than others, until players learn to multiply types of fruit by coefficients as they would with subscripts and coefficients in chemical equations. Gradually, the representation of the components of the equation changes from fruit to fruit-with-subscripts, and finally to molecules-with-subscripts, so that by the end of the game, the player is working with a recognizable chemical equation (see Figure 2).



Figure 1: Balancing bunches of fruit



Figure 2: Balancing a chemical equation

Learning Objectives

Students will be able to use the engineering design process to adapt and refine their catapult designs to meet their design goals efficiently.

Target Population

Bongo Balance targets 6th - 8th grade students in classroom environments.

Next Generation Science Standards (2013)

PS1.B: Chemical Reactions:

Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2), (MS-PS1-3), (MS-PS-5) The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS 1-5)

(NGSS Lead States, 2013)

Common Core State Standards

CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.ELA-Literacy.RST.6-8.8: Identify when two expressions are equivalent (i.e., when the two expressions name the same number regardless of which value is substituted into them). For example, the expressions $y + y + y$ and $3y$ are equivalent because they name the same number regardless of which number y stands for.

(National Governors Association Center for Best Practices et al, Council of Chief State School Officers, 2010)

Development Process and Teacher Feedback

Bongo Balance is a lean game, meaning that it targets a small number of learning objectives efficiently so that development resources can be conserved to allow the game to be iteratively refined through more cycles of development and feedback than a larger game could sustain. Filament developed this game through the AGILE process, in which each development cycle aims to produce a complete feature or set of features that can be evaluated. This game is part of a series of lean games targeting STEM standards that Filament developed in consultation with teachers during each development cycle.

Bongo Balance Demo Video and Launch Page

The game's launch page can be found here: <https://www.filamentgames.com/fws2/products/tikiquations>

A video demo of *Bongo Balance* is available here: <http://www.youtube.com/watch?v=g7rS4TyE1zc>

References

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common Core State Standards*. Washington, DC: National Governors Association Center for Best Practices, Council of Chief State School Officers

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Reach for the Sun: The Seeds of Strategy

Ellen Jameson, Filament Games
Fiona Zimmer, Filament Games
Marshall Behringer, Filament Games

Game Description

Reach for the Sun is a game about the plant life cycle aimed at 6th – 8th graders. In *Reach for the Sun*, players take on the role of a plant, managing its resources over the growing season as it sprouts, grows, respire, photosynthesizes, and produces flowers, pollen, and hopefully seeds. Beyond the first plant, which can act as a tutorial, players can grow several other types of plants, each of which have different growth and resource use profiles that players can learn to optimize.

In response to feedback from *Reach for the Sun*'s release on Steam, we designed a turn-based strategy mode to accompany the time-based standard mode of play. *Reach for the Sun*'s Strategy Mode allows players to spend time considering resource costs and benefits before they make each turn's decision about investing in growth, photosynthesis, or reproduction (see Figures 1 and 2). In strategy mode, resource costs are explicit, and the game shows what resources will be gained at the end of the turn based on the plant parts the player has grown so far (see Figure 3).



Figure 1: Timed growth season, standard mode.



Figure 2: Turn-based growth season, strategy mode.



Figure 3: Current resources, plant part costs, and additional resources that will be gained at the end of the turn are explicitly shown.

Gameplay

The primary goal in *Reach for the Sun* is to produce as many seeds as possible at the end of the growing season for each plant. Every plant part the player grows increases the plant's storage capacity for water, nutrients, and starches. Water and nutrients can be taken in periodically from the environment, while starches must be made by photosynthesis in the plant's leaves. Each plant part has a certain resource cost to produce, but then provides additional capacity for collecting and storing resources (see Figure 4). There are tradeoffs involved in deciding which plant parts to grow at different stages in the growing season. For example, roots allow the plant to replenish its store of water and nutrients from the soil. Stems increase storage capacity and provide more nodes for growing leaves and flowers later. Leaves allow the plant to make starch, which is important for growing plant parts, especially pollen and seeds. Flowers give the plant the ability to make pollen and seeds. Investing in pollen prepares flowers to seed, which allows players to invest in seed production for each flower they manage to fertilize with pollen.



Figure 4: Storage capacity grows as more plant parts are added.

Players can unlock up to five different types of plants, which vary in the ways they gather resources and use them to produce plant parts. The sunflower is the “easiest” plant, and most players will be able to produce seeds from at least one flower on their first play-through. The sunflower level provides an optional tutorial explaining the interface and actions the players can take. Each type of plant requires players to adapt their strategies to its strengths and weaknesses. Even though all plants are being grown in the same garden, the differences in plants abilities can be a good jumping-off point for discussing adaptation to different environments.

Curriculum for Game-Based Learning

Reach for the Sun is the game component of a game-based learning unit, *Plant Structure and Processes*, which is part of the PLEx Life Sciences Suite. The unit guide embeds *Reach for the Sun* in a series of lessons which support and build on the experiences students have during gameplay (see Figure 5). A brief video overview highlighting key game features accompanies the unit plan to help teachers prepare to facilitate the game in class.



Figure 5: The *Plant Structure and Processes* unit guide contains assessments, suggestions for implementation, lessons, and extension activities.

Research on learning games in classrooms broadly indicates that games can have a greater impact on learning when they are played over multiple sessions (Clark et al., 2014). This gives students time to reflect on their experiences in the game and to refine their strategies as their understanding develops. The *Plant Structure and Processes* unit includes a brief pre-assessment activity so that teachers can gauge students' incoming experience with key concepts. Then students play the game right away so that they can start the unit with a discussion of concrete experiences. Subsequent lessons focus on supporting and building out different components of the learning objectives. These lessons include gameplay but also involve activities that give students opportunities to work with alternative representations of the content.

Classroom Implementation

As with any classroom experience, it is not sufficient for the students to sit and play the game in a vacuum. Teachers are active facilitators before, during, and after gameplay. The curriculum materials provide a guide that teachers can follow for implementing the game and leading discussions and side activities, but they may choose to draw on it in part or not at all depending on the hardware and time available and the lessons they have prepared. While hardware availability sets some limits, *Reach for the Sun* can be played by the class on one computer, by small groups on multiple computers, or by students individually if enough computers are available.

Learning Objectives

Students will be able to use a model to explain plant structure, life cycles, photosynthesis, use of resources, and reproduction. They will understand the life cycle of temperate plants and how it relates to seasons. They will understand the resources plants need to survive and reproduce, the role of photosynthesis in plant growth, plant anatomy and the functions of plant parts, and the role of pollination in plant reproduction.

Target Population

Reach for the Sun targets 6th - 8th grade students in classroom environments.

Next Generation Science Standards (2013)

MS-LS1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms

MS-LS1.B:

- Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction (MS-LS1-4)
- Genetic factors as well as local conditions affect the growth of the adult plant (MSLS1-5)

MS-LS1.C: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-8) (NGSS Lead States, 2013)

Common Core State Standards

CCSS.ELA-Literacy.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Reach for the Sun Demo Video and Launch Page

A video demo of *Reach for the Sun* is available on the Filament Games website:

https://www.youtube.com/embed/ezAH_WY6a8I?rel=0&wmode=transparent&width=640&height=390&i-frame=true

Reach for the Sun can be played as part of the Plant Structure and Processes Unit in the PLEx Life Sciences Suite: <https://www.filamentgames.com/plex-life-science#learning-games>

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Acknowledgments

Filament Games would like to thank Curriculum Specialist Heather Wentler, and NSF Research Experience for Teachers (RET) Fellows Tammie Schrader, Cheney Middle School, Cheney, WA, and Kate Slabosky, Central Middle School, Columbus, IN, for their collaboration in the design and development of this game and game-based curriculum materials. Filament is also grateful for the playtesting and feedback from middle school science teachers in Bartholomew Consolidated School Corporation, Columbus, IN, whose efforts helped shape the game during development.

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Cellvival! Evolutionary Concepts as Playable Mechanics

Andrew Jefferson, Cornell University

Introduction

Cellvival! is a game designed to teach high school students biology, particularly evolutionary concepts in a highly engaging way. The player controls a single *Tetrahymena* cell (a common freshwater protist) as it tries to survive and maintain its population for as long as possible.

Context and goals

This game is distributed to students as part of a module that repeatedly cycles between playing the game and discussing and reflecting on the experience with the class. This gives students a chance to compare experiences and perspectives and bring those to the next round of play. It also gives teachers a chance to guide discussion, introduce ideas, and correct possible misconceptions (“The cell is making an intelligent choice during reproduction”, for example).

The learning goals include developing a better understanding of 1) the ecosystem *Tetrahymena* live in (what are its food, its predators, how do they interact), 2) selective pressures, 3) the accumulation of changes over generations, and 4) how fitness depends on environmental context. It is hoped that by presenting these concepts through the game in an experiential, integrated way and facilitating reflection on them, students will develop a deeper understanding of the concepts, intuitions based on that understanding, and a better ability to apply evolutionary reasoning to novel situations. The educational effectiveness of the game as part of a module, relative to other approaches to this material, is being evaluated by an ongoing research project.

Game play description

Players control a single *Tetrahymena* cell, using simple mouse controls, as it navigates the environment and reproduces (as seen in Figure 1).

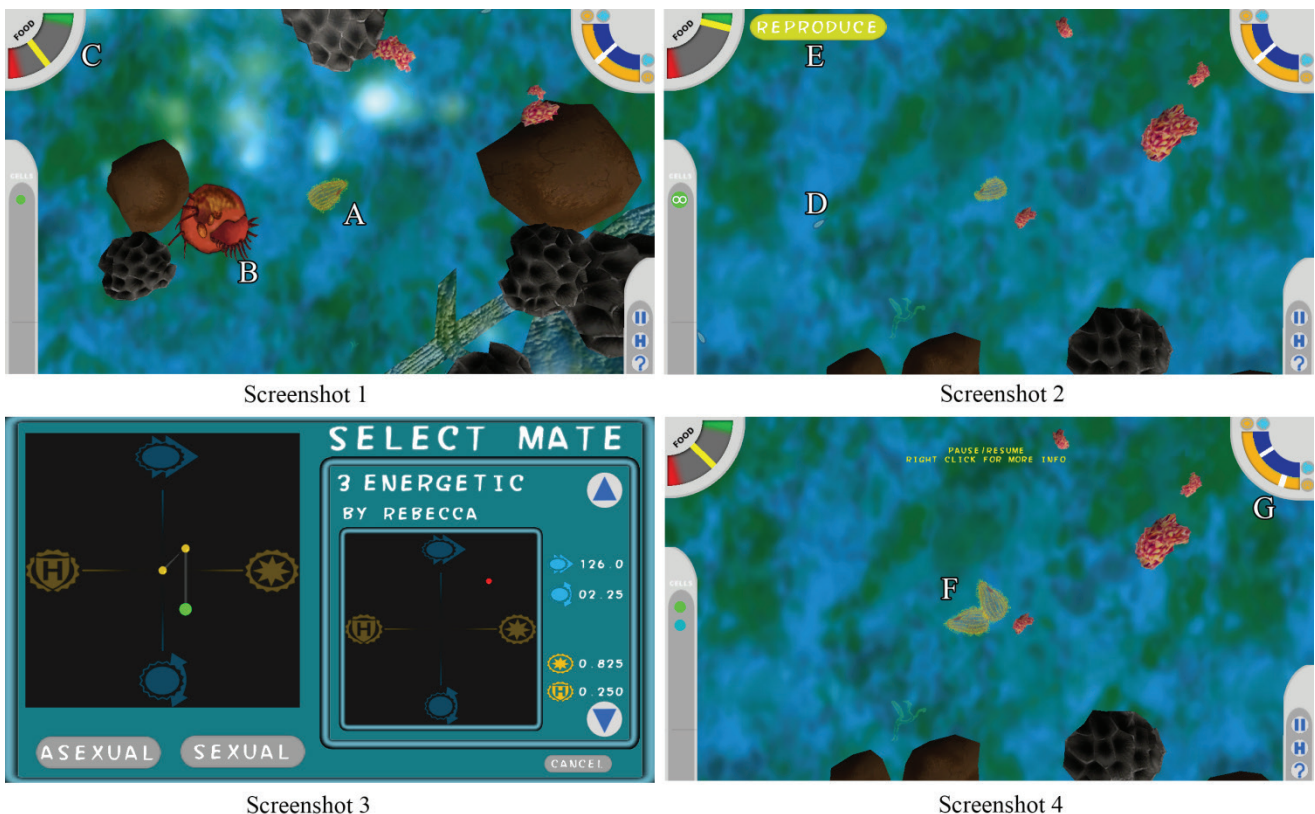


Figure 1: Annotated screen shots of game play.

The player's cell (A), must avoid predators (B) while trying to fill their food meter (C). When they have consumed enough smaller food bacteria (D) to fill their food meter, the reproduce button appears (E). This button takes the player to the reproduction interface (as seen in Screenshot 3), which gives them feedback about their cell history, and allows them to choose to reproduce asexually or sexually (as *Tetrahymena* can do both). If they reproduce sexually, they also have a choice of mates, which they can browse and select using the right side of the interface. Once they make their reproductive choice, they return to normal game play, now controlling the offspring (F) while an AI takes control of the parent cell. The change in the traits of the offspring is shown by an indicator (G) during normal game play, as well as the cell history graph during reproduction. Following reproduction, the player continues trying to survive and attempts to get enough food to reproduce again, either to alter their traits more or to get a larger population as both will help them survive longer.

Design considerations

Normal game play

The normal game play conveys a lot of information about the ecosystem of *Tetrahymena*, provides an immediately engaging experience, and provides a basis for more advanced concepts. The scale of controlling one cell (as opposed to a population) allows the player to invest and identify with that cell, and pilot testers often vocally enthusiastic about finding food and anxious when predators are near.

All the predators are based on actual predators (including their feeding behaviors) and they are kept to scale, relative to the player's cell. This includes one predator that is approximately 100 times as large as *Tetrahymena*, making it larger than the screen in game. Encountering it has proven exciting and memorable with pilot testers. The differences between predator behaviors and scales are made sharply salient by putting the player in the role of a *Tetrahymena* trying to avoid being predated.

The reproduction interface and graphs

One of the distinguishing features of *Cellvival!* is the "genespace graph" used repeatedly in the reproduction interface. These graphs use the cell's four traits to form a 2D space of all the possible cells. A cell's traits define a point in the space, and a cell with different traits defines another point; this means the change in traits across generations can be visually presented as a line. This allows the game to present the accumulation of changes across generations visually by plotting a path. Additionally the four traits all directly affect game play: move speed, turn speed, metabolism (the amount of food each prey is worth), and hazard resistance. This makes changes in these traits both very relevant to the cell's survival, and noticeable in play, even if the various indicators are ignored.

In the reproduction interface, on the left graph is the history of the player's current cell line, showing both the cell's current traits and the traits of past generations (which the player has experienced playing as). To the right is one possible mate and its histories and current traits, with an option to browse through others. Reproducing asexually produces more offspring for a larger population, but changes the cell's traits very little, while sexual reproduction allow for larger changes but creates fewer offspring (as in actual *Tetrahymena*). In this way the game demonstrates the pros and cons of both methods. It should be noted that if the player's cell dies, they are shifted to controlling any surviving members of the population, providing incentive to maintain a large, healthy population. Feedback on current population size is provided in the lower left side of the basic game play interface.

By having the player play as each generation, they experience how difficult it is to survive with one set of traits, get to change traits, then play more experiencing the impact of the changes on the difficulty or surviving in that environment. By letting players experiment repeatedly, the game attempts to convey how changes accumulate over generations and selective pressures work through game play.

Level design

Cellvival! currently has two non-tutorial levels, which are designed to favor different traits. These provide not only variety to the visuals and challenges, but can demonstrate how traits that are advantageous in one environment are detrimental in another; how fitness is context dependent.

Acknowledgements

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Ravenous

Jamie Larsen, EdGE at TERC
Erin Bardar, EdGE at TERC
Jodi Asbell-Clarke, EdGE at TERC

Think you are a smart biped at the top of your food chain? Re-skin yourself in black feathers and see if you've got what it takes to survive and fly the farthest in *Ravenous*. Get from here to there, find what you need to survive, avoid predators, and show you've got the feathers to hook up with that special "somebird." *Ravenous* encourages you to engage in the virtual to uncover how the real world interplay between adaptation, natural selection, and energy influence survival. Play like a bird, be the bird.

Introduction

Think life is tough? *Ravenous* portrays "nature red in tooth and claw," through a Raven trying to find and use energy efficiently, prove its fitness, and pass on its genes to the next generation. As you look out from your starting perch (see Figure 1a), how will you take advantage of the Raven's adaptations, honed over millions of years, which allow it to meet the challenges of its environment? Can you find the sweet speed spot where flying is most efficient? Will you make the right decision when to fly versus bide your time on the ground or perch? Will you replenish your energy stores by finding and eating food that meets your needs? The game, like life, can be unforgiving if you make the wrong decisions. As George Carlin said: "*Life is tough, then you die.*"

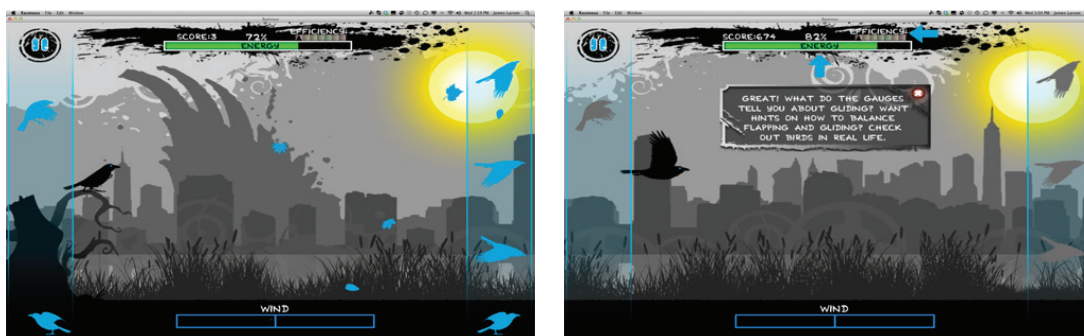


Figure 1: *Ravenous* a) Start of game and, b) Tutorial with efficiency and energy gauges

Ravenous is part of a larger suite of *Leveling Up* games—including *Quantum Spectre (QS)* and *Impulse*—being developed with support from the National Science Foundation. The focus of the work is to develop games that teens (and the general public) like to play in their free-choice time on mobile devices and the Web. They are also designed to show empirical evidence of fundamental high-school STEM content learning. The research around these games focuses on the development and validation of a set of game-based assessments using an indwelling model of tacit learning that emerges through game play (Polanyi, 1966; Thomas & Brown, 2011). Since their release, over 10,000 players have played *QS* and *Impulse*, and our research has shown that these games can improve science learning. In an implementation study with hundreds of high school students, learners who played the game *Impulse* and also had teachers who used examples from the game in class, showed higher gains on a pre/post test of Newton's laws of motion (Rowe et al., 2014).

About *Ravenous*

Ravenous is a side-scroller game, modeled after real world Ravens and specific adaptations that help them cope with the challenges of their local environment. Game play provides opportunities to uncover how these adaptations influence survival. The player controls various aspects of flight that include flying speed, gliding, ascending, descending, and landing. As the bird moves from left to right, the player must make decisions that influence the amount of energy used and available. For example, flying into a headwind or landing requires the player to realize there is a "best" strategy, just like in real life, that is based on energy cost that will impact their ability to survive and, subsequently, increase their score. As the game progresses, opportunities for replenishing energy, in the form of food, are presented that, depending on various conditions—current energy levels, difficulty of getting the food, or presence of predators—the player may or may not choose to utilize. Factors like predators, wind, thermals, or physical obstacles to avoid, which are part of the game environment, reflect real world environmental biotic and abiotic factors. The game challenges the player to uncover how the Raven's adaptations help it to use the available energy in the most efficient manner. Success is measured by earning points through distance flown before

running out of energy and dying. An added score multiplier is earned if the player has enough energy to find and mate with another bird.

The game, through a tutorial and in-game billboard “advertisements,” provides hints to players on how to improve play by going outside and observing birds. In addition, bridge activities (currently under development with input from teachers) will help players extend and apply their understanding of science concepts in the game. These activities will link the game to activities and observations of birds and their energy needs as they relate to survival in the real world.

Balancing Science and Learning with Game Play

The basic design of *Ravenous* started with attempting to model in great detail actual bird flight in a 3D game with the player having precise control of the bird and its behavior. Working with experts in the field of bird flight and behavior, and studying high-speed videos of Ravens and other birds in flight, it soon became clear that a Raven flight simulator was not possible for a variety of reasons. The development shifted to something more attainable given time and money considerations, a side-scroller, and efforts centered on staying true to the science of flight and bird behavior balanced with making the game fun to play. For example, it was important to the science for the game to include the understanding that Ravens, like most birds, have adaptations that define an optimal speed where they are most efficient for long distance flight. Balancing this with fun required us to keep the focus on flying, surviving, and interacting with the more engaging challenges of the game and include unobtrusive opportunities to link learning and game play. As such, the game has an efficiency gauge that appears only when appropriate to provide a hint to help the player make the connection between actions and energy use (see Figure 1b).

Developing the game, like in nature, resulted in many tooth and claw moments. But we survived to deliver *Ravenous* for testing in the classroom—a bit bloodied but excited about releasing it in the wild!

Ravenous Research

We are using *Ravenous* to test our assumption that we will be able to measure the development of players’ tacit understanding of the science concepts infused into successful game play. We expect to see that as a player hones in-game play strategies we will see improvements in understanding how the interplay of adaptations and efficient energy use are crucial to survival in Ravens, and by extension, all living things. For example, successful players, as measured by high scores for surviving longer and traveling farther, should show that they learned to take advantage of gliding rather than constant flapping, just as birds do in real life when they exhibit flap and glide strategies to minimize energy use. Data should show that the player takes advantage of flying with a tail wind or lift opportunities to save energy or avoid obstacles, and to land without crashing by positioning their wings to slow descent through stalling. We also hope to look at how connecting the game to outdoor observations improve game play as well as demonstrate application of in-game learning to understanding adaptations of birds other than Ravens.

Get Your Bird On

Ravenous extends our research, begun with the physics games *Impulse* and *Quantum Spectre*, to a more Biology infused side-scrolling game. To study players’ understanding of the concepts built into *Ravenous*, we are collecting and analyzing click-data as well as screen-capture video of game play and audio and video of players’ faces as they play the game as we did with other *Leveling Up* games. In addition, *Ravenous* offers an opportunity to connect the virtual to the physical world, through bridge activities, to see how observing real birds influences game play. Come play *Ravenous* to learn more!

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- Polanyi, M. (1966). *The Tacit Dimension*. London: Routledge.
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Go Extinct! Go Fish... Evolved

Ariel Marcy, Stanford University

Abstract / Introduction

Go Extinct!, a *Go Fish*-style card game, teaches players how to read evolutionary trees as well as land vertebrate natural history. Instead of collecting sets of numbers, however, players collect closely related groups of animals, called clades (def: all of the animals that descended from a common ancestor). Winning requires players to understand the hierarchical structure of evolutionary trees while the game's vocabulary emphasizes traits that scientists use to classify vertebrates in the tree.

Over 200 students, ranging from 5th grade to college undergraduates, have played versions of the game. Afterwards, students are able to define a clade (an important concept in biology) and make evolutionary observations such as, "Chickens are dinosaurs and we've been eating them!" One middle school explored evolution by creating expansion packs for *Go Extinct!* Students successfully incorporated mechanics about catastrophes and geologic ages as well as adapted the game for more specific groups of animals, like the cat family.

Gameplay and Science Pedagogy

Go Extinct! builds off of the basic rules of the traditional card game, *Go Fish* by incorporating an evolutionary tree game board (Figure 1) and a deck of animal cards (Figure 2).

Teaching Players How To Read Evolutionary Trees

In order to gain cards and complete clades, players can ask other players for any category of card on the tree. For example, a player trying to complete the Terrible Lizard clade, could ask for a Stegosaurus specifically, any Terrible Lizard, or an even deeper clade, such as the Toothy Grinners. Since a player gets only one card from the other player, it is often in their best interest to ask for more general categories. If the player has cards in the Terrible Lizard and the Croc clades, they would be more likely to get a useful card if they ask whether the other person has any cards in the deeper clade, Toothy Grinners because it includes both Crocs and Terrible Lizards (see Figure 1). This winning strategy encourages players to search for common ancestors between any two cards in their hand, organically teaching them how to read evolutionary trees and to understand the tree's hierarchical organization.

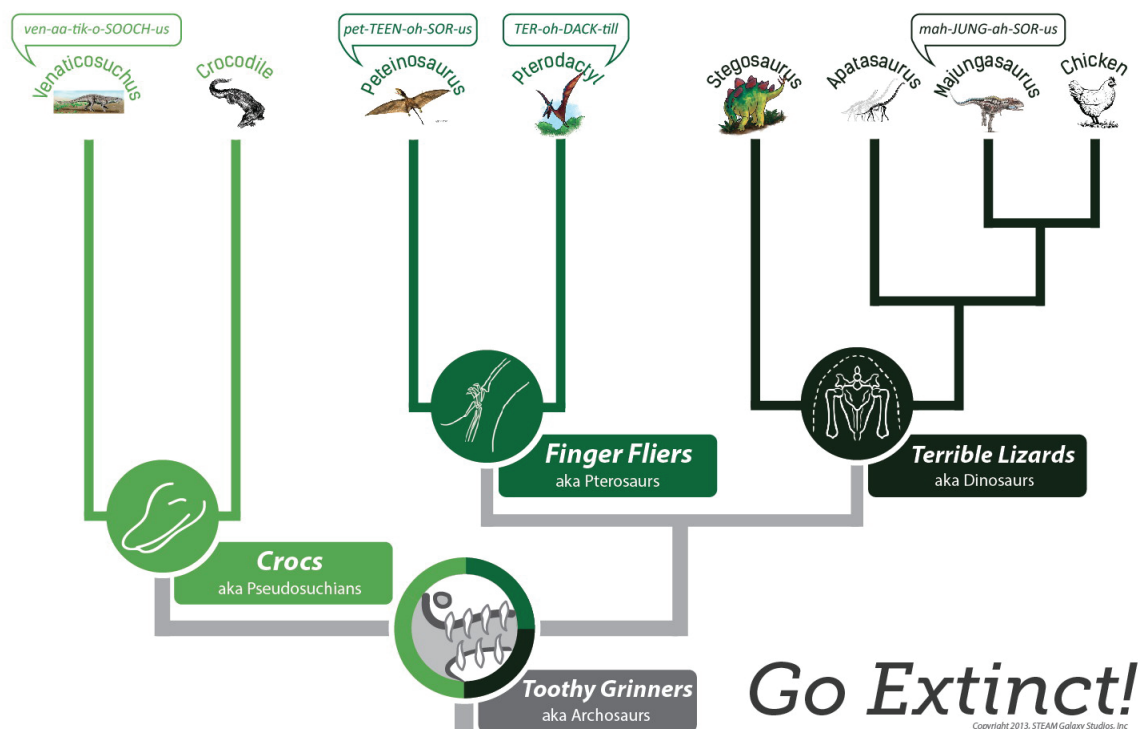


Figure 1: A Portion of the *Go Extinct!* Evolutionary Tree. Teaching Players About Land Vertebrate Natural History

The names of the clades, such as “Terrible Lizard” for Dinosaurs or “Warm Fuzzies” for Mammals (see Figure 2) either translates the scientific name into English or captures an important trait unifying that group (i.e. Dinosaur means Terrible Lizard from Greek roots; Mammals are both warm-blooded and have fur/hair). By using these fun nicknames to ask each other for cards, players associate certain traits with certain animals. For example, many middle school students who played *Go Extinct!*, were surprised to learn that “Fur Scrambles” are mammals that still lay eggs.

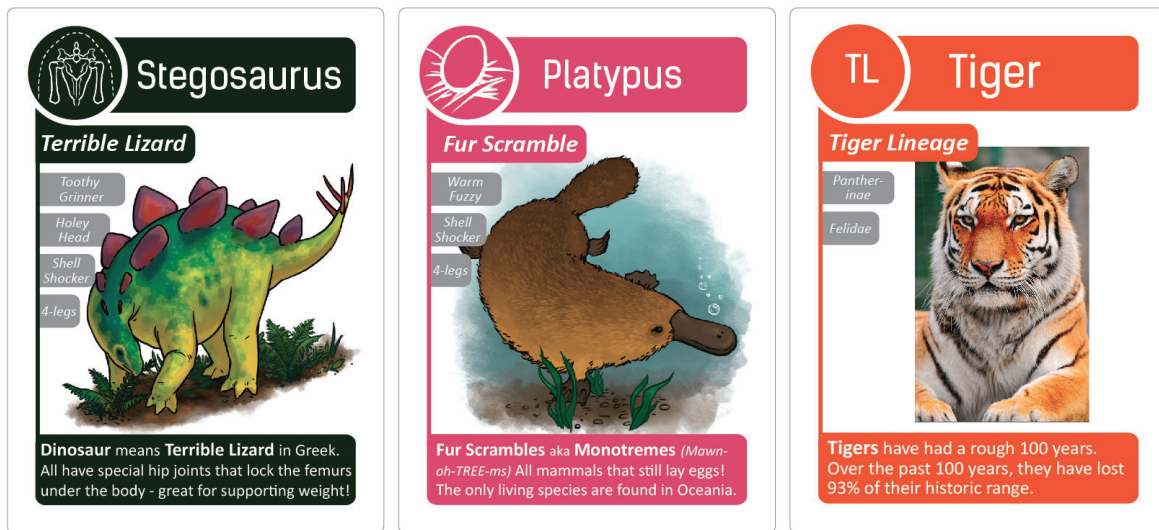


Figure 2: Examples of *Go Extinct!* Animal Cards; the Tiger card is student-created.

Incorporation in the Classroom

Over 200 students, ranging from 5th grade to college undergraduates, have played versions of the game. The most successful implementations used the game to introduce an evolution unit. We worked with one middle school, San Francisco Brightworks Academy, over the past two months to challenge students to create expansion packs as a long-term project on evolution. Students created expansion packs that added onto to the basic *Go Extinct!* deck with Geologic Age cards that limited the clades you could play based on when they evolved, as well as catastrophe cards that caused special events to happen. The mechanics they chose for these cards reflected knowledge they gained about how different geologic time eras impacted animal evolution and how catastrophes might impact one group of animals more strongly than others. Another student created an entirely new *Go Extinct!* game based on the phylogenetic tree of the cat family, Felidae. She used a scientific paper and chose cats that best represented the lineages specified by the paper’s genetic analysis and then researched facts and creative commons images to complete each card (See the Tiger card in Figure 2).

Links to More Information and a Playable Demo

Go Extinct!’s Facebook page: <http://www.facebook.com/GoExtinct>

Go Extinct!’s successful Kickstarter Page: <https://www.kickstarter.com/projects/aemarcy/go-extinct-go-fish-evolved>

Go Extinct! Next Generation Science Standards Alignment documentaton: <http://bit.ly/QnJOrG>

A blog post written by middle school students about playing *Go Extinct!* for the first time: <http://www.sfbrightworks.org/2013/12/siphon-go-extinct-timeline/>

The Google folder containing the rules as well as the print-and-play files for the most recent version of *Go Extinct!* (May 2014): https://drive.google.com/folderview?id=0B49HnPtCPjzakNLUmc2dGF2V00&usp=drive_web

Acknowledgments

Many thanks to KIPP San Francisco Bay Academy and San Francisco Brightworks Academy for allowing us to come in to do extended playtests with students. A huge thanks to teachers, Melissa Crosby, Danya Clevenger, Phillip Filastre, Christie Seyffert, Tracy Trimpe, John Stapleton, Stephen Taylor, Maribel Pregnall, Barbara Marrs, Prof. Elizabeth Hadly, and Prof. Jessica Martin for incorporating the game the game into classes and/or giving pedagogical feedback. Many thanks to Vanessa Kerr and Charlie Chung for their help every step along the way of creating this game. Artwork for cards created by Anita Tung.

The Gravity Ether: A Physics Simulation Game With Level Editor

Kevin Miklasz, Iridescent

Description of Game

We will present the *The Gravity Ether*, the second in a planned six-game series of physics simulation games designed to help middle school students develop an intuitive understanding of complex physics concepts through experiential play (Figure 1). *The Gravity Ether* explores concepts related to forces in space, like the relation between force and distance or the speed and radius of orbits. Players can only interact with the objects in the game (namely, planets) indirectly by adding and removing black holes to create gravitational fields. Thus, becoming better at controlling objects in the game is directly related to more thoroughly understanding the nature of gravitational forces. By more accurately being able to control the motion of planets, players can accomplish simple level objectives like breaking blocks and collecting coins. *The Gravity Ether* integrates physics learning directly with gameplay, with levels and goals that are designed to highlight core concepts. With an appealing sandbox and a safe environment for experimentation, the game provide students an open and undirected opportunity to observe and interact with complex forces that are difficult to demonstrate in the traditional science classroom.

The games breaks up the more free-form, open sandbox levels with a few very directed and constrained “challenge levels.” These levels are focused on a particular concept, and typically only have a few ways that they can be solved. They act as a very explicit test of a particular concept, drawing a player’s attention to aspects of the simulation that they previously may have taken for granted, like how planets of different sizes generate different gravitational forces. This both allows students to notice and reflect upon physics concepts in the game, as well as very explicitly testing their understanding of those concepts in a puzzle-like task.

Students can create their own content in the game using a robust and intuitive level editor (Figure 1), and then publish that content for anyone to access and play. This promotes engagement and teaches students through the active process of creation. We consider the level editor to be the most valuable learning component to the game. By forcing students to balance competing design elements and work within the simulation’s constraints, they will be asked to engage in systems thinking, problem solving and demonstrate a deep understanding of the physics concepts involved in the game. The level editor also increases the game’s potential for innovative use in the classroom: student-created levels can be used in science classrooms as a vehicle for synthesis and analysis of a complex topic. This can support project-based learning, and the delivery of complex projects rather than standardized test questions as a demonstration of understanding.

The Gravity Ether also has embedded assessment capabilities; as players go through the game, the game will collect data about play performance (e.g., what level components they create and test, how they redesign levels, etc.). Educators can access data from their student’s gameplay through a web interface (Figure 2). We plan to use this data for assessment purposes, and we are looking forward to discussing possibilities for how to analyze this data or how best to present this data back to students for feedback with GLS attendees. In particular, we are interested in using the game to assess skills like persistence, creativity, and problem solving, as well as the more obvious content knowledge around gravitational forces.

The Gravity Ether is designed to reflect Iridescent’s overall learning philosophies, including learning by doing, learning in a goal- and task-oriented environment, using open-ended challenges, creating a safe environment for failure and encouraging performance before competence. Tools with these attributes can promote self-directed learning and scaffold more innovative and student-oriented classroom practices. These games were in part designed as a vehicle to bring our learning philosophy into classrooms and other educational environments.

Additional links

The Gravity Ether is freely available as a desktop download from Iridescent’s website, at <http://iridescentlearning.org/ethers/gravity/>. It can also be downloaded for free from the App store for iPhones or iPads at <https://itunes.apple.com/us/app/the-gravity-ether/id721028894?mt=8>.

For a demo video of *The Gravity Ether*:

<http://www.youtube.com/watch?v=l0DIU1hmZiw&feature=youtu.be>

For a video showing how students create levels for a similar game in the series, *The Fluid Ether*:

<http://www.youtube.com/watch?v=DcJJ2t9S1Z0>.

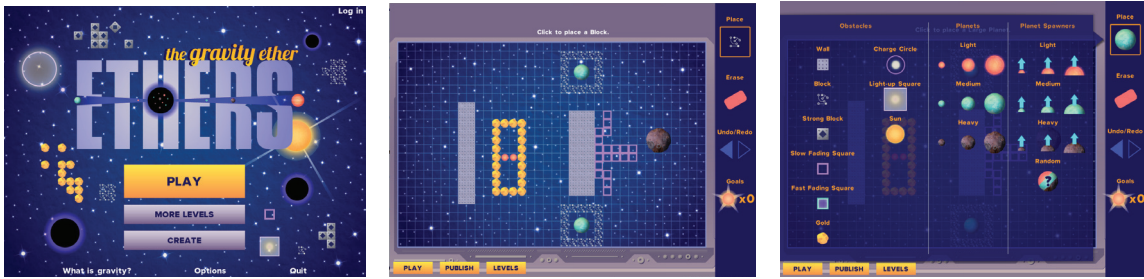


Figure 1: The Gravity Ether screenshots.

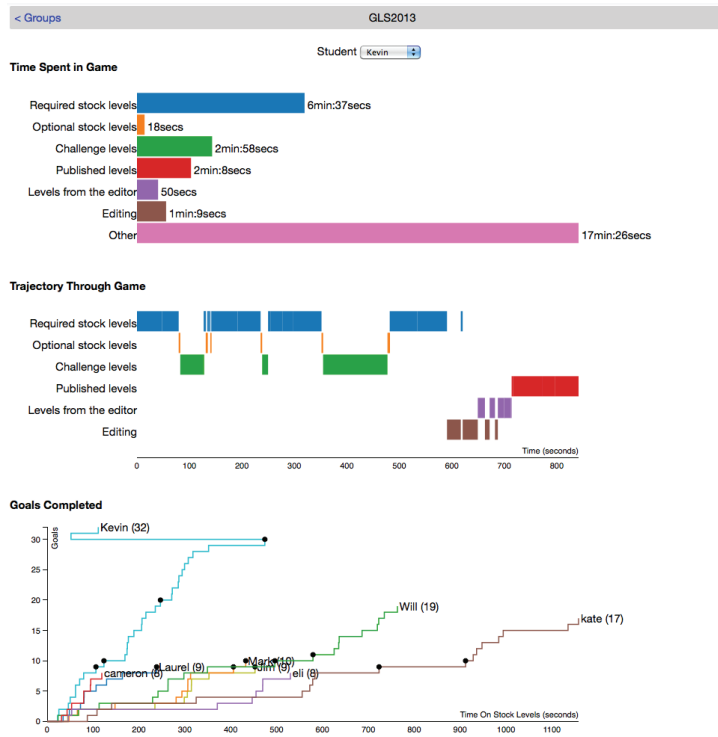


Figure 2: Screenshots of the educator interface, showing gameplay data.

Acknowledgments

Robot Super Brain was the game developer, also offering valuable game design support. Ioana did a spectacular job on the graphic design of the game. This game is made freely available with generous funding provided by the Hive Digital Media Fund of the New York Community Trust, and the Office of Naval Research.

NELL: A Game based Approach to Neuroplasticity in Early Language Learning

Bert Snow, Muzzy Lane Software
Cynthia Barrios, Muzzy Lane Software
David Martz, Muzzy Lane Software
Jeremy Monken, Muzzy Lane Software
Kennedy Schulz, Explore-a-World

Project Objectives

For decades, studies have shown that young children have a unique ability to rapidly acquire new language skills. Today's researchers from neuroscience, psycholinguistics, and second language acquisition have been able to locate the biological foundations of this ability and measure the cognitive benefits associated with it, gaining a better understanding of the brain processes and the overall benefits bilinguals exhibit in executive functioning and general learning.

The NELL game aims to create an interactive game for children ages 6-9 that will immerse them in a naturalistic language environment in order to enhance their ability to distinguish new sounds and structures, helping to 'prime the brain' for language learning experiences. Research shows that when specific language learning pathways are established in the brain at an early age, those pathways can facilitate the building of new language connections later in life.

We hope to replicate the thinking process that young bilinguals experience: balancing knowledge of two different languages at the same time and having the mental flexibility to choose between them in a given situation. Neuroplasticity in Early Language Learning (NELL) will provide players with practice in these mental balancing skills by focusing on a variety of unique sounds and grammatical structures from several stylized languages in order to generalize the learning behaviors involved in natural language acquisition.



Figure 1: NELL game screen showing language interaction

Language Interaction Goals

To meet our goals, we need the game to create a series of specific language interactions. We wanted these interactions to emulate the natural-language learning experiences that young children might experience. From the following list of language-interaction goals, we developed targeted game mechanics:

1. Hear distinctions between similar sounds, especially sounds not present in English
2. Pick out familiar words and phrases in a natively-spoken sentence
3. Use context to determine what is being said

4. Recognize patterns in the language and apply them
5. Use novel grammatical structures (different from English)
6. Develop sensitivity/ear for tones as potential components of phonemes
7. Sort and make meaning from input from different languages (as a bilingual does)

NELL Game Design

Overview of Game Mechanics

The game provides challenges where players will engage with and learn a game pseudo-language in order to interact and communicate with friendly “aliens”. Within this context, we have developed sets of game mechanics that create specific natural-language-learning experiences, including:

- Listening to and identifying novel syllables and phonemes sounds (with non-English characteristics), and “collecting” sounds
- Combining sounds to create words that describe objects in the game environment
- Listening and Identifying known words within sentences spoken by “aliens”
- Use known words and context to understand meaning of friendly alien’s statements
- Develop awareness of differing grammar systems among languages by comprehending and constructing statements using simple grammar and word order

Player Role, Game Story and Gameplay Summary

In the game, players assume the role of a space explorer. Arriving at a new planet, they receive a message in an unknown language. Unable to understand the message, the player descends to the planet and, with the help of a Computerized Human-Alien Translator (“CHAT”), the talking computer in their spacesuit, the player interacts with friendly aliens on the planet to learn some of their language, and decode the messages.

The game features multiple planets and aliens, each with different languages – so players will have the chance to compare and work with sounds and structures across multiple languages. This experience with multiple languages has been shown to be a factor in bilingual children’s abilities to more easily learn additional languages. The game will provide multiple ways for players to interact with language fundamentals with the aliens, starting with learning phonemes, then putting those together to form words, learning the meanings of words from the aliens, and working out how the words go together in different ways to form simple questions and statements.

The completed game will utilize voice recognition to enable players to actually “speak” alien words as part of the gameplay. In multiplayer mode, two players will communicate with each other (in the “alien” language they have learned) to complete tasks together.

Computerized Human-Alien Translator (“CHAT”)

The player’s suit has a friendly onboard computer AI that communicates to the player about objectives and gives them tips on what they might be doing wrong when communicating with the alien. CHAT is encouraging and helpful without being condescending and serves more as a friend to the player than a teacher. CHAT will be the source of any in-game tutorials on how things function, as well as being a source of subtle hints, and constructive reinforcement. CHAT will provide commentary and point out things we want the player to pay attention to as they play the game. CHAT will be the voice of the game and communicate anything we need to the player.

Interacting with game Pseudo-languages

The game aims to engage students in natural-language-learning experiences with several different “alien” pseudo-languages. The pseudo languages will be the languages of “alien” creatures in the game.

- The pseudo languages are strongly based on real languages
- Sounds and phonemes come directly from the language.

- Grammar structure is taken from the real language
- It is important that the pseudo-languages differ from the real language in some ways:

Gameplay Levels

The game has a series of Levels that lead students through an ordered sequence of language interactions so they build on vocabulary and skills to take on more complex language challenges in the Alien game-languages. The activity for each Level are repeated with variations for each new Alien language and set of Aliens the player encounters.

Level 1: Identifying sounds, constructing and learning words.



Upon landing on the planet, the player meets and can talk with an alien. The alien speaks a simple, complete phrase which the player, naturally, can't understand. CHAT is encouraging, and suggests a way that the player can learn some alien words (with the alien's help):

- The player collects images by looking around their surroundings and tapping on them. Images without words are added to "unlearned words" collection. As the Alien speaks, each sound they speak is added to the player's Sound Inventory. These sounds will be shown as symbols on Sound Tiles.
- The player drags these tiles to try to match the sounds the alien has spoken. When the player gets the sounds right, the alien gives a happy response, and the word is added to the player's Learned Words. (The aliens give humorous responses and reactions to "wrong" sounds.)

Level 2: Identifying words in natural speech

Once the player has learned some words, they can try identifying them in phrases the alien speaks:

- When player hears a word they know in a sentence spoken by an alien, they can speak it back to the alien and tag that part of the sentence with the image that represents the word.
- Once the player has tagged all the learnable words in a sentence, CHAT will help the player work out its meaning.
- Through this process, players will recognize different sentence structures and grammar rules that overlap between alien sentences. Once the player has learned all the words and spoken to each Alien and under-

stands their sentences, they will be able to translate the message they received on the spaceship. The message will lead them on to the next challenge in the game.

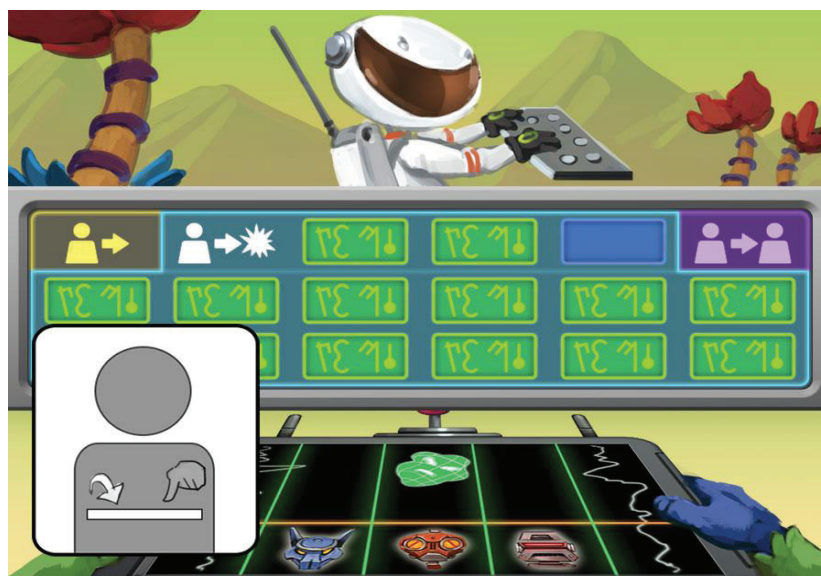
Levels 3 and 4: Intrinsically Learning Simple Grammatical Structures

In Levels 3 and 4, players will work with different kinds of grammatical structures to help their alien direct a trio of robots to carry out an important task. Our goal is for players to understand through experience that different languages use different word orders and structures to construct meaning, and to look for those differences. The player will be required to learn a few words throughout gameplay. This includes the names of the three robots climbing the walls, four verbs, two adverbs (up and down), and an additional noun (zapper). These 10 words can be combined in many ways to represent the grammatical variations listed above. Studies with children have shown success in implicitly teaching grammar with a limited vocabulary so that the learner quickly begins to process the input like a native speaker (Lichtman, 2013). This game will make use of that method.

Later in the game, the player and alien will “switch”. The player will see a radar-like readout of the mountain that clearly shows all of the obstacles. They will then give instructions to the alien using the alien language. This will either be done using voice recognition software, or by using a modified version of the syllable palette.



Level 3: The player controlling the robots will see a control panel with a series of images representing the different robots and a series of images representing the actions the robots can perform. Listening to the player with the radar, they will translate what’s being said into commands they will input with the control panel buttons.



Level 4: The player lowers their tablet and sees a selection of alien words and grammatical structures where they can plug those words in. The player will use the information gained by looking at their radar to give directions to the other player controlling the robots.

Testing and Assessment Plan

In the Testing and Assessment phase (Task 2), we will evaluate neuroplasticity using behavioral and physiological measures, before and after students work with the NELL game software. The following section describes the Assessment and Testing in detail.

Language learners at higher levels of proficiency are capable of displaying behaviors and patterns of brain activity that resemble those of native speakers, suggesting that the neural substrates supporting language processing can be modified during the long-term learning process (e.g. Stevens & Neville, in press). Our plan of research identifies how these neural pathways are established, seeks ways to exercise them through a game design, and then assesses how well our prototype achieved the goal of improving cognitive flexibility.

Given our understanding of neuroplasticity, we are focusing on evaluating the project's effectiveness using cognitive measures which directly relate to language learning. We identified these factors based on studies which delineate the cognitive advantages of bilinguals over monolinguals. These studies found that bilinguals demonstrate increased abilities in learning additional languages later in life, including:

- increased metalinguistic awareness;
- increased ability to tune out distractions,
- focus on relevant information, and maintain information in working memory (elements of Executive Function) and;
- an ability to balance multiple language forms simultaneously in order to communicate effectively in a given situation.

While these cognitive functions are not exclusive to language learning, their combined effects contribute to language learning success. We anticipate employing a mixed methodology that encompasses pre- and post-tests of executive function and metalinguistic awareness, and student interviews to evaluate learning strategies as they engage in the project. In addition, event-related potential (ERP) studies measure brain responses to audio and/or visual language input both pre- and post-game exposure.

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Accessing the Game prototype

We are interested in getting feedback from interested parties on the NELL prototype. Please email Bert Snow at bert@muzzylane.com to get a link to the prototype.

Practice Spanish: A Task-Based Immersive and Mobile Language Learning Game

Bert Snow, Muzzy Lane Software

Game Design Overview

The PracticeSpanish game is designed to provide additional practice for first year Spanish students. The game uses a Task-based approach to language learning - students will first prepare their language skills for a task, and then use that language to carry out meaningful tasks in contextual situations communicating with game characters in immersive scenes. The game will support single-player play, with optional multiplayer experiences available.

The game consists of several primary parts: an immersive, interactive 3D game- **the Main Game** where the player will accomplish tasks by using their knowledge of Spanish; and a series of phone-based **Pre-Task Games** where the student will practice the skills they need to succeed in the adventure game.

The student's experience and progress in the Pre-Task games and Main Game will be controlled and motivated by a **Metagame**. This metagame will control unlocking of Tasks in the Main Game, scoring and points, student advancement, and adaptive capabilities to direct students to Pre-Task games for additional practice where needed.

The Metagame will be run from the MH Practice website, and progress information and feedback will be given there. the MH Practice site will also provide Instructor tools and reports and Student feedback and tools, as well as controls to set up multiplayer play.

Immersive Task-based language learning Game: Study Abroad Adventure

The core of Practice:Spanish will be an immersive task-based language learning game. Students will complete a series of Task-based scenarios which will take place in immersive 3D game locations set in appropriate cultural locations. Students will customize and control an Avatar, taking on the role of a student studying abroad, facing the challenges of travel abroad and taking part in adventures with game characters in locations in South America and Spain. The game will include useful real-world travel-abroad interactions including travel communication, meeting families and friends, and more.

The game will include 16 Task Activities in which the student must uses language and language skills to complete a useful, meaningful task.



Figure 1: Constructing conversations in quest-based game environmen

The game will use a set of mastery-based language-interaction mechanics, where the student must use and prove vocabulary and grammar skills to complete tasks and advance in the game. Many of the language interactions will be with computer-controlled game characters, and it will be possible to play the entire game as a single player. Optional multiplayer game features will also be available.

Pre-Task Games

Practice: Spanish will include Pre-Task preparatory games designed to run on iOS and Android smartphones. These will be designed to provide adaptive vocabulary and grammar practice to prepare for Task Based Scenarios in the Main game. There will be two Pre-Task game types, each designed to support a variety of vocabulary or grammar content. For each Task in the Main Game, there will be a “set” of one or two Pre-Task games outfitted with the vocabulary and grammar content needed to prepare for that task.



Figure 2: Mobile pre-task games prepare players for the Quest

How the Study Abroad Adventure and Pre-Task games work together

Players play the Pre-Task games in order to practice the language skills necessary to successfully complete the Scenarios of the Study Abroad Adventure. When a player has demonstrated mastery of the targeted Spanish vocabulary and grammar by playing the Pre-Task games, the associated Task unlocks. Once the player has completed this Task, the Pre-Task game for the next Task can be unlocked. Each Pre-Task provides new vocabulary and grammar topics for the student to practice, and then apply in the following Task.



Figure 3: Screenshot from Quest 1 showing Goals and Mastery Mechanic.

Education Arcade: Build-a-Tree

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Florian Block, Harvard University, MA
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Abstract

In order to increase public understanding of evolution and life on earth, a team of computer scientists, biologists, learning scientists, and museum staff partnered to create *Build-a-Tree* (BAT). BAT is a multi-player puzzle game played on interactive tabletop surfaces in natural history museums. BAT has been on display at the California Academy of Sciences since October 2012 and has been played by thousands of visitors. It was developed to help players understand the proximity and distance of species relationships through their shared—and not shared—traits. In order to level up, players must drag-and-drop icons to assemble scientifically-valid trees that show particular species inheriting certain traits while others do not. BAT is designed to encourage experimentation, collaboration, and reasoning about the evolutionary relationships between species. See a video demo of the game here: <http://vimeo.com/97068984>.

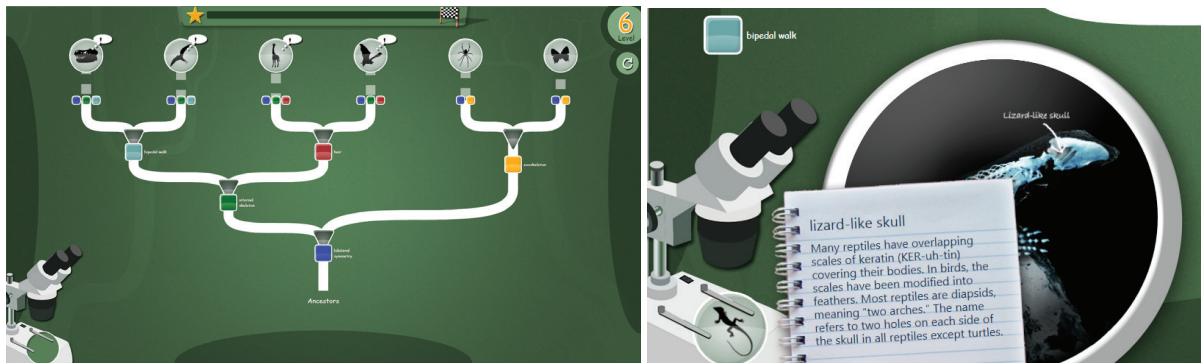


Figure 1. Build-a-Tree is a multi-level phylogenetic tree-thinking game with a microscope tool (right) that helps players learn more about the organisms in the game and their shared traits.

Evolution in Everyday Life

Evolutionary theory is a central organizing principle of modern biology and has far reaching implications. For example, recent innovations in farming methods have their origins in our knowledge of evolutionary principles (Forbes, 2006). The increase in pesticide-resistant agricultural pests is the direct result of natural selection; this has informed the design and development of new pesticide formulations intended to protect crops from insects and disease (Forbes, 2006; Driver, Leach, Millar, and Scott, 1996). Evolutionary concepts such as adaptation and mutation have also helped to answer many questions about diseases such as influenza, HIV, and cancer and have led to the identification of new drugs that assist in both detecting and treating these diseases (Forbes, 2006; Smith, 2010). Unfortunately, repeated studies have shown that the general public has difficulty understanding and accepting the basic mechanisms of evolution (see Rosengren et al., 2012).

Interactive Tabletop Surfaces

Interactive tabletops have gained increased attention in recent years and researchers and educators alike are interested in their use for science learning. Tabletops allow multiple users to interact concurrently, which supports collaborative learning. The tabletop's ability to "support awareness of other's actions and [their] ability to support concurrent input" gives agency to every engaged learner while providing incentive for individuals to interact with each other (Rick, Marshall, and Yuill, 2011).

Build-a-Tree: In Action

Build-a-Tree is an interactive, tabletop puzzle game that tasks players with building an accurate evolutionary tree (also known as a cladogram). The game provides players with circular species tokens, square trait tokens, and triangular branching tokens (see Figure 1). A microscope is also available for the players to use at their discretion; when a species token is placed onto the microscope, information about that species' traits, along with images, is given to the player (see Figure 1). Players must build trees step-by-step, creating branches then placing species and trait tokens on those branches based on the traits they have in common.

When a trait is correctly "inherited" by a species, the species token displays a green check mark and a star appears in the progress bar at the top of the screen. Otherwise, a red X pops up on the species token. If a species is missing a trait, it will display a black exclamation point. There are no points or progress lost for incorrect trees, nor is there a timer to limit gameplay at any level. This encourages players to experiment without fear of being penalized. Players are thus free to rearrange tokens and debate the arrangement of species and traits amongst themselves, encouraging collaboration and dialogue that lead to the construction of scientifically-valid trees, allowing them to move to the next level.

This version of BAT is a second revision based on the results of a comprehensive research study that demonstrated the need to make traits more explicit in the gameplay. We are currently testing BAT with museum visitors. While we are still in the preliminary stages of our evaluation, we look forward to sharing our initial findings with the GLS community.

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Collapse of Rome

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Overview

Collapse of Rome is a PC based educational strategy game designed to complement an academic unit on the Roman Empire, either as a classroom station or enrichment activity. Game play begins at the start of Rome's "Crisis of the Third Century", and ends at its conclusion upon the ascension of the emperor Diocletian in 385. Players have the option of continuing to play until the year 476 AD, when the Western Roman Empire finally collapsed.

Download Link

<http://mrwrightteacher.net/rome/download.html>

Video Tutorial

<http://mrwrightteacher.net/rome/tutorial.html>



Figure 1: Screenshot

Gameplay

The game play is similar to that of the board game "Risk", so it is very easy to learn. The interface is simple click and drag: Left click and drag moves a legion, right click ends the current turn. The goal of the game is to maintain control over as many provinces as possible. Each turn, provinces controlled by the player pay taxes and raise legions. The player uses these legions to attack enemy held provinces or defended against attacks from Rome's enemies. The enemies in this game are the various "barbarian" tribes along the Rhine and Danube, as well as the Sassanid Persian Empire in the east. Occasionally, legions will rebel and the player will lose control of them and the provinces where they are located. The empire can also be hit by plagues which halt tax collection and the creation of new legions. The player wins by controlling at least one province in the year 285 AD (fifty turns). The play cycle is designed to be short, so that a game can easily be completed within one class period, although it does support saving and loading games.

Educational Goals

Gameplay is designed to convey the learning objectives a teacher would build into a unit on the end of the Roman Empire. The best way for a teacher to gauge whether the game is achieving the educational goals is to ask the students about the gameplay, either directly or through a short reflection piece. They will usually complain that it is frustrating because they are constantly faced with rebellions and invasions, but never have quite enough resources to deal with them. If a student can articulate this, that student has identified the situation facing the Empire. After playing the game, a student will...

- be able to locate provinces in the Roman Empire.
- be able to name the Empire's most and least valuable provinces.
- be able to name Rome's primary adversaries during the 3rd century.
- be able to list ways in which plagues effected Rome's ability to defend itself.
- be able to identify regions of the empire where rebellions typically occurred.
- be able to experience the difficulty of meeting multiple threats simultaneously.

Game Mechanics

Collapse of Rome was designed to let the player experience the broad range of difficulties which the Roman Empire faced from the third century until its final fall. Toward this end, the game simulates the following historically accurate behaviors.

- Provinces will automatically pay tax and raise legions.
- Legions will demand donatives (cash bonuses), draining the treasury.
- Plagues will periodically halt tax collection and the recruiting of legions.
- Legions which win battles will occasionally rebel.
- Legions will disband if there are insufficient funds to pay them.
- Barbarians and Sassanids will invade from the north and east respectively.
- Peace along the Rhine/Danube frontier can be secured by paying tribute to the Germanic tribes.
- Losing control of North Africa will result in food riots in Rome.
- Losing control of Italy will result in the treasury being looted.

This game was designed based on my own experience working with middle school students as well as several research articles on educational gaming. It is designed to be easy for non-gamers to learn, yet challenging for students who may already be accomplished gamers. Integral to the game are concise history lessons which activate when the game turn corresponds to an important year in Roman history. These history lessons have audio narration so that below grade level readers can still learn the material. Gifted and talented students can use the map editor to create historical or counterfactual scenarios and then play them, or simply play the built in historical scenarios. The game is coupled with an online study guide and a quiz which can be used as a pre-test and post-test. A set of debriefing questions is provided in the download area of the game's website (<http://mrwrightteacher.net/rome/download.html>) to help the teacher facilitate a discussion tying the experience of game play to the text-book material.

Micropresentations

Growth, Reproduction, and Environmental Stress: The Evolution of a Botany Game in Response to Rapidly Changing Conditions

Arthur Low, Filament Games
Trevor Brown, Filament Games

In an age where many students are hard-pressed to identify even the most common garden vegetables, relating complex concepts like photosynthesis and pollination to a middle school audience is no small task. *Reach For the Sun* aims to do just that by exposing students to a simplified model of a highly identifiable annual plant growing from seed to mature fruit-bearer over the course of a single growing season. In our presentation, we will explore the unexpected evolution of our game's design in response to two starkly different play environments: a typical middle school classroom and Valve's juggernaut release platform, Steam. While we have no hard data to present, we do offer engaging anecdotes that raise important questions about how player expectations and environment impact a game's learning potential.

Reach For the Sun was designed to introduce middle school students to basic concepts of plant function and anatomy. Our design team constructed a simplified plant model with resource management-style gameplay to support one of our primary learning objectives: that students understand the importance of key resources in the growth and reproduction of photosynthesizing plants. Players engage with the system by making strategic decisions about where and when to expend energy. Crucially, players must choose when to transition from resource acquisition to reproduction. If they wait too long, they may reach the end of the growing season with huge quantities of resources but no mature seeds. Players are exposed to concepts of pollination, photosynthesis, and seasonal growth along the way.

Early on in the design process, we considered turn-based gameplay, but ultimately decided against it due to assumptions about our target audience. In particular, we were concerned that students playing at school may lose interest in the game if we failed to keep them constantly engaged. Our solution was to require players to click on leaves and roots throughout the growing season to maintain photosynthetic processes.

Our first in-school playtest revealed that the game was too difficult for both students and teachers. Students struggled to collect sufficient resources to produce a fruit before a killing frost terminated their plant. Teachers were befuddled by the (intentionally) sparse user interface, and seemed equally frustrated by the relentless pace. Unfortunately, we failed to take into consideration the expectations of our audience at this critical juncture. Instead, we focused on the symptoms: our players found the game too difficult, so we made it virtually impossible to fail. We hoped that by removing the pressures of success from the game, we would allow players to spend more time thinking about how plants grow and reproduce. What we were really doing was tuning the game to non-gamers.

Six months after our second release, Steam presented us with the opportunity to bypass their "Greenlight" process. As one of the first overtly educational titles on the distribution platform, we were unsure how gamers on their home turf—far removed from a structured classroom environment—would receive the game. Our only reviewers had been game-centric educational media bloggers, and some of our number were concerned that gamers accustomed to triple-A production values and conventional mechanics would balk at our unique take on the resource management genre. We placed the game in Steam's "casual" catalog in an attempt to connect with gamers accustomed to shorter titles and unconventional gameplay mechanics, but we neither obscured nor called attention to the game's educational nature.

Within hours of the game's release on Steam, the community began to respond. Within a matter of days we had received more direct feedback to *Reach For the Sun* than we had gathered in the year and a half since our first release. But it was the nature of the feedback that surprised us most. Instead of dismissing the game as edutainment as we had feared, the vast majority of negative reviews focused on one of two problems: excessively click-happy gameplay and insufficient strategic depth. Our Steam audience, accustomed to games that demanded mastery of mechanics in order to succeed, found *Reach For the Sun's* predetermined win state anticlimactic at best. A handful of players commented on the game's educational bent, but critics and supporters alike judged the game on its entertainment qualities. It shouldn't come as a surprise that players who purchase and play games on their own time with their own money expect to be entertained and will judge their experiences accordingly, but we were nonetheless primed to expect players to scrutinize our learning game as a learning experience.

Most of our reviewers identified themselves only as gamers, but some of our most valuable feedback came from users claiming to be parents and educators. This small subset of our rapidly growing community acknowledged the game's classroom potential, but their expectations were clearly different than those of the parents and educa-

tors who had tested *Reach For the Sun* as a learning tool. It seems possible that our carefully gathered “in vitro” feedback had been muddled by the attendant expectations.

As we considered a gameplay patch, we finally recognized that by giving players so much to manage, we had inadvertently inhibited their ability to contemplate growth and resource strategies—the very crux of the game’s learning potential. Our solution was to introduce a separate, tightly balanced, turn-based “strategy” game mode that players could switch on or off at any time. (A small but vocal group of users advocated on behalf of the original game mode.) Early in-house playtests suggested that the new constraints required players to think about the system—and therefore the learning content attached to that system—in order to succeed, as opposed to the old setup that rewarded a brute-force approach.

As we prepare to release a second game on Steam, we hope to address some of the provocative questions raised by our *Reach For the Sun* release. In particular: How does the environment in which learning games are acquired and played impact players’ expectations about their educational content? How can we structure playtests to refocus reviewers’ attention on the entertainment potential of learning games? Can Steam serve as a reliable litmus test of objective quality in learning games? What techniques can we employ to mitigate players’ bias against learning games played in classrooms?

CARD-tamen™ TPACK: Assessing Teacher Ability to Wisely Integrate Technology in the K12 Classroom

Beomkyu Choi, University of Connecticut
Stephen T. Slota, University of Connecticut
Michael F. Young, University of Connecticut

Introduction

Amid a growing influx of smart devices, mobile phones, laptops, and tablets, the ability to seamlessly integrate technology and pedagogy has emerged as a crucial component of 21st century master teaching. In response, Koehler and Mishra (2009) developed the Technological, Pedagogical, and Content Knowledge (TPACK) framework to better define and catalogue the complex dimensions of technology integration as associated with innovative instruction and domain expertise. The authors have expanded upon Koehler and Mishra's vision by adding the context of contemporary learning theory and adapting a commercially available card game, *CARD-tamen™*, such that players (i.e., practicing educators) can externalize their knowledge concerning issues commonly associated with TPACK. The authors anticipate that this approach will improve integration strategies at the intersection of Technology, Pedagogical, and Content knowledge and provide important assessment information for decision-making concerning in-service teacher program coursework.

Unpacking TPACK

TPACK serves as a framework for categorizing teacher knowledge of technology integration across three key factors: Technological, Pedagogical, and Content Knowledge (Koehler & Mishra, 2009). At the heart of the system is a dynamic and transactional relationship between content, pedagogy, and technology that yields a distinct outline intended to guide the overall improvement of technology integration and teacher performance (Figure 1).

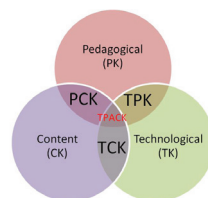


Figure 1: Transactional relationship between technological, pedagogical, content knowledge

While TPACK primarily aids the identification of teacher technology integration practices, technology coordinators (specialists in a leadership position that monitors a school's technology plan) benefit from using TPACK as a guide for the implementation of new district-wide technologies—helping educators, staff, administrators, and boards of education meet the standards and goals established under their respective district technology plans. Expanding this framework, we have added knowledge and understanding of major learning theories that operate to explain the TPACK integration, including behaviorism, cognitivism, constructivism, social learning theory, and situated learning.

A New Approach to Game-Based Learning

CARD-tamen™ and TPACK

Much of the literature steering game-based learning research has focused on video games, specifically, and the singular effects of gameplay (e.g., achievement, motivation) under sub-optimal conditions (e.g., games unavailable for replication research, small participant numbers) (Slota, 2014; Young et al., 2012; Young, Slota, & Lai, 2012). Studies focused on the benefits of a TPACK framework have been similarly limited and more driven toward theoretical implications than practicable application. In order to reconcile these issues, we have developed a research agenda that targets player intentionality and goal emergence through the examination of player-player, player-game, and player-environment interactions. By pursuing this line of investigation, it may be possible to establish a valuable, new stream of educational gaming literature that will emphasize learning outcomes, game affordances, and player intentions over and above one-dimensional variables that are mostly non-transferable from one gaming context to the next.

To achieve this end, we have chosen to modify a commercially available card game, *CARD-tamen*[™], designed to help educators consider how games can provide evidence of teacher's thinking about technology integration in the classroom (<http://www.practomime.com/cardtamen/cardtamen.php>). The researcher-modified version encourages players to articulate technology integration strategies by elaborating on situations in which they must roleplay as technology coordinators tasked with offering a solution to a given instructional context. Winning relies on one's ability to integrate pedagogy, theory, policy, and technology, externalizing TPACK competencies in light of established master teaching practices and reflections on technology integration strategies.

***CARD-tamen*[™] Redesigned for TPACK**

As with standard *CARD-tamen*[™] play, there are two roles in the researcher-modified version: judge (i.e., the individual who evaluates player competency) and player (i.e., individuals tasked with establishing the best possible argument for their CARDS). The game begins with one player acting as the judge and the others acting as technology coordinators—these roles rotate in a clockwise fashion after each round. At the start of a round, the judge announces a content objective of his/her choosing (e.g., teaching geometric proofs, identifying bacteria types). The content objective is then paired with a series of three face-up CARDS, one from each of three “suits” (i.e., Instruction, Theory, Challenge). Five CARDS from the fourth suit, Technology, are then dealt face-up in the center of the table. The player sitting to the judge's left has two minutes to examine the face-up CARDS, consider his/her approach to the content objective, and declare which Technology CARDS s/he will use to offer an instructional approach to the judge's content objective and the three face-up Instruction, Theory, and Challenge CARDS. This player then has up to two minutes to present his/her proposal to the group. After the proposal has been made, the remaining players may offer counter-proposals, spending up to two minutes presenting alternative approaches to the same problem and face-up Instruction, Theory, and Challenge CARDS. These counter-proposals need not rely on the same Technology CARDS chosen by the initial player, but they must use one or more of the five face-up Technology CARDS positioned in the center of the table. Once all proposals and counter-proposals have been made, the judge declares a winner and provides a brief explanation justifying his/her selection. The justification must be rooted in the technology integration strategies described by the TPACK framework.

Discussion & Future Research

Preliminary qualitative research conducted with university faculty and graduate students suggests that externalized thinking exemplified in the debate and discussions during game play may provoke the kinds of visioning and planning defined by the TPACK framework. This has led the authors to believe that games designed with similar structures and aligned with particular content area objectives can be used to support domain-specific teaching, learning, and assessment. If true, the game mechanics associated with *CARD-tamen*[™] TPACK could be used to establish rich contexts for assessing the spaces teachers must navigate when attempting to foster learning environments that creatively and effectively draw on innovative pedagogies, emerging technologies, and rigorous content.

Additional investigation of the game's effectiveness for establishing player intentionality, goal-setting, TPACK, and learning theory application will be introduced to Master's-level educational technology students in July 2014. Ideally, this will complement the program's existing formative assessment e-portfolio tool and clarify how learning over the course of an educational technology program is directly applicable to real-world educational technology coordinator responsibilities. It is the authors' hope that both the game and the evaluation of its mechanics will become a fruitful avenue of game-based learning research as educational psychologists continue grappling with the difficulties associated with introducing effective games for learning in live classroom environments.

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“Smarter Thinking and Trial and Error x 17” – Building Epistemological Presence in Game Spaces

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In looking at the impact games have on kids, there are a number of popularly held perspectives. Out of school, many see games as a frill – harmless, but needing to be closely managed, for example through limitations on screen time. Others see games as a potential menace that need to be controlled through careful consideration of ratings scales to preserve childhood innocence. Games in school are often monitored and measured for their educational outcomes. The goal here is to Raise Test Scores. Where the tasks are odious or dull, gamification through on screen rewards offers the potential of making the task palatable. The metaphor of “chocolate-covered broccoli” captures this nicely. For game design, the easy way out is to adopt a “curriculum in a box” teaching manual (e.g. Floor, 2013) which provides extensively pre-scripted game design processes, expect very little of the teacher, and leads to uniform, grade-able student outcomes. Whether the goal is playing or designing, we can do better. A critical step in this process is the careful architecture of the environment in which the game is played.

Whether pursued informally or in a structured environment, well-crafted game play and game design spaces can support important cognitive and non-cognitive skills. When this happens, there is a level of engagement that resonates with basic human needs, eliminating the need for artificial inducement and pre-scripted activities. Participation becomes organic and emergent. This is an ambitious claim, which I will support with philosophical and psychological frameworks populated with examples from my work over 18 years leading a regional math game involving more than 1,000 kids each year, and from more than a decade of game design camps which have involved more than 400 pre-teen designers. Methodologically, it is a process of phronetic social science, which Flyvbjerg et al (2012) describe as “field research that produces intimate knowledge of localized understandings of subjective human relationships, and especially in relationship to the values and interests that drive human relationships (p. 2).”

First, to lay out the philosophical groundwork. The goal is academically framed as *epistemological presence*, which Sockett (2012) defines as “an atmosphere in which the complexity of knowledge and the knower’s experience of it is constantly in play” (p. xii). Phrased differently, the environment is characterized jointly by the life of the mind engaged in active intellectual pursuits, and by a degree of moral agency as participants pursue individual growth and work toward building a community of inquiry. To that end, Sockett describes complementary agendas for public and private experience. Public, observable dimensions of a space with epistemological presence would include active engagement with issues of knowledge, truth, and belief. *What do we think? How do we know?* Private or personal dimensions would include opportunities for participants to build commitment, experience, and identity.

What would this look like in a game space? Imagine a gymnasium floor with 300 kids ages 8-13, grouped around tables in sets of five age-mates playing a local variant of Equations (Allen, 1963). To start, one of the kids rolls 20 cubes with numbers and operations on the faces. After the goal setter positions a few of the cubes on the board to set a numeric goal (say, $7 + 4 \times 3$), each player in turn requires, permits, or forbids one of the cubes not yet played. Play continues, working toward the goal but with each player being careful not to make it impossible to reach the goal, or to make it possible to reach it on the next play. Each of these can be challenged as a “flub.” Instead, the challenge is to keep a mathematically viable solution possible until someone flubs. At that point the kids need to consider the situation, assess if a flub has happened, and assign points based on their collective judgment. Throughout, there is a deep appreciation of mathematics being built among the kids, growing out of their reflections on strategies, mathematical relationships, and the need both to assert one’s own solution and to evaluate those offered by others at the table. Each year more than 1,000 students across the St. Louis region prepare for months, meeting in school, after school, at the library, and even in mall food courts to prepare.

In a well crafted game design camp, kids likewise benefit from an environment filled with epistemological presence. As the young designers work on creating an engaging game structure, they wrestle with complex mathematical relationships underlying interactions on screen, and they engage in psychological projections as they seek to optimize the player experience. As with the Equations game just described, the net result is a much more intellectually and personally engaging space compared with either free play or a traditional school environment. As Ross, an 11-year old game designer, framed it, his experience at game design camps “is a lot different than school because it requires smarter thinking and trial and error x 17. In school you don’t get a second trial because when it’s done it’s done and that’s your grade.”

Complementing these public dimensions of game play and design, there is also a complex level of personal and social engagement that is nurtured in spaces where there is epistemological presence. Here, kids are challenged to sustain their commitment and draw the most from the experience, iteratively developing craftsmanship through their own efforts and from what they learn from their peers. In *Equations*, kids learn math principles from each other and add them to their repertoire as they build an identity as a mathematically capable person. Likewise, over the course of a week-long game design camp, it is routine for kids to embed strategies and techniques they have learned from observing what another designer has created. Whether a participant ever aspires to become a mathematician or game designer, there is a more important process of personal and social identity development at work. Throughout, there is a cultural norm reinforcing the idea that there are interesting problems ahead that I can set for myself, and if I work diligently I can succeed for myself and contribute to the group. The identity of being an autonomous learner and a creator is arguably not a priority in most formal learning environments, and collaboration is largely banned. Hence, the critical need for environments such as these which are imbued with epistemological presence, and which hold forth the potential for kids to think and act critically and creatively. As they do this, they both draw from and contribute to the social good.

The argument so far suggests that there are intellectual and personal benefits that emerge within a well crafted game space – benefits that schools aspire to achieve but rarely do. What is it about this space which fosters kids' growth but which requires no coercion or artificial inducements (the chocolate covered broccoli)? For this, we need to turn to Self Determination Theory (SDT), a framing offered by Deci and Ryan (2002) and extended by legions of other researchers., including some focusing specifically on the link between gaming and SDT (Rigby and Przybylsky, 2009). Self Determination Theory posits that people thrive if they are in spaces which foster autonomy, competence, and relatedness. In a well structured game space, there is a dynamic interplay of freedom to explore and investigate, framed by an intended outcome for which kids will be accountable – both to the group leaders and their peers. Through this process of setting goals, realizing incremental progress toward those goals, and sharing ideas and techniques with peers, participants have their needs for autonomy, competence, and relatedness addressed. Unlike school, where power is generally a one-directional effort toward enforcing compliance, a productive game space shares power among participants in an effort to nurture everyone's growth.

To summarize, play and design can be most meaningful within a space imbued with an epistemological presence. Ideas need to be aired, challenged, refined, and put into practice in an environment that supports sustained effort and which leads to personal and social development. Simply giving kids time to play — or even design their own games — is not enough. As architects of the learning space, we need to provide opportunities for participants to iteratively cycle through roles as teachers and learners.

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A Caution on Computers, Luck, and Children

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In what is sure to be a jam-packed near-seven minutes, I will quickly explain how games are time machines for human identity, why this is important, and how our current fixation on data-driven outcomes for kids kills an important part of humanity in them as well as in our culture. Core to this argument will be an understanding of Callois' "alea," (or chance) (1961) and how deterministic computational models can remove this core aspect of self-determination. Traditionally, Americans have ironically preferred cultures of control to cultures of chance, banning gambling and touting a meritocratic ideal that hard work pays off even as fundamental components of our economy thrive on chance. I will argue that current attempts to computationally track, assess, and predict our kids are ideologically driven and fundamentally at war with something at the core of why games and gaming are important to us as humans, and that the GLS Community is in a key position to push back.

The era of "big data" is upon us, and educational entrepreneurs and academics alike are, for a wide variety of reasons from that run the entire gamut from base greed to a genuine desire to help individual children (as opposed to trying to make predictions about what might happen on average in the population from a sample). The idea is to collect student data from their performance on tasks, frequently surreptitiously, and make probabilistic models of what students know and in extreme cases, who they are. There is good and interesting work being done here, but there are some extremely salient features that need to be considered. Where this information goes matters immensely.

If students are passed information about how they're doing, it can have a strong influence on their identity as a learner, limiting their ideas about who they believe they can be. There is also research that indicates that if this information is passed to them, it influences who the teacher believes the student is, and their subsequent treatment of the student (Rosenthal & Jacobson, 1968). Unlike assessments and opinions received from human opinions, there's evidence that we treat algorithmic material with considerable weight and without expertise we don't know how to interrogate or make inference about the nature we've been provided. It's information about our children whispered by a black box. At least the bias and error in grades from a human can be understood based on our everyday understanding of one another.

This matters because many of these algorithms aren't great and we're ironically worshipping the wrong randomness. I argue that instead of using to tell us who we are in systematic and deterministic ways, carving out likely tracks of performance, we should be using randomness to inform us in more traditional ways, through serendipity and whimsy. This is something that I believe the GLS community is well suited for. Games have used teetotums, dice, spinners, and other randomness to help humans make sense of the very real randomness of life for thousands of years. Of course, U.S. culture tends to prefer safe, deterministic routes, so there were long periods of our history where, as my Media Lab colleague Kevin Slavin notes, dice were more regulated than guns or prostitution (2013). As he also notes, we live in a world where we can use computers to "solve" Snakes and Ladders, but of course the experiential point of Snakes and Ladders was the not knowing (2013). Players, especially children, rise and fall as one does, making sense of fortune and misfortune, emphasizing our inability to control our fate sometimes.

Of course, this is not an endorsement of allowing kids to only build an identity based on luck. The mindset research (Dweck, 2006) is too compelling to believe we should let our children accept the randomness of the world around them. Hard work its rewards are important lessons. I like this understanding of "grit" (as opposed to a valence where students are expected to learn a degree of self-regulation to endure and grind through makework their intuition rightly tells them is such). Finding *what* we want to work hard on is a somewhat more felicitous process. Instead of allowing computers to artificially "solve" the serendipity from our students' lives, let's use computers as pathways to serendipitously discover what's interesting to them. The Wikipedia hole, in which one investigates one phenomenon only to find oneself learning about something else an hour later was not a foregone conclusion – the technology was not necessarily created with design affordances to support hour-long self-learning fugues. Instead, hyperlinked knowledge and the human desire to learn united in glorious bursts of self-directed curiosity slaking. Our engineering efforts may make better use of probability in learning by working on ever better ways to interconnect knowledge and supporting serendipitous discovery instead of just allowing a black box to make a guess – however educated – with impersonal authority.

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We Are(n't) the Champions: Gamer Identity and Failure

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Introduction

Failure is a key to innovation and discovery (Dunbar, 1999; Schank, 1977). In his studies, Dunbar found that many (if not most) scientific innovations occurred when experiments failed to go as planned. It makes sense that new knowledge would come from behaviors and models that we do not completely understand. In educational settings, aversion to failure may hinder discovery learning (Author, 2012).

In contrast, games celebrate failure. Games often feature low stakes situations in which failure is a necessary part of success. Players must often fail a great deal before becoming proficient in most games. For example, in the *Lego* series (TT Games, 2005) and *Kirby's Epic Yarn* (Good-Feel & HAL Laboratory, 2010), there are many ways to fail, but that failure is explicitly designed to be an enjoyable part of the overall experience. In cases such as these, failure often leads to "recursive play" in which players reflect and hypothesize ways to improve (Gee 2005; Juul 2013; Squire, 2011).

We do not fully understand the effect of failure on gameplay. In this study, we explored how self-efficacy and feelings about failure predicted gamer self-identification. Educational data mining were used to discover a valid connection between self-efficacy and gamer identity. Educational data mining includes a variety of techniques that are otherwise known as knowledge discovery, or the process of discovering novel information from a great deal of data (Baker & Yacef, 2009). The data show a statistically significant correlation between the statement that "people are expected to fail the first time they try something new" and self reported gamer identity. Due to this correlation, we speculate that gamers perceive failure in a different way than non-gamers and suggest further investigation.

Methods

A survey consisting of 30 Likert scale and free-response questions regarding failure and General Self-Efficacy (Schwarzer & Jerusalem, 1995) was posted to the Reddit community *r/samplesize*. The surveys received 65 participants in total with 33 self-identifying as Gamers and 32 identifying as Non-Gamers. Survey data regarding self-efficacy and beliefs about failure was cleaned and normalized in order to reduce redundancy and improve our ability to identify outliers in the dataset. To classify respondents, we considered a score of 3-4 to the likert question "Do you consider yourself a gamer?" to be a Gamer and a score of 1-2 to be a Non-Gamer.

To determine significant connections among identity, failure, and self-efficacy, we ran the J48 decision tree algorithm in WEKA (Hall, 2005). The J48 algorithm is a greedy data mining technique which finds the attributes to split corpora into best-fit subsets (Quinlan, 1993). The J48 algorithm is commonly used among researchers for its ability to visualize statistical boundaries in a human-readable way. For our purposes, a human readable representation of our data is useful because it allows us to both identify and understand the connections between survey responses and gamer identity. By using the self-reported identity of Gamer or Non-Gamer as our classes, J48 evaluates which survey questions hold the most information gain while reducing the likelihood that the resulting classification is simply due to chance.

Initial Findings

Three models were produced by WEKA after running J48 on raw survey data. The first model produced indicated that responses to "If you play video Games, how many hours do you game per week?" and "What is your tolerance for failure?" were sufficient to classify the data with 80% accuracy. Because the correlation between number of hours gaming per week and Gamer/Non-game was expected, we removed the item and re ran the algorithm. This model correctly classified 75% of the data correctly when all data was used as a training set. The model indicated that "People are expected to fail the first time they try something new" and "What is your gender?" were the two best predictors for determining whether a participant was a Gamer or a Non-Gamer. Exact binomial tests were conducted on the male and female populations to see if there was a bias to identify as a gamers due to gender. There was a significant number of males who self identified as gamers ($N = 23, P < 0.05$). There was no significant difference for the female exact test ($N = 41, P > 0.05$). One participant listed their gender as Ninja and was not included.

To discover other salient features, we decided to remove "What is your gender" from the data and re-ran the algo-

rithm. The resulting model, indicated that the best predictors of Gamer or Non-Gamer were “People are expected to fail the first time they try something new”, “Is Gamer a bad label”, and “What is your tolerance for failure”. This model predicted 72% of the data correctly. A Mann-Whitney U test was run to determine if the Gamer population differed from the Non-Gamer population when it came to the question “People are expected to fail the first time they try something new”. The test was significant (N = 65, P <0.05). GSE scores, “Is Gamer a bad label”, and “What is your tolerance for failure” failed to be a significant factor in determining gamer identity.

Discussion

From our initial analysis, the response to the question “People are expected to fail the first time they try something new” provides the greatest information when predicting if the respondent self identifies as a gamer. Given that gamers expect initial failure, replicating this mindset in a classroom, or another environment where failure is avoided, may lead to gains in learning (Gee, 2005; Squire, 2011; Vygostky 1978). Ways to encourage this mindset include generating a game-based curriculum that would encourage student to attempt things outside of their expertise while allowing for failure (Squire, 2011; Author in press).

The question “Is Gamer is a bad label” was determined to provide the second largest source of information gain, which supports the notion that gamer is a divisive label. Only those who denoted the highest possible approval of the label Gamer were immediately classified as a Gamer by the algorithm. There is also evidence that players may identify as a gamer, but do not appreciate the negative implications associated with it. Overall, the inclusion of gender as a factor in determining gamer identity provides a better model; this has potentially provocative or problematic implications for the use of the term ‘Gamer’.

Our initial work provides a foundation for future exploration between failure and gamer identity. Future studies should investigate the link between a stated tolerance of in-game failure and verifiable accounts of gameplay. Evaluating the transferability of in-game failure tolerance to other contexts is appropriate. We hope to add to the growing corpus of research that supports gameful pedagogy in the classroom and beyond.

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Role-taking As An Advocacy Strategy For Policy Reform: A Comparative Analysis of Presentation Modes In Evoking Empathy and a Willingness to Act

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In major U.S. cities and in many nations globally, sex work is a criminal activity and the active status of the condoms as evidence of prostitution policy allows law enforcement to treat condoms as contraband (Shields, 2012). Advocacy groups internationally are actively petitioning to repeal the condoms-as-evidence policy. Using this international issue as the subject matter, this study evaluates the effectiveness of using games as an advocacy tool for policy reform in comparison to written reports and addresses the need for more quantitative research supporting the use of advocacy games.

Cops and Rubbers (Tran, 2012) is a tabletop game that simulates the systemic consequences the police practice of using condoms as evidence of prostitution has on sex-workers' lives internationally. By taking on the role of a sex worker met with unconscionable adversity, players experience the emotional struggle this population endures because of a policy that violates their health and human rights. This serious game serves as a captivating alternative advocacy tool and interactive demonstration of these policing practices and aims to elicit heartfelt reactions and independent conclusions about the policy.

In 2011, the Joint United Nations Programme on HIV/AIDS estimated 34 million people were living with AIDS (UNAIDS, 2012). While the infection rate is steadily declining, 2.5 million people were newly infected with HIV in 2011. Condoms have been proven to significantly reduce the risk of HIV transmission through sexual exposure, and global health organizations including the World Health Organization (WHO), United Nations Population Fund (UNFPA), and UNAIDS continue to request the accelerated promotion of condoms in AIDS prevention and care programs (WHO, 2009). However, in countries around the world police carry out legal and illegal searches of sex workers and confiscate or destroy condoms found in their possession even when they are not engaging in sex work. A female sex worker in New York reported, "[The police] locked me up.... because I had a condom. I wasn't even prostituting. They took the condom" (Shields, 2012). In many cases, prosecutors then used the possession of condoms as evidence of prostitution. This treatment of condoms as contraband forces sex workers to make a choice between safeguarding their health and avoiding police harassment or arrest. In 2012 Open Society Foundations (OSF) released its report *Criminalizing Condoms*, which documents these practices in six countries and identifies their consequences on sex workers' lives, including their vulnerability to HIV. The report launched at the 2012 International AIDS Conference in Washington, D.C., alongside *Cops and Rubbers*, a simulation game based on the report, in which players take on the role of sex workers trying to survive.

The use of games as a communication platform for social change is a growing movement with the prolific use of the term serious games to describe games that are not just for entertainment (Ritterfeld, Cody, & Vorderer, 2009). Much game studies research focuses on player engagement, narrative, and violence in commercial video games or learning outcomes of education games. Little formal research addresses the impact games have on people's perceptions of or prosocial behavior towards real-world issues. As a result, humanitarian organizations and their partners may be hesitant to use games as advocacy tools. This is in spite of the fact that games provide unique experiential learning opportunities whereby players take on someone else's perspective via role-taking (when an individual temporarily pretends that he or she is another person in order to gain insight into that person's thoughts, attitudes, intentions, and behaviors in a given situation) and to internalize in-game cause and effect to draw independent conclusions leading to a call to action in real life (Gee, 2008; Peng, Lee, & Heeter, 2010).

Serious Games and Role-Taking

In this serious game, participants play as one of six sex worker personas and share individual game-end goals: earn \$25 for a personal need and avoid a sexual transmitted infection. In each of the six rounds, an outreach worker may provide each player with a condom that he or she must then hide from the police. If a player is caught in possession of a condom by the non-player police character (based on the spin of a wheel), he or she must face a consequence like police damaging the condom or extorting money or sex to avoid arrest. The police cards' narrative is not only inspired by accounts from real sex workers but also includes a related quote from a sex worker, reinforcing the reality. These personas provide players the opportunity to role-take, a theoretical concept dating back to Mead (1934), who defined role-taking as being empathetic toward a character and adopting the character's point of view. This cognitive activity requires the participant to see oneself as similar to the character and as having similar values and goals. In *Cops and Rubbers*, it is critical for players to take on the perspective of a sex

worker, reducing the influence of stigma, and therefore allow them to connect the negative effects of the condoms as evidence policy on one's health and human rights. Tal-Or and Cohen (2010) further developed Mead's concept and applied it to television characters. Their definition of role-taking is merging with the character and adopting the character's goals is particularly important for application of this concept to gaming. Tal-Or & Cohen's (2010) identification scale assesses the perceptual, cognitive, emotional, and motivational outcomes of role-taking and can also be applied to game characters.

Method

This study used a quasi-experimental design with two groups in a post-test only setting. Nonrandom assignment was utilized in this study to maintain external validity: participants who were friends were assigned to the same condition, as people generally play games with friends. Assignment to the treatment (*Cops and Rubbers*) or control (OSF's *Criminalizing Condoms* report) condition was based on the number of participants at each session and the availability of game facilitators. The game-playing group was divided into smaller sub-groups in order to have an appropriate number of participants for each game set. The principal investigators as well as research assistants served as game facilitators and answered any questions regarding the gameplay. While participants in the gaming condition (group 2) played the board game, participants in the written report condition (group 1) read the 32-page illustrated booklet report. After completion, participants answered a questionnaire. This preliminary data was analyzed using *t*-tests to compare group means on intentions to oppose the condoms as evidence policy. This measure included six items – sign a petition, donate to raise awareness, discuss the policy with family and friends, join an email listserv, find more information online, and forward a link about the condoms as evidence policy – and demonstrated acceptable reliability ($\alpha = .88$).

Preliminary results ($N = 60$) suggest that the treatment condition (*Cops and Rubbers*; $M = 4.00$; $SD = 1.34$; $n = 35$) resulted in higher intentions to oppose the condoms as evidence policy, $t(58) = 3.35$; $p = .001$, than the control condition (report; $M = 2.81$; $SD = 1.37$; $n = 25$). Further, there were no significant differences in knowledge between the two conditions, suggesting that the *Cops and Rubbers* game offers an acceptable alternative to a written report for informing people on the condoms as evidence policy.

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Games vs. Gamification: The Ultimate Showdown

Moses Wolfenstein, University of Wisconsin-Extension

Micropresentation Full Script

The full script from this talk is included below. Please contact the author (moses.wolfenstein@uwex.edu) if you would like a list of references in this talk and additional works that influenced its development.

When I proposed this talk, I intended to discuss the ongoing issue of conflating the gamification of learning with the design of games for learning, and it is a topic worth addressing. However, as I thought more about games and gamification, the full implications of the title of this talk began to dawn on me. I realized that confusion about terminology is the least of our problems.

...and that an “ultimate showdown” means getting into some much heavier stuff. It also means not pulling any punches, so I’m gonna go big here, and say that while using games for learning is challenging, there are serious problems with the gamification of learning, and even more serious problems with the ways in which the gamification of learning is being marketed.

Let’s start there. It’s not uncommon to hear about gamification being associated with increasing engagement, making learning more enjoyable, increasing a sense of autonomy, and a whole spate of related outcomes that we often associate with games. But here’s the thing, as a designer, I see some serious fundamental problems with that idea.

All of those outcomes, and almost everything else that we have described and documented as positive features of games for learning including most of Jim Gee’s 36 principles, are either associated with play activity in relation to games, or with the construction of social spaces around games, or affinity groups as they’re commonly known in these parts. There are a few exceptions like amplification of input (which is to say feedback in games), but they are very few.

Before I go any further, I should mention that I’m defining gamification of learning pretty narrowly here based on the most common conversations and examples I’ve seen in the last few years. I’m not using it to mean just any attempt to bring game principles into the classroom to make it more immersive, and I’m definitely not using it to refer to game design as a learning activity.

When I talk about gamification, I’m talking about the design of a system of rules and rewards, and possibly an interface. In this sense, gamification is about structuring and tracking activity, it’s about creating a sense of progress, it’s about giving rewards, and at its best it’s about giving effective feedback and creating some sense of transparency for the user with regard to activities, goals, and outcomes.

So, when I say that gamification doesn’t produce the outcomes for learners that some of its proponents would like you to believe, there’s a very simple reason for this. The one thing that the gamification of learning (or really of anything else) is definitely not about, and that good games are fundamentally about is play. From where I sit, play (not to be confused with fun) really is the thing when it comes to learning.

The other thing that gamification has a hard time doing as a design activity is creating that essential sense of affinity, or for that matter a shared set of practices, because frankly, even at its best, gamification is just a shell. When you do a gamified activity, what you actually do is not gamification. Gamification is just the system around what you’re doing.

That doesn’t mean that people can’t identify with one another through a system of gamification. I have friends who have used Progress Quest together, and they shared approaches to dial in the system and leveraged challenges to achieve the sorts of habit formation they wanted. It definitely qualifies as working together to improve a shared set of practices, and I mention it because I’m not actually anti gamification. Still, Progress Quest isn’t designed to gamify learning.

So, this next part is where anyone who is really deeply pro-gamification might want to leave the room, because what I’m going to say might be perceived as inflammatory. I’m not the first one to say something in this vein, but I have come to believe that gamification is essentially a system of control. It’s just another way to encourage users to do what you want them to do they way you want them to do it.

Now in fairness, all games have rules that limit the choices we can make, so in some sense the idea that games grant any real autonomy in the first place is suspect. Obviously, some games give us a lot more autonomy than others do, but I think it's worth taking a moment to recognize that most of the time games may give us a *sense* of autonomy, but the biggest choices we actually get to make are deciding which games we want to play, or whether or not to play at all.

So, games often only give us a sense of autonomy, but this isn't necessarily that problematic because, among other things, we generally choose to play them in the first place. Even if we're talking about playing a game for learning because it's an assigned activity, the sense of autonomy within the game space is internally bounded within the activity of playing the game.

By contrast, if we layer gamification on top of a required set of learning, or performance, or compliance objectives, and claim that learners are enjoying autonomy, there's something fundamentally disingenuous about it. We may be allowing learners to track activity and progress, but unless the curriculum actually gives them choices in meeting those objectives (which is an instructional and not a gamification design decision), there's no real autonomy.

I've spent a lot of time on the autonomy question, so let me say something about engagement and enjoyment before putting in a final word about play. First, on engagement, I don't believe that either gamification or games inherently enhance engagement. The difference is that when games are engaging the learning is in the game, so if the learner is engaged with the game they're engaged with the learning.

On the other hand, if a learner is engaged with the gamification system wrapped around the learning experience, they're not engaged with the learning itself. They're focused on their progress, or they're focused on their status, or they're focused on getting that next reward, but this mirrors the core issues that happen in bad learning games where mechanics and learning aren't connected, or duplicates and reinforces the worst aspects of grade fetishism.

How about enjoyment? While, gamification may increase enjoyment for some, but the notion of it as a universal palliative for improving inherently dull learning (and never mind the problems that phrase suggests), is definitely flawed. To deconstruct this just a little bit, I'd like to turn to the science fiction author Charlie Strauss and his book *Glass House*

Glass House, published pre-gamification in 2006, is a tale of a post singularity future and some people trapped inside a generations ship where an increasingly sinister entity awards points to the inhabitants for completing a variety of actions. The main character uses the wildly politically incorrect term "score whores" to refer to people who chase points unquestioningly.

In other words, reward systems can create perverse outcomes. Anyway, I don't have much time left, so let me say just a little bit more about games and play. When it comes right down to it, there's very little question that play as an activity is fundamentally tied to learning. I would assert that play can even be essential for adult learning in addition to its well documented role in child development.

To borrow Deterding's terms, the thing about great games is that their ludic elements don't obscure their paideic ones. To be clear, unless you define fun as the neurochemical response to learning the way Raph Koster does, I'm not saying that games can "do" learning better than gamification because they're fun. What I'm saying is that gamification can be about many things, but it isn't intrinsically about play.

You gamify an activity, but you don't play gamified activities. Gamification can enhance a sense of competition or progress, but neither of these things is inherently playful. More than anything else, play requires a space set aside, where the consequences are somehow different from those we face in our day to day. That's something that games can give us that gamification never can.

Posters

Learning Math through Competition, Design and Social Play

Brandon Bell, DePaul University

Abstract *+Plus Out* is a card game where players practice math skills by battling with high numbers to win the game. It is a competitive, 2-4 player short-form game, designed to increase fluency in addition, subtraction, division and multiplication. Students, parents and teachers can design new rules to create their own games and modify the deck to fit different knowledge levels. The principles of player control, exploration and interaction keep players engaged in practice at home and school while easy customization helps meet a range of teacher needs in the classroom.

Way to Play: A Game of Strategy in High Numbers

A full 72-card deck holds 48 Number Cards and 24 Power Cards, which range through 1-12 for all four types: (+, -, x and ÷) (see Figure 1). Each turn, everyone draws three new cards. Players combine two Number Cards from their hand to build a high number. Whoever has the highest number wins the battle, and first to win six battles wins the game. After everyone has played their Number Cards, they can counter-attack with rare Power Cards, such as adding +10 to boost their score and win the battle.

Following is a short player scenario between Tsai and Nala who are playing at school.

Nala has two Number Cards: a Red-5 to add and a Blue-3 to multiply. She can build a combo for 8 points ($5 + 3$), by choosing the addition sign, or build a combo for 15 points by multiplying (5×3). She plays her combo for 15 points and Tsai plays a combo for 24 points! Next, they can counter-attack. Nala uses two Power Cards: a (plus) +10 to boost her score to 25 and a (minus) -10 bring Tai's score down to 14. Now the score is 25 versus 14! Tsai can also counter-attack but Nala's quick strategy reversed the battle!



Figure 1: Numbers Cards are on the top row and Power Cards on the bottom row. The 48 Number Cards range through 1-12 for all four types: (+, -, x and ÷).

Informed Design: Learning Principles and Practice Spaces

Solving and creating number problems are core mechanics of gameplay. Players are empowered to have control over what they solve; they can take risks on the interactions between numbers and, unlike a quiz, the game allows players be social, competitive, and collaborative in their problem solving. Challenge, exploration, risk taking, agency and interaction are a few key learning principles that informed the mechanics design (Gee 2004, 2006).

Game designer and researcher Kurt Squire calls this setting a “*social practice space*”---a motivational safe zone where learners can socialize, compete, compare and help one another while practicing through gameplay, using the same skills they rely on for homework or in the classroom (Squire 2010). Used as a fun practice tool, teachers can engage with students while refining their skills. There is also room for independent playful learning among

groups to focus on their strengths or tackle weaknesses.

Versatility: Building Ways to Play and Learn

Customization is a core principle that helps accommodate differences between learners (De Freitas 2008). Teachers can build decks for specific goals, like a deck of only addition and subtraction Number Cards, geared toward first and second graders. Or switch all positive numbers in a deck with negative numbers to gear toward fifth and sixth grade. Gradually introducing higher cards lets students to grow at their own pace (see Figure 2). Special education teachers may be interested in sharing collections of rules to fit the learning and playstyles of their students. Following is scenario in a 3rd grade classroom.

Mrs. Ella sees most of her students are enjoying the game while four students seem to be struggling. Later in the day, she creates two new simple winning goals and a multiplication-only deck for them to focus their skills. Mrs. Ella saves the deck style and the new rules so she can later build an addition-and-subtraction-only deck for her husband's second graders to play and create their own games too.

Conclusion: Opportunity to Design Their Own Learning

Like teachers, players can be co-creators of their practice spaces too: building new decks, creating their own rules, sharing their strategies and making self-paced challenges (De Freitas 2008). What if students designed games for one another? What if homework involved playing or designing with mom, dad or siblings at home? What if players also become designers of their own learning? *+Plus Out* provides players and educators a high level of flexibility for custom experiences and a foundation for fun learning.



Figure 2: Teachers might introduce high card numbers gradually (like 15 to 30). Or create a deck of negative numbers to fit fifth and sixth grade concepts (-1 to -12).

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Greenify: A Mobile Platform to Motivate Sustainability via Game Mechanics and Self-Determination

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Abstract: This paper discusses the design rationale behind Greenify, a mobile platform that leverages game mechanics and self-determination theory to foster sustainability.

Background: The Need for Intrinsically Motivated Sustainability

Communication about climate change needs to move away from threat-based responses to focus on the opportunities and possibilities for a sustainable world (Grant, 2012). This will allow us to tap into the kind of values-based, self-determined motivation (Deci & Ryan, 1985, 2000) that Osbaldiston and Sheldon (2003) describe as “high quality” with regard to fostering environmentally responsible behavior. This kind of intrinsic motivation has been correlated with greater creativity and increases in the scope of possible action (Grant, 2012; Ryan & Deci, 2000). In dealing with a problem as complex as climate change, a restricted scope of action will not allow us to meet the daunting challenges ahead. We must change the way we communicate about these problems to allow for novel behaviors and solutions. Strategies are needed to engender novel thinking through the use of intrinsic motivators.

Motivation for Sustainable Change

Traditionally, games motivate players through the use of simple operant conditioning – i.e., performing this action gives you this reward (c.f. Bang, Torstensson, & Katzeff, 2006). However, extrinsic rewards of all types have been shown to undermine intrinsic motivation (Deci, Koestner, & Ryan, 1999). On the other hand, a number of empirical studies have shown that more autonomous sorts of extrinsic motivation correlate with a number of positive outcomes, including more engagement, better performance in several areas, deeper learning, better maintenance of weight loss, and even more intimate relationships (for a review, see Ryan & Deci, 2000). That is to say that, if we perform a task solely for a reward, the task ceases to be intrinsically motivating. If we try to instill new habits simply by rewarding positive behavior, the habits will not become autonomously motivated. Mere alteration is not the right direction, but lasting change in peoples’ behaviors should be the direction we take.

The question then becomes how to use games to internalize motivation, to which we offer two possible solutions: First, Self Determination Theory (SDT) (Deci & Ryan, 1985; Ryan & Deci, 2000) posits that fulfillment of the basic psychological needs for competence, autonomy, and relatedness facilitates intrinsic motivation. Second, McGonigal (2011) suggests that games provide intrinsically motivating experiences by (1) increasing satisfaction by showing the impact of user input; (2) allowing users to experience success; (3) expanding social connection; and (4) providing frameworks for meaning beyond the individual lives.

Greenify

Greenify is a community-based social mobile platform that seeks to promote vision-oriented sustainability (Grant, 2012) by using game mechanics to support the internalization of motivation, behavior and value changes through social elements and open-ended challenges. In Greenify, players complete user-generated real-world missions that ask a player to think of creative solutions and to act upon them. Unlike many climate change or sustainability games that are more extrinsically-driven and checklist-based, a mission in Greenify is a question that invites a player to respond to hypothetical playful missions that are a manifestation of a person’s vision for a more sustainable community and world. For example, a sample mission in order to teach sustainable practices might be: “Be a locavore.” Under this mission, more specific deeds will be given such as “Share a food made with local ingredients,” as a scaffold for the given mission. In this way, a participant could respond by taking a photograph of locally sourced food that is good for the environment, and others can react to it. Moreover, users can create new deeds for a particular mission. Social dynamics encourage positive behaviors and scaffolding fosters sustainable learning. Thus, consistent play of Greenify means practicing pro-environmental behaviors within a community, which has been shown to be promising to direct behavior changes in real lives (Kollmuss & Agyeman, 2002).

Perhaps more importantly, Greenify is designed to promote feelings of autonomy, competence, and relatedness, as well as a sense of meaning (Lee et al., 2013). It fosters autonomy by allowing users to freely choose what missions they would like to take on, and even to create their own; it fosters competence by providing feedback on mission completion and by offering selected scaffolded missions of increasing difficulty that enhance a player’s understanding of sustainability; and it fosters relatedness through growing community, as well as the ability to join

groups and participate in group missions.

Further research is needed to evaluate whether a design based upon self-determination theory and gamification is an effective strategy to facilitate value change, identity formation and sustainable behavior change.

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Arctic Saga: A Game of Negotiation and Environmental Conscientiousness

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Introduction

Arctic Saga is derived from a classroom exercise developed by Teachers College, Columbia University titled Arctic SMARTIC (Strategic Management of Resources in Terms of Crisis). As its title suggests, SMARTIC was designed as an informative experience for students interested in learning about the current Arctic environmental and economic climate. The purpose behind the creation of *Arctic Saga* was to design a self-facilitated version of the classroom exercise that conveyed the central tenets of the SMARTIC classroom exercise that could be distributed and played at a number of venues including cruise ships, museums, and middle-school classrooms.

At Teachers College, Columbia University, a team of game designers created *Arctic Saga*, an educational board game designed to simulate marine spatial planning, a conflict resolution technique used to mediate stakeholder spatial interests in disputed geographical areas. In the game, players negotiate stakeholder economic interests while working together to maintain the Arctic environment.

Takeaways from gameplay will certainly be influenced by these differing environments and we plan to observe these differences in gains during the upcoming year. Ultimately, we hope that players will learn about the Arctic region, negotiation, environmental welfare, systems-thinking, and connectivity.

ARCTIC SAGA

- Marine spatial planning game to manage competing Arctic/Antarctic marine resources
- Understand the complexity of managing stakeholder interests during changing conditions



Figure 1: Resolving an Event in *Arctic Saga*

Gameplay

Arctic Saga is a three to four player board game of strategy, resource management, and negotiations. Players will explore territory, create a network of developments for profit, and withstand nature's fury for not developing green technology and preserving the environment. To avoid such disasters, players must negotiate and resolve game events and player-motivated developments in consideration of the current environmental climate (see Figure 1). The game ends when the environmental damage reaches its peak, or when a player first earns seven victory points. Players can score victory points in two ways: 1) by developing on territories they control or 2) achieving secondary victory point objectives.

Players embody the roles of stakeholders with an interest in the area: Oil, Shipping, Fishing, and Tourism (see Figure 2). Also present is a collaborative environmental preservation mechanic where players must work together to preserve the environment. As players acquire materials and resources, they will often negotiate with other players to improve their own standing via trading. *Arctic Saga's* endogenous mechanics, such as territory placement, negotiations, and environmental conditions, are largely based on actual science and reality (see Figure 3)

(Paras & Bizzocchi, 2005).



Figure 2: Initial proofs of stakeholder character screens

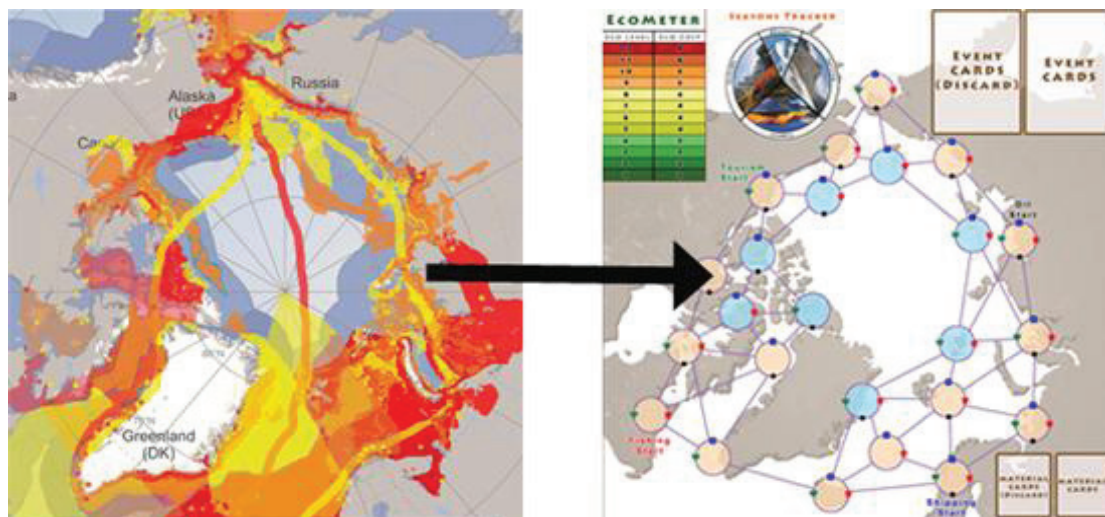


Figure 3: Evolution of the game board reflecting real-world stakeholder interests.

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Game Genre and Computational Literacy: Situating Design and Programming Practice With Kodu

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Introduction

In this paper we investigate an after-school program that uses the *Kodu Game Lab* software to teach young people ages ten to thirteen about computational literacy and game design. We argue that young people's development of computational literacies is tied to their understanding of both *game genre* and the *design grammar* of creation tools.

Theoretical Framework

Game creation tools like Kodu and Scratch employ high-level programming languages to teach youth *computational literacy* (sometimes called computational thinking) - thinking algorithmically about complex problems (Disessa, 2000). These tools, however, have their own *grammar of design* (e.g. Kress & van Leeuwen, 1996) that presents users with unique creative possibilities. Moreover, game genres produce distinct activity spaces that subsequently shape computational literacy development (e.g. Schon, 1983).

Methods

This study employs multimodal semiotic analysis (Lemke, 2012) to examine the genre-linked design grammar of participants' game artifacts, and utilizes ethnographic Discourse analysis (Gee & Green, 1998) to examine changes in participants' participation over nine-weeks time.

Data and Research Context

For purposes of length we focus on two pseudonymous participants' cases: Enrique, age 13; and Alan, age 11. Over four weeks, the participants learned to make a racing game like "Shy Guy's Beach" level in *Mario Kart Wii* (see Figure 1), which both had played extensively.

Data analyzed is drawn from Kodu's game creation files that researchers archived each week, audiovideo recordings of participants' activity, and researcher field notes.

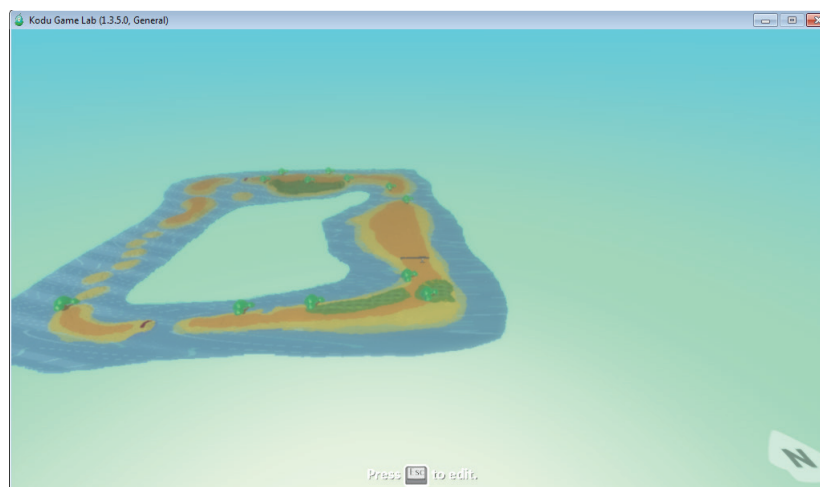


Figure 1: A researcher reconstruction of Shy Guy's Beach

Results

The two participants' understandings of the relationship between game creation tool and game genre influenced their development of computational literacy. Enrique's designs focused on the primary elements of the racing

game genre – object collection, scoring and finish locations. Alan, in contrast, attended to shooting and combat, secondary elements of the racing game genre. The participants' final products showed differences in genre and tool competencies. Enrique used event-driven programming to craft a racing level with multiple opponents, object collection and competitive scoring (see Figure 2).

Alan, in contrast, struggled to craft a level that he said would combine elements of third-person shooter and racing game genres, but in the end could not fully implement either (see Figure 3).

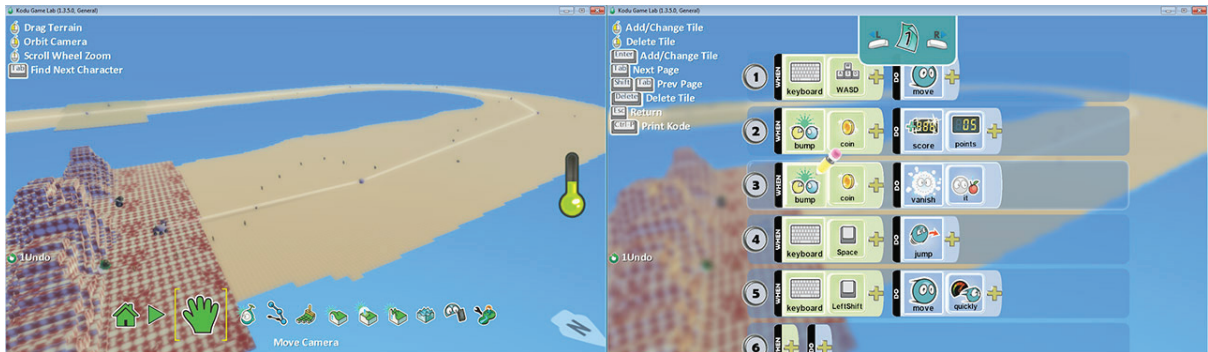


Figure 2: Enrique's level and character programming

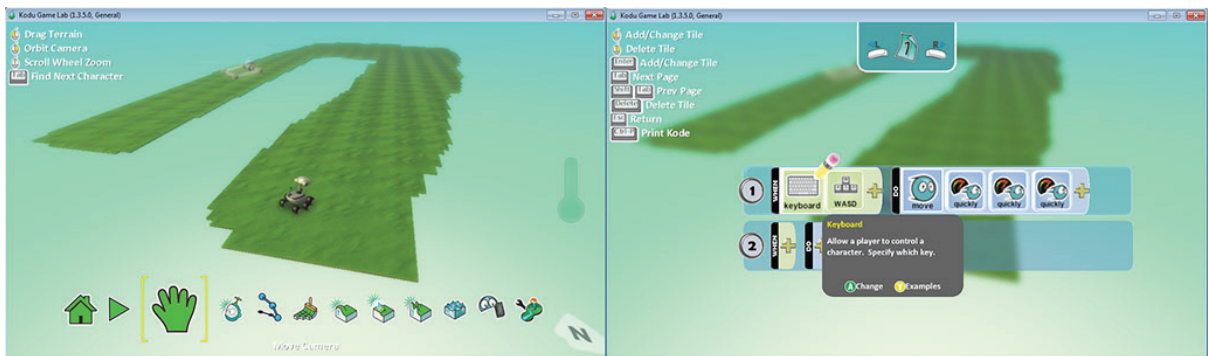


Figure 3: Alan's level and character programming

Enrique's work exhibits a beginning understanding of programming using events and conditionals. Alan's product seems to indicate that he struggles with said concepts.

Conclusion

Game creation software is often treated as a transparent instructional medium and youth engagement of game design is tacitly regarded as a homogenous activity. However, this investigation suggests that the relationship between participant's prior knowledge of game genres shapes how participants engage with the computational problem of design. What then are the implications for computational literacy learning environments that employ game creation tools?

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Digital Learning Design Laboratory

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Abstract: The authors outline a Working Examples project, the Digital Learning Design Laboratory (DLDL) that is under construction at Northern Michigan University. The DLDL is a new design space for k-12 students, teacher education students, and professional educators to explore teaching and learning with new media and technology. The authors respond to Working Examples prompts to provide an overview of the project.

Project and Vision

The Digital Learning Design Laboratory (DLDL) is an emerging space for individuals to interact with new media and technology at Northern Michigan University (NMU). Our vision is that the DLDL will allow k-12 students, teacher education students, and professional educators to explore teaching and learning with new media and technology. Deeply informed by constructivist and constructionist learning theories, the DLDL will have three fluid zones: one for design (design thinking), one for playing (game-based learning), and one for making (Maker Movement).

Problem and Why it Matters

Public education in the United States has largely been defined over the last decade by the increased focus, in political and public spheres, on standardized tests and standardized test scores. The result is that many schools are caught in the cycle of reacting to outside forces that limit freedom, narrow thinking, and effectively leave many disillusioned with k-12 education. As the industrial age efficiency model for education remains largely intact, the affordances of new media and emerging technologies are largely muted.

Innovative education models seek to unlock the affordances of new media and technology. Innovative approaches allow for many possibilities including the reimagining of time and space, the development of interest driven individual pathways, and the repositioning of the roles of teachers and students to that of designers. School models that value design thinking, game-based learning, and the Maker Movement, are increasing in number, as society continues to dialogue about the 21st century learner and what contemporary students need in a schooling experience.

The DLDL is being designed to help cultivate reimagined visions for what teaching and learning can be in the high tech world of the 21st century. The DLDL will be home to a range of technologies that will afford students and educators the opportunity to choose tools with intentionality, as they follow their interests and focus on developing the requisite skills to address a specific problem or need.

Relation to Others

The Digital Learning Design Laboratory was deeply inspired and informed by the ongoing work of a number of teams and their associated organizations. The Principles of Connected Learning and the HOMAGO framework were foundational to the development of the DLDL, as we sought to build an interest driven space where learners of all ages could interact with new media and technology by Hanging Out, Messing Around, and Geeking Out. We looked to YOUmedia and the Digital Youth Network as exemplars for how to translate the Principles of Connected Learning into action. Schools such as Quest to Learn and PlayMaker informed both the design aesthetic and the curricular design process. The DLDL is attempting to build on the aforementioned work to engage a range of learners including k-12 students, teacher education students, and professional educators.

Process and Evolution

In late August 2013, following an unsolicited alumna gift, the concept for the Digital Learning Design Laboratory started to emerge. With only a seed of an idea at the time, NMU undergraduate students became involved in the design process through the 'Education Media and Technology' course at NMU. The students were confronted with a game-like course structure that positioned them as the designers of the new space, in need/search of 100K in grant funding. The students explored game-based learning and the Maker Movement, while developing design skills, as they followed unique learning pathways based on their individual interests. Students experienced game-based lessons, they dabbled with game design, and they hosted a mid-semester Maker Faire to engage university decision makers with new media and technology. By the end of the fall semester, the students had assisted in designing the physical layout of the room and effectively lobbied for technologies to include in the space. During the final meeting of the semester in December, the students learned that funding for the room had already been secured, dating back to August, and that construction on the room, inclusive of many of their ideas, would start in

January.

In January, construction on the Digital Learning Design Laboratory (DLDL) started. Some of the unique design features of the DLDL include: double decker maker tables that were made on campus by undergraduate students, the majority of furniture rests on casters which allows for the room to be reconfigured to match each desired experience, and more than 50 percent of the walls in the 1500 square foot space are covered with whiteboard paint to support group design work.

The room has been utilized on a limited basis throughout the construction phase of the project, which allowed for the integration of new equipment over time. The DLDL is currently outfitted with two 4K LCD TVs, three short throw projectors, four Makerbot 3D printers, a Makerbot Digitizer, Makey Makeys, Arduino boards, a MinecraftEdu server, a poster printer, GoPro cameras, Narrative Clip cameras, LEGO Mindstorms EV3 and WeDo kits, assorted wearables, an industrial sewing machine, a total of 24 Apple computers and tablets, and a robust collection of professional design software.

Next Steps

Construction on the Digital Learning Design Lab will be completed during the summer of 2014, with a grand opening planned for the beginning of the fall semester. While the physical construction is nearing completion, the DLDL concept is still fluid and will continue to evolve. What types of programming should be considered for k-12 students, teacher education students, and professional educators? How can we best grow this community? What experiences will have the deepest impact on learners? How can we connect and sustain a relationship with the broader (national) community?

A number of individuals and organizations have been engaged in hopes of solidifying plans for connecting a wide range of learners and educators with the DLDL. The ongoing process of reimagining education in the Digital Learning Design Laboratory is underway.

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Mobile-Enhanced Field Research: BioCore Plant Identification

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Purpose

We use a case to compare mobile technology with traditional methods for field research activities to answer: 1) Can using mobile devices make field research data collection more efficient? 2) Can using mobile devices make field research data collection more accurate?

Context, Tool, and Data

In Autumn 2013, we piloted a mobile-enhanced field research activity for a college course where students engaged in field activities to learn the ecology of native ecosystems. Three lab sections (ten students each) focused on plant identification. While the mobile application was inspired by traditional dichotomous keys used in field guides, it also employs unique affordances of mobile design and user experience conventions.

The app (Figure 1) displays plant components such as “Leaf Shape” and “Flower Color.” Touching a component displays fixed options such as “Elliptic” and “Oval” with associated illustrations. For open-ended or numerical components, such as flower width, a text field is presented. Users select options to progressively narrow possibilities. The species details page includes descriptions and relevant images.

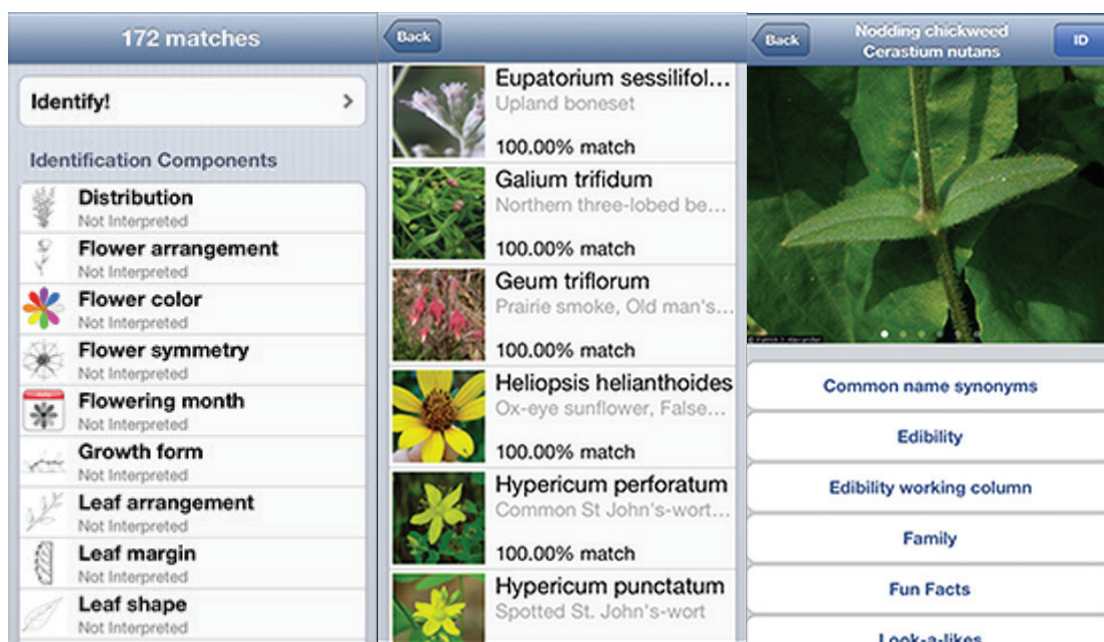


Figure 1: Mobile App screen.

In the design experiment (Brown, 1992), we compared across mobile device, mobile device/book, and book conditions. In each, five pairs of students identified ten plants. To also capture efficiency and accuracy across conditions, students reported times they began and finished identifying each. Additionally, to evaluate how mobile technology impacts students' *discourse* about plants, we compared students' self-generated content-related vocabulary across conditions.

Mobile technology versus book technology

Across quantitative items (efficiency, accuracy, and content knowledge), we used a Kruskal-Wallis test to determine differences between the three conditions. Where appropriate, we followed up with a Tukey's HSD post-hoc test to specifically identify where differences lie.

Efficiency: Mobile-based methods seemed to enable filtering and sorting information more quickly than book-based methods. Mobile-only pairs took ~43.4 minutes to complete the task; mobile/book pairs took ~57.8; and book-only pairs took ~78.8. Analyses revealed a significant difference [$p=.000$] between mobile-only and book-only pairs, and [$p=.010$] between mobile/book and book-only pairs. This suggests that providing novices with mobile devices for field research activities increases efficiency in identification tasks.

Accuracy: An expert botanist evaluated whether students correctly identified the plants. Mobile-only pairs averaged 72% accuracy; Mobile/book pairs averaged 66%; and book-only pairs averaged 20% accuracy. Both the mobile-only and mobile/book pairs achieved significantly higher accuracy than book-only pairs, $p=.007$ and $p=.016$, respectively. This suggests that novices who use a mobile device to complete field research activities make more accurate identifications than those with a traditional field guide.

Content knowledge: After the plant identification activity, students wrote or drew terms or ideas related to plant identification. Interestingly, mobile-only and book-only pairs averaged a similar number of words or drawings — 5.1 and 7.2, respectively. Yet, mobile/book pairs averaged 13.8 words or drawings — significantly higher than other conditions, $p=.000$ for both. This suggests that having two resources available to each pair (one with book, and other with mobile), may increase their ability to build discourse, as students were constantly checking and confirming with each other. This may significantly improve *learning*, as defined as picking up and using expert *discourse* of plant identification. To explore this further, we may next compare groups where every student has a resource, rather than pairs of students sharing.

Takeaways

In this pilot study, we found solid evidence that both variables are significantly improved through mobile use, and found evidence supporting one-to-one ratio structure of implementing field research activities. With this, we are designing field research activities that immerse learners in both the practice and discourse of *actual* scientists in a given field. Thus, we gathered a range of feedback and evaluative data of the mobile field research application in order to further development of a generalized field research platform.

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No Budget, No Experience, No Problem: Creating a Library Orientation Game for Freshman Engineering Majors

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Background

As the Applied Sciences Librarian at James Madison University (JMU), I hoped to develop an engaging, hands-on activity to introduce freshman engineering majors to the resources and services available at JMU's Rose Library. A search of library journals turned up several examples of academic libraries that had used games as an orientation activity. Some of these games were special events resembling murder mystery dinner parties (Boykin & Willson-Metzger, 2005), and used props and actors to add realism. Others combined a computer game with real-world elements (Donald, 2008; Broussard, 2010). At Trinity University, an alternate reality game titled "Blood on the Stacks" required students to search for clues online, in videos, and in the library building to solve the mystery of a stolen Egyptian artifact (Donald, 2008).

While reading about the success of these library games was encouraging, several factors constrained my project. I had no budget to purchase materials for the game and no previous experience as a game designer. The game would also need to be quiet and largely self-directed to avoid interfering with normal library operations. With these limitations in mind, I set out to design a simple, inexpensive library orientation game modeled after "Blood on the Stacks."

Development

The game, titled "Mystery at the Library", was intended to familiarize students with the Rose Library building and give them experience with basic library tasks such as checking out an item on reserve, looking up a book in the online catalog, and finding a book on the shelf by call number. I also wanted to introduce the students to RefWorks, an online reference management program.

While many library orientation games involve solving a murder or missing persons case (Marcus & Beck, 2003; Boykin & Willson-Metzger, 2005; and Kasbohm, Schoen, & Dubaj, 2006), the theft of a rare book seemed a more suitable crime for a library setting. In order to appeal to engineering students, I decided that the stolen book would be the (fictional) lab notebook of inventor Nikola Tesla. The suspects were four researchers who had been working in the library the night of the theft. A series of paper clues containing citations and call numbers allowed players to retrace the thief's steps through different areas of the building. One clue included the username and a password hint for a RefWorks account. After logging in, players could match the saved citations to the research interests of one of the suspects and identify the thief.

"Mystery at the Library" was introduced as a library orientation activity for freshman engineering students in 2010. Although response to the first iteration of the game was generally positive, feedback from players, comments from library desk staff, and my own observations identified several places where players tended to get stuck. If the sticking point was an element that added challenge to the game but did not actually teach players anything about the library, such as a puzzle that required deciphering a coded message, I eliminated it. Player comments indicated that navigating a large, unfamiliar library provided enough challenge to make the game interesting. In fact, one of the most common suggestions for improvement was that the game should involve even more exploration of the building. A revised and expanded version of "Mystery at the Library" made its debut in 2012.

Evaluation

Two sections of a 100-level Engineering course participated in "Mystery at the Library" in the fall of 2012. A third section that did not participate in any library orientation activity served as a control group. A survey was distributed to all three sections of the course after the experimental group completed the game. This survey asked students to rate their familiarity with library tasks on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree). The experimental group was also asked to provide feedback about the game. The response rate was 92% for the control group and 77% for the experimental group. I compared the mean level of familiarity from the control group to the mean level of familiarity from the experimental group. The experimental group indicated greater familiarity with each of the listed tasks (see Table 1). Reaction to "Mystery at the Library" was favorable (see Table 2), and the game was recommended for use with future classes by 79% of respondents.

	Control (N=22) Mean	Experimental (N=34) Mean
Get an item that is on reserve for your class	2.7	4.0
Look up a book in the JMU catalog	3.2	4.1
Find the book you want on the shelves in the library	3.2	4.1
Find the periodicals section (magazines & journals)	3.0	4.2
Find the reference section (dictionaries & encyclopedias)	3.0	4.0
Log in to RefWorks	2.3	4.1

Table 1: “Do you know how to perform the following tasks at Rose Library or online?”

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I had fun with this activity	3%	9%	26%	47%	15%
I learned about the library from this activity	3%	3%	6%	61%	27%
I feel more comfortable using the library now	3%	3%	21%	53%	21%
I feel more comfortable asking for help at the library now	3%	3%	24%	47%	24%

Table 2: Evaluation of game by experimental group (N=34)

Conclusion

Lack of money was not an obstacle to creating a successful game. The puzzles in “Mystery at the Library” were designed to make use of existing library resources and the building itself. Input from players and library desk staff was valuable in identifying areas for improvement. Although it was tempting to include extra puzzles to make the game more challenging, this led to unnecessary confusion for some players. A simple narrative with puzzles focused on learning objectives was sufficient to provide structure for the game and keep players engaged.

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Water+: An Educational Game Based on System Thinking

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Abstraction: Team GameGrid worked with Creativity Labs at Indiana University to promote system thinking design through an educational game for upper elementary and middle school youth. Systems thinking is the process of understanding how components, regarded as systems, influence one another within a whole. We developed Water+, a 3D pipe-building game that can help children express their unlimited creativity and gain understanding about how systems work.

'Water+' consists of two parts – puzzle mode and sandbox mode. In puzzle mode, children need to combine pipes and game items to build their own system and fill given tanks with certain colors. In sandbox mode, they can create whatever system they want. While they play the game, children should consider the characters of components and the relationship between them. In this way, children can have a hands-on experience in system building. The pipe-building experience will guide them how to think more systemically.

Goal of the game

In our game, children need to combine components to build their own system. They should consider not only the characters of each component but also the relationship between components. Eventually, children can learn that a system is not a group of components but interconnections between components. In this way, children can have a hands-on experience in system building. We hope this lesson can give children a broader view about how things around them work. With our game, children will enjoy the gameplay while also learning how to think more systemically.

Challenges

Scope

The first challenge is scope. To build a puzzle/sandbox game with some degree of depth, we need a variety of well-designed mechanics. The version we showed at halves only had three mechanics: pipes, blender and pattern generator. And by the time of softs we were barely able to implement three more: T-shape pipe, pump, shifter, along with a few levels to show off these mechanics. As a result, the feedback we got from softs were most around the bugs and lack of well-designed levels. And we realized that we need to focus on not creating new mechanics, but polishing existing ones. Then we spent the next two weeks on fixing bugs and redesigning the levels of the game, which were proven to be a right decision and made our game a much smoother experience.

Interface

Another challenge is creating a smooth 3d pipe building interface. This was proven to be particularly challenging, partly because there really hasn't been many successful examples that we can learn from, partly because our platform requirements limited our interface to mouse and keyboard, which is not very suitable for locating an object on the screen. Even though still a bit too over responsive, but it remove the interface complexity from the overall complexity of the puzzles.

Learning Curve

The third challenge is designing a good learning curve. Up until softs, only a few people were able to play our game without some sort of help from us, the rest were usually frustrated before even trying out all the mechanics. We discusses this with our advisors and faculties, and we finally realized that the mistake we're making was giving our player too many challenges at a time.

How we handled them

Since half point of the project, we had two playtests with visitors of our school, who are children aged from 10-14. And we also had playtests with peers and faculties when 80% of the product done. Along with playtests, we kept collecting feedback, iterating on UI and updating game mechanics.

After it, we realize that although we understand our game well, the communication between our game and the user is broken. So changing the learning curve is very crucial for our game since we have a unique 3D gameplay and many rules that the user need to understand.

By redesigning the tutorial levels and UI, we focused on UX, which turned out to be a significant chaining point for our project. People started enjoying the puzzles without suffering from frustration.

In the latest playtest, children gave us a 4.5 average score in scale of 5 on feeling comfortable with our 3D gameplay, which was 3.5 in the earlier playtest. And 100% of the children understand the fundamental tools in our game now.

How Kids Inform the Development of a Science Game

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Abstract: *Down With Food* is a game designed to teach upper-elementary school students about the intricacies of the human digestive system. Using design-based research, we document the process by which children's motivations for playing, as well as their interactions with and understanding of the game, influences the game design and drives further user testing. We detail the misconceptions players have in early prototypes, discuss the overarching principles of these misconceptions, and propose design solutions to address these misconceptions. Specifically, we redesigned the user interface and graphics to address visual misinterpretations and are adding a narrative layer to help children contextualize what is happening in the mini-games with the corresponding biological functions and processes.

Overview of the game

Down With Food is an educational iPad game, composed of a story narrative, that links a series of mini-games, each corresponding to an organ in the digestive system. Each mini-game integrates inherently enjoyable aspects of non-educational games directly with educational content. For example, the small intestine mini-game uses game mechanics commonly found in Tower Defense games: players place enzyme towers and release enzymes at oncoming blobs of food to absorb nutrients. Specific towers must be strategically placed to correspond to the types of nutrients that pass, such as proteins and carbohydrates.

Insights from user testing

The focus of the user testing sessions was to understand whether players understood how the tower defense game mechanics connected to the biological function of the small intestine. During user testing sessions, 19 participants (ages 7-10) played our prototypes. Research assistants tested participants individually or in pairs. Participants were asked to think aloud as they played the game and research assistants subsequently interviewed participants about their interests and intentions. Below, we describe examples in which our intended outcomes did not occur and how we are addressing them in current research and game revision.

Problem: Contradictory Schemas

Previous knowledge and perceptions can affect how players learn game mechanics and how they understand what is happening in the game. For example, we used a Tower Defense paradigm in which players strategically place towers to ward off oncoming enemies as the game mechanic for our small intestine game. In our game, players need to place towers along the small intestine and release enzymes at oncoming food to absorb nutrients. This contradictory schema of nutrients not being an "enemy" but rather an "ally" posed a problem. During the user testing sessions, players frequently referred to the enzyme towers as "killing the blobs" that then "disappear" and "die." Re-designing the game to take these players' previous experiences into consideration is the next step in our work.

Potential Solutions: Refining In-Game Visualizations

In order to correct for these misconceptions, our new designs focus on presenting the process of absorption as a positive gain in reaction to the user's interventions. One solution has been to modify the visualization of nutrient absorption by adding plus signs as the nutrient particles are absorbed. Another solution under development is having the nearby villi glow, signifying nutrient absorption in a localized area (see Figure 1).

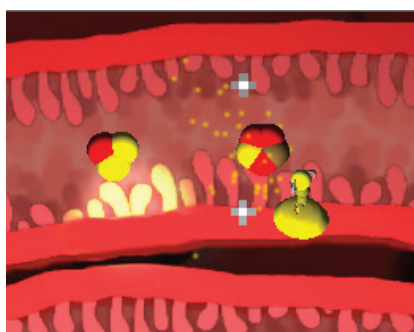


Figure 1: Plus signs appearing and villi glowing as nutrients are absorbed.

Developing an E-book layer

In our new game design, we are introducing a narrative structure in the form of an e-book layer to address the misconceptions discovered in previous user testing sessions and to illustrate connections between the mechanisms of the games and those of the physical human body. The e-book is an interactive storybook narrative that acts as a demonstrative guide, providing context for the mini-games. The narrative of the e-book is structured to match the biological digestion process, following a journey from the mouth to the large intestine. The goal of this added context is to break the schema that the food blobs in our game are an oncoming enemy.

The e-book will also juxtapose the digestive process with its representative game mechanic (see Figure 2). For example, the pages in Figure 2 illustrate that the nutrient blobs featured in the small intestine game are symbolic of real food particles. While reading about the digestive process, children can experience what they have learned by playing the interactive games. By forging this connection, we hope that children will better understand the digestive process as they play the game and become more familiar with the game mechanic.

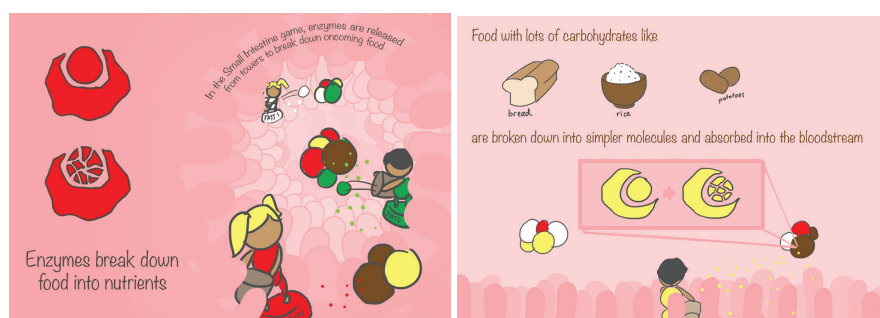


Figure 2: Pages from e-book detailing nutrient absorption.

Current Research

We recognize that young children do not enjoy reading large blocks of text when playing a video game. However, this e-book is designed to integrate seamlessly with the game, reflecting the game's stimulating visuals. In current play sessions with children, we are determining how children respond to the new visuals and how effectively the e-book presents information. Our new findings will be used to further develop our game, as well as give insight on elements to consider when developing other educational games. Updates to our research and development are at www.downwithfood.com.

Game Design and Their Toolkits as Vehicles for Expression

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As the technical requirements to produce games diminish, the idea of creating games is occurring to more and more people with more and more purposes in mind. We propose that game design experiences—made possible to an untrained many through toolkits like those mentioned above—are relevant to learners of all ages, and the products and practices of these activities can be positioned to take on more relevance in the world as part of the design of the educational programs that enact them. Like the creation of other forms of media, game design can be a path to agency, giving people new tools to communicate about and in their lives. The games they make might be capable of contributing to a wide set of situations in their lives. We should not only take from these toolkits the distilled, testable, STEM-justifiable competencies educators need for their various quotas and crusades, but see our use of them within educational situations as being inherently about enabling people with new ways to make meaning. This perspective has implications for the kinds of games we ask our students to make, the kinds of toolkits we make for them to use, who we include as learners of non-professional game design, and the other activities and experiences educators connect to game design. In particular we recommend more emphasis on the use of non-professional game designs than their inherent properties as games. To help illustrate this general thesis, in the following sections we will look at examples at increasing levels of detail within a given realm of purpose-driven game design, Augmented Reality (AR) games in relation to learning.

Augmented Reality Games and ARIS

Experiments with AR games in learning scenarios have until recently been rare because of their difficulty and expense to enact (Squire et al, 2007). Covering a proportion of the inherent possibilities of AR games for learning (Klopfer & Squire, 2004) by iteration of typical researcher-led experiments, let alone proper analysis or efficient scaling, seems infeasible. Although in theory AR has a general reach, in practice it has looked somewhat unlikely to reach the masses (Dunleavy et al, 2009). This is one of the problems that toolkits help solve. For the last several years, ARIS has made it possible for non-programmers to participate in the high tech space of AR games (Holden et al, 2013). Besides helping to define the AR genre, the diverse practices of ARIS users represents the significant interpretive flexibility of ARIS and AR games. Some look at it and see an engine for producing collective tours to elucidate historical happenings, others may see a way to investigate the invisible aspects of their communities today, while still others might see a prototyping tool for creating interactive exhibits in a science museum.

Local Games Lab ABQ - by Christopher Holden

ARIS has given me access to forms of experimentation I would not have been able to attain previously without a large grant and several well-trained employees. I use it as a tool for prototyping and production—creating games as classroom curricula for example—and I also try to make fun games others might enjoy, a somewhat more personal side to my learning about AR games. But ARIS has also enabled me to organize a broad range of AR game design and play activities among faculty and students at my university. Using Jim Mathews' (2010) design studio concept, I reorganized some of my teaching using AR games, and share it broadly with other informal learners (Holden, 2014). That these teachers and students also see something to be said with AR games—and that many have actually thought enough of these ideas to really run with them, far outpacing developments that I could have helped them to directly—is what makes AR game design feel like an area that is capable of generating its own meaning beyond the computational literacies obtained. I am especially emboldened by the way that engaging in game design activities has allowed myself and others to take on and share new roles within our school. Next, an undergraduate student describes her game design experiences within the Local Games Lab ABQ.

Quest for the Cities of Gold - by Gianna May

My experiences with game design began when I created a prototype game that combined my interests in local history, writing, and teaching. Based on this prototype and conversations with personnel at the Albuquerque Museum I made another game, *Quest for the Cities of Gold*, specifically tailored to the exhibit space at the museum that they might actually want to use to appeal to youth. I created an independent study with Dr. Holden to continue the work I had already been doing and recruited a small team. Together, we spent two months planning and creating the game until it was ready to be playtested by museum patrons. We were able to create a working version of the game and released it to the public during a Family Day event held at the museum (May, in press).

Starting as a total beginner, I was able to build a working prototype and learned a lot from the experience of creating a game for educational purposes. In my follow up, we were further able to pull the game out of its digital space (a virtual map on the screen) and bring it out onto the museum floor as well. I now have a clearer understanding of how games can enhance a museum experience (and how they can do so successfully) and the ways in which videogames can provide an immersive, educational experience unique to other learning methods. ARIS made it possible for a non-CS student such as myself to explore this field, which would have normally been unreachable.

Interpretive Flexibility as a Value

Interpretive flexibility (Kline & Pinch, 1996) is a key factor involved in successful strategies for transforming educational agendas and practices via learning technologies. It is how something like a game design toolkit can become more than a way to teach a concept and pass over into a tool for expression. But interpretive flexibility is not directly a feature of software. It is co-constructed between its users and its producers and is a feature of the ecosystem in which the toolkit finds use.

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Designing a Game-Inspired Classroom: Videogames as Models of Good Teaching

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Abstract: Games provide insight into methods of good teaching, not just good learning. This paper uses a case study of an upper-division undergraduate course to interrogate specific design choices using game-inspired teaching methods. In particular, this paper explores a model of instruction which promoted collaborative and cooperative learning and the shared production of knowledge. Further, this game-inspired theory of instruction stresses the role of teachers as designers of a learning experience.

This paper describes the design of a “game-inspired” undergraduate course based on the premise that games demonstrate good *teaching methods*, not just good learning contexts. It uses games as an inspiration for designing instructional experiences in which learners can realize the various principles Gee (2003) first described without *necessarily* creating game-like experiences. Instead, this game-inspired teaching is a way of recognizing the effective pedagogical methods videogames use as part of the “good learning tools” Gee has described tied to what we know about learning and teaching, particularly as described by Hattie and Yates (2013). Gee’s argument is not that games are good for learning (they can be in the right circumstances, with the right support and in the right application), but that games show *how* good learning happens, and *what* good learning looks like.

Further, it’s possible to reconsider Gee’s learning principles as *design principles* which can drive instructional practice. When Gee describes the Identity Principle or the Multiple Routes Principle, for example, these can be seen as goals or strategies for teaching and not just for learning. Game-inspired teaching principles are not necessarily direct correlates to Gee’s principles, but they are tied closely to these insights. These design features allow teachers to structure learning experiences in ways that work for their particular learning goals. These design principles also allow for flexibility in creating a course or other learning environment by serving as guidelines and not absolutes; the type of content, the type of learner, and the various affordances and limitations of the teaching spaces change the ways in which game-inspired teaching methods might be useful, so teachers may use them as guidelines rather than being stuck within rigid boundaries of game scenarios.

Design principle: Collaborative learning

One key design principle is covered in this paper: the notion of collaborative learning, cooperative practice, and shared production of knowledge. There are many other principles; this example highlights the *specific* design rationale behind a *specific* course in order to show the various ways game-inspired methods can be used and adapted to various teaching moments. The course, titled “Videogames and Digital Rhetorics,” focused on exploring rhetorical concepts through the lens of videogames with an emphasis on experiential practice. Students played games—primarily *World of Warcraft*--as a regular part of their course meetings and assignments. In fact, the course was a “hybrid” course, with one face-to-face meeting each week and an online component; for this particular course, the online portion was held in *World of Warcraft* with a group Skype call for voice communication.

WoW provided a core organizing principle for cooperative play (learning), that of the “party” system in which various specialized experts work cooperatively to accomplish a task (e.g. a 5-player dungeon party includes a tank, a healer, and three damage dealers in order to defeat enemies). The course was designed around a similar concept in which students chose one of three content-area specializations to focus on during the semester (identity, design, or teaching and learning); each week students read an article common to the entire class as well as a supplemental article specific to their domain. Students became “experts” in a given concept in order to collaboratively develop a weekly principle within their cohort of experts which was then shared out to the rest of the class. Students from the other disciplines did the same, and then utilized the various principles to tackle a weekly challenge in class.

In addition to the weekly problems the students faced in-class (in which they used the various principles they developed to complete the task), students faced three “mini-bosses” which served to group several weeks’ worth of related topics (such as looking at games as texts, or games in society etc.). These mini-bosses provided unique opportunities for students to apply the knowledge they collectively developed around a specific problem, and to create a solution *as a class*. For example, the class was faced with the problem of creating games (in small groups) using the various principles they created; students were provided a game template which they “filled out” by incorporating the knowledge they shared and then play-tested their games with each other.

This principle is fueled in part by the observation that learning is an inherently social act and that meaning making is contingent and works through dialogue and dialectic practices. Further, the science and psychology of learning suggest that it is highly interpersonal (Hattie and Yates, 2013) and that the human mind is geared for social collaboration in knowledge building tasks. In modern classrooms, however, students are often simply parallel learners (learning side-by-side) with various instances of shared labor (group work). The *WoW* party model is an effective metaphor for how teams can blend specialized perspectives, abilities, and interests around a shared goal. Since each role has unique functions, and each player has a specific knowledge of their tasks in each encounter, the team distributes their knowledge across the various players--and relies on each others' expertise. This is similar to various observations on collective intelligence in which the group as a whole might be considered the unit of analysis; the group collectively has more knowledge, and more capacity to put that knowledge to work, than any individual member. The course design owed much to Aronson and Patnoe's (1978) concept of the "jigsaw classroom," in which each student had one "piece" of the knowledge necessary to complete each weekly tasks but it required the efforts of all students.

Further, by sharing out their knowledge to the other cohorts, they served as masters/experts and teachers for the other groups. They provided enough information for the other students in the other cohorts to understand (at least superficially) the particular perspective in order to both incorporate it into their own perspective as well as to synthesize as a class around a weekly problem. For example, one week the topic was "big 'G' gaming," and in class students were tasked with building a model of a network of "big 'G'-like" sites for a classroom. The students various perspectives were each necessary--indeed, essential--to creating a more robust model. Students who specialized in identity, for example, brought many issues of identity play (being a student, being a peer such as a dorm mate or sorority-mate, being a child, being an adult and so on) when deciding what features and what sites would go into a "big 'G' -like" network. Similarly, the students focused on design brought issues of access, user-centered design, aesthetic and technological concerns and more; students specializing in teaching and learning helped ground the types of content and the methods each site might need to include in order to effectively structure the other perspectives. In total, each group helped illuminate, complicate, and strengthen the other perspectives.

Importantly, just like in a *WoW* party, each member does not need to be an expert in each role (e.g a DPS player doesn't need to know all the specific actions of a healer); however, each player needs to know enough about the other two roles in order to gauge how the group is doing and how their own performance might be altered. That is, players need to know at least something about the other roles in order to more fully understand and act within their own role. In a similar sense, this course was designed to give students an opportunity to engage with other perspectives and know at least something about them in order to complicate their own thinking. In a sense, sharing the cognitive load across all the students helped cover more ground than any single individual student could handle. Students taught each other by distilling at least a key idea from their own perspective, and they learned enough from each other to gain a deeper understanding of each weekly topic.

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Touching Triton: A New Direction for Biomedical Serious Games

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Introduction

The field of genetics is no stranger to simulation and serious games. A recent count of the number of interactive games and simulations at one of the most popular sites for online genetics content, <http://learn.genetics.utah.edu/>, produced no less than 22 different online activities for students. Other online gaming environments like Phyllo (<http://phylo.cs.mcgill.ca/>) (Kawrykow A., et al., 2012) and eterna (<http://eterna.cmu.edu/web/>) are designed to bridge gaming and scientific research. Many of the serious games about genetics that have been developed thus far focus on Mendelian genetics, simple inheritance patterns and/or structures of molecules involved in inheritance. Although these games align with traditional teachings that occur in many middle school, high school and college classrooms, there is much room for expansion in complex genetics and complex disease. Using, common good practices of simulation, social interaction and student feedback (Swanson, 2014), Touching Triton was developed as a serious game focused on common complex disease and how genetic factors, environmental factors and family history all play a role in a lifetime risk of developing these diseases.

Game Design

The initial idea for an activity to engage students in an exploration of the genetic, environment and family history factors that play a role in the development of common complex disease was formed during the summer of 2009 by an experienced educator and a group of summer interns working for HudsonAlpha Institute for Biotechnology. The activity, Risky Business, used a large printed sticker, magnetic foam flags and a magnetic white board to which the sticker was attached (see Figure 1). Hundreds of students pilot tested the activity in this form with great success. However the activity was material intensive limiting the ability to use it in area schools. A National Science Foundation Science Education Partnership Award (NIH-SEPA) was awarded in 2010 to make the transition from material intensive activity to computer-based interactive. In May of 2010, two members of the grant team attended the annual NIH-SEPA meeting and were introduced to good practices of online interactives and games. The decision was quickly made that Risky Business could not simply be reiterated on a computer screen, but needed major redesign in order to bring it into the world of serious games.



Figure 1: Material intensive Risky Business activity.

The redesign of Risky Business began with creating an engaging storyline, characters and theme for the activity. This provided some challenge in portraying cutting-edge technology, not overselling the clinical utility of current genomic risk assessments for complex disease, and minimizing the possibility of genetic discrimination. The decision was reached to design the storyline around a 20 year round-trip space flight mission to a moon of Neptune called Triton for six crew members. Given the new direction, the name was changed to Touching Triton.

At Touching Triton's core are four core learning concepts: 1) Many genetic and environmental factors interact together in a complex manner to influence health and disease risk, 2) Genomic data can be used to determine a quantitative disease risk for an individual, 3) Current knowledge about genomics and risk factors for disease is ever changing, and 4) Personalized disease risk can inform decisions regarding lifestyle and medical interventions. Touching Triton asks the player to analyze three types of data (genomic data, family history and medical records) related to a crewmember and make an assessment of his/her lifetime risk of several complex diseases. Then players are asked to use their assessment to make medical packing recommendations to help mitigate risk

and potentially treat each of six common complex diseases, ultimately packing and launching the spacecraft on the 20-year mission.

During programming it was critical for students to engage with actual scientific data and for data used to determine mission outcome to be based in scientific research data as well. To that extent, a complex algorithm including population risk data, genomic risk data, and data about the effectiveness of packing options on mitigating and treating disease was used. Educators can obtain real-time data on student progression via a specially designed teacher portal. The teacher portal shows individual student performance and decision-making during play making a gradable dataset easily accessible (see Figure 2).

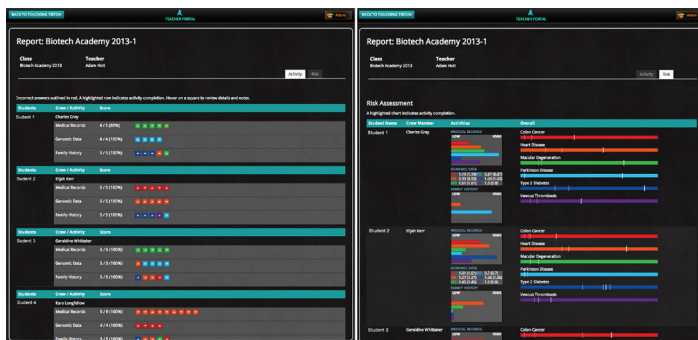


Figure 2: Teacher portal and student data report.

Touching Triton features 91 live-action videos; including end sequence videos portraying each possible combination of crewmembers returning to earth from the mission. Other videos include content advisors (PhD Scientist, Physician and Genetic Counselor) and a pedagogical agent providing just-in-time learning of key content. Both short and long interviews with each of the crewmembers and a 1.5-minute trailer have also been included to provide an additional level of engagement in the storyline.

Testing and Outcomes

A comprehensive, mixed methods evaluation has been taking place on Touching Triton for the past three years. Initially, evaluation was focused on very early alpha and beta versions of the application collecting data on student interactions. Many of the final visuals and sequencing was influenced by that data. Formal evaluation of Touching Triton in classrooms across the state of Alabama began during the 2013-2014 academic year. Evaluation was conducted using a set of early adopting teachers that were trained on implementation of the activity during the summer of 2013. Sixteen classrooms across the state of Alabama have participated in the evaluation of Touching Triton.

Early analysis of data indicates teachers think that Touching Triton not only fit into their existing genetics curriculum (77%), but also were very likely to recommend the application to their colleagues (79%). Student familiarity with the terms “Genomics” and “Odds Ratio” increased significantly compared to controls. Other vocabulary familiarity gains were also seen, especially relating to terms connected with careers like, genetic counselor and pharmacologist. Additionally, a content survey showed a significant difference in student ability to correctly answer questions regarding complex traits after playing Touching Triton than in controls. Touching Triton is meeting expectations and delivering complicated content material to students in an effective and engaging manner.

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Raid the fridge!": Promoting Healthy Eating Habits Through the Game Monster Appetite

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Abstract: Monster Appetite is a web-based health education game, modeled on a previously developed card game by the same name. In each round, a player is presented with a number of food items and tries to select the superlative card, measured by the calories per serving. The player must select the highest caloric food card before another player does, resulting in a race to identify the best (i.e., highest in calories) card first. The subversive approach (i.e., making one player's monster avatar as fat as possible), fast decision-making and competitive game play keep players engaged and encourage them to rethink their daily food choices. A flexible backend implementation allows the game mechanics to be easily modified and rolled out to subsets of the user base to run control-treatment gameplay testing. Monster Appetite is designed to collect anonymized user data to build a dataset of health food awareness in relation to demographics.

Background

The obesity epidemic is one of America's largest public health challenges and a growing concern in the rest of the world that creates disparities among race, ethnicity, region and income (F as in Fat, 2010). Currently, there are over 12 million obese American children and adolescents and there has been an 82-percent increase of obesity in the last 20 years worldwide (Nair, 2012). Acknowledging the severity of the issue, in 2013 American Medical Association decided that obesity be recognized as a disease so that appropriate measures are taken for treatment and prevention (Frelick, 2013).

Much research has been done on genetics and physiology on appetite control and consequently individual treatments such as calorie prescriptions have been introduced to the market. However, there is still great concern over a lack of research on preventative care programs to avoid obesity and other related diseases (Han, 2010). Monster Appetite is at once a game targeted at preventative care and designed to facilitate further research into the effectiveness of preventive care policies in a fun, game-based approach.

Game Design

The original card game version of Monster Appetite (hereafter simply 'the card game') (see Figure 1) asked users to select the food card with the highest caloric value. The accompanying narrative of the game was to make the player's monster avatar as fat as possible after one week in game time. Each game day has three meals and a midnight snack. A meal consists of choosing the food card in competition with other players. The midnight snack introduced different elements to drastically alter player's scores, for example giving another player a nut allergy and preventing them from choosing foods containing nuts. In addition to allowing for exploration of more nuanced health topics such as allergies, the midnight snack round serves as a critically engaging game mechanic. In initial testing, students received the game as first and foremost entertaining, instead of as a pure, preachy educational activity (Author, 2013).



Figure 1: Monster Appetite paper-prototype.



Figure 2: Monster Appetite digital-prototype.

Many games promote nutritional awareness by teaching healthy eating habits. The card game version of Monster Appetite employed the opposite approach by teaching players to identify the least healthy choices. This mechanic was abstracted so that the game can be reconfigured so that the goal is to choose the card based on lowest caloric value, most calcium, most fatty, etc. Little investigation has been done into the relative effectiveness of each approach. The digital version of Monster Appetite has been programmed to be easily reconfigurable so that we can deploy both versions to subsets of the user base for treatment-control testing to see which approach manifests the most effectiveness in self-efficacy and behavioral change.

Data Collection and Analysis

During user registration we ask the player to allow us to use their information in our study and record their approximate location of residence. Evidently there are privacy concerns and legal implications in the collection of personal data, especially if minors will be using this platform. Working through these legal details remains a problem to be solved in future work. During game play we then record every click the user makes. For each round (meal), we record the options given to the player, the player's choice and the speed of the player's choice.

We hope to use data collection techniques towards two ends in this project. On a user level, our data collection allows us to track the progress of individual users as they play the game multiple times. We hope to see users improve on their selections and pick the best cards more quickly and accurately. Our hope and expectation is that this would then translate into the players' daily food choices, and help them avoid unhealthy options. This data would also allow for the development of an automatic tutor in future work.

Additionally, this data can work in the aggregate to build a big data set. Since each meal yields a data point per user, a single play of the game yields 21 data points. This allows us to quickly collect data and build user profiles, even if they play only one round. With these data points we can perform queries to investigate the relationship between food knowledge and demographics.

As an example study, we may wish to investigate the correlation between income and ability to identify high caloric foods. For this we simply query the database for each users location and average accuracy (of selecting the highest card out of the given options) over all rounds. From locations we can build an income map to estimate the user's household income (U.S. Census Bureau, 2010). If there is a direct correlation between income and accuracy, we may infer that a primary causation of obesity in low-income areas is due to lack of education. However, if there is no correlation between income and accuracy, we may infer that a primary causation of obesity in low-income areas is due to lack of accessibility. Studies like these become simple when large data sets (i.e., the one generated by Monster Appetite) are available and can provide strong evidence to support policy decisions.

Future Work

One of the major hurdles for this project is the legal implications and practicality of demographic data on the users. We could simply collect the user's zip code, from which we can retrieve general demographics of the region (U.S. Census Bureau, 2010). Far more helpful would be to ask the user more intrusive questions to directly discern race, age, income, education, weight etc. However, before this step is taken, we must investigate the legality of requesting this information over the Internet. One of the venues the researchers are looking into is already available public data sets such as the ones from National Health and Nutrition Examination Survey (NHANES) provided via the Center for Disease Control and Prevention. A similar survey model of NHANES was used for the NYC HANES survey project that was conducted in 2004 and the survey collected information such as demographic indicators including gender, age, race/ethnicity as well as BMIs and health conditions such as diabetes, high blood pressure, high cholesterol and depression (NYC Health and Mental Hygiene, 2013). Since there is precedent of such information being collected the researchers next step would be to learn how such licenses are obtained.

While the majority of the coding has been done for the backend implementation, the frontend is not yet polished to have the look of a commercial game. Since a major goal of this project is building a user base of repeat players to collect data over a period of time, the game must be as engaging as possible. A large part of sustained engagement will come from a finely tuned interface.

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Simulation to Teach Concepts of Evolution: The Finger-Painting Fitness Landscape Application

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Challenges in Teaching Evolution

Principles of evolution can be difficult to learn. The processes involved often take place over long periods of time, placing direct observation outside of the experience of most people. When taught through abstract, mathematical modeling and memorization, students often struggle with the counter-intuitive concepts and retain prior misconceptions about evolution which traditional, direct-instruction methods often cannot unseat (Alters, Nelson, & Mitton, 2002).

Experiential learning techniques have been shown to improve understanding of difficult, abstract concepts (Koebler, Lawroski, & Bischoff, 1995) especially when computer simulations have been included (Squire, 2006). Simulations, computer games, and virtual worlds have proven useful in experiential learning when learners are unable to directly observe phenomena because of difficulties in scale. Processes that are too slow, too fast, too large, too small, or too complex can be made accessible through computer modeling, allowing learners to experience a system, devise theories about how it works, and test those theories, thereby developing an understanding of the system (Johnson, 2012).

Fitness Landscapes

The Finger-Painting Fitness Landscape Application makes use of a model first proposed by Sewall Wright in 1932 to explain how combinations of genetic characteristics interact in determining the success of a population of organisms within a particular environment: the fitness landscape metaphor. Fitness landscapes are depicted as a plot on two axes representing two traits. Hills and valleys of the theoretical fitness of an organism with traits at that location can be plotted. The fitness landscape is an over simplification, but it has been found to be a helpful visualization in developing evolutionary thinking (Zaman, Ofria, & Lenski, 2012). It directly addresses a key idea in understanding evolution, namely how populations of organisms evolve from one successful form to a more successful one.

The simple, finger-painting system used in the demonstrated simulation has been used in other programs as a quickly learned tool for interactive exploration. In particular, we are building on earlier prototypes that used more abstract representations of organisms (e.g. Zaman, Ofria, & Lenski, 2012) in order to build a simulation that can be used to teach principles of evolution to high school and college biology students.

Description of the Program

The program creates an instantiation of evolution by using a genetic algorithm with tournament selection and overlapping generations. During each round, individuals are chosen to reproduce with a probability that depends upon their location in the fitness landscape (i.e., their fitness). Those located in the darker, more favorable areas have a higher probability to reproduce. If an individual does reproduce, another is randomly chosen to die off in order to maintain a constant size population. The offspring is placed on the fitness landscape offset from the parent's location in both dimensions. The distance from the parent is determined probabilistically along a normal distribution, based on the mutation rate chosen by the player. Thus, offspring may be similar to parents or may differ greatly in both attributes, potentially allowing the population to evolve into more favorable combinations in any given fitness landscape devised by the player.

The light grey default background represents a baseline area of fitness for the population of organisms. The user can click and drag to darken the background, creating regions of higher fitness for the population. The darkest regions are the most suitable (organisms with those traits would have the highest fitness), and populations of organisms might eventually cluster there as the simulation progresses if the population is able to evolve to that fitness peak.

This simulation uses a representation of alien-looking plants in order to reduce the level of abstraction found in previous simulations that used the finger-painting fitness landscape. These plants vary in size and color depending upon where in the two-dimensional space they are born.

Learning with the Simulation

The learner can use the interactive system to visualize and simulate how a population evolves in real time. They can create a fitness landscape of their own, modify some parameters (mutation rate and size of the total population) and see what happens over time.

The simulation can be paused or reset so that the learner can start over. There is an example fitness landscape from which learners can start and observe before they start creating their own hypotheses. Learners can then hypothesize about and experiment with what might happen and what types of evolutionary paths might result from various types of complicated fitness landscapes, providing an environment for experiential learning (Kolb, 1984). Learners can change mutation rate and population size before and during a simulation to see the effects these important environmental conditions have on evolution.

Conclusion

The Finger-painting Fitness Landscape application allows the player to explore the important concept of evolution through free-form creation of a wide variety of fitness landscapes and manipulation of the landscape, population size and mutation rates, even while the simulation is running. While it is limited in that it reduces the complexities of evolution to a two-dimensional system, just as Wright's original metaphor of the fitness landscape does, there is evidence that it assists learners in developing an evolutionary mindset (Zaman, Ofria, & Lenski, 2012).

The program is currently available for PC and Mac at <https://sites.google.com/site/anyaejohnson/finger-painting-fitness-landscapes-app> and we will soon extend it to be used with or without a touch screen on a variety of other platforms (iOS and Android in particular). The program includes an example fitness landscape that a player can use for learning about how populations evolve across fitness valleys. A sample lesson is available for download to supplement that example landscape.

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Solving the Hard Problem of Educational Video Game Design with Modeling Instruction

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The Hard Problem of Educational Video Game Design

Modeling instruction is a pedagogical method for teaching physics developed by David Hestenes and colleagues at Arizona State University (Hestenes, 2010) that has profound implications for educational game design. Modeling instruction has been little explored by game designers. (SURGE (Clark, Sengupta, Biswas, & Nelson, 2011) is a rare example of a physics video game that attempts to incorporate modeling instruction.) Research on modeling instruction shows that the practice of modeling is one of the few paths to robust conceptual understanding for physics and other subjects. As Hestenes says, “Modeling is the name of the game” (Hestenes, 1992; Hestenes, 1993). If educational game designers want to achieve similar results, modeling pedagogy implies real constraints that cannot be ignored. Effective game designs must fulfill model assumptions or risk being ineffective. This leads to what I call the Hard Problem of Educational Video Game Design: How do educational video game designers create game mechanics, which are mostly rooted in player actions, that allow players to instantiate models, especially when so much of the modeling process is discursive? Some following questions: Are educational video game designers forever dependent on activities outside the game to achieve learning outcomes? What implications does this have for production and video game genres, especially for subjects such as Newtonian mechanics? Are effective educational casual (small-scale) games even possible? I submit that no educational video game worth playing for a subject, where modeling instruction is effective, will have a large impact without resolving the tension between game mechanics and modeling discourse. Educational game designers must be able to identify and articulate the model for the phenomenon they want to teach in their designs. Models are necessary, if not sufficient, for educational game design, and learners must be able to instantiate those models in the game.

If discourse, which includes relevant practices, is a necessary condition for conceptual change in areas such as physics—and modeling research and socio-cultural learning science strongly suggest this is the case (Gee, 2007a; Gee, 2007b)—, what are the options for game designers? When making a video game, designers have to make decisions in at least two categories: creating a single player versus a multiplayer game and creating a standalone experience versus an integrated experience. Single player games are most likely easier to release because multiplayer games typically have administrative and production issues that single player games do not have such as personal security, networking, hosting and maintaining servers, having too few or too many players, etc. Single player games may be harder to design for educational outcomes because modeling discourse must be handled by the game engine. In a multiplayer game, however, discourse must still be guided by either the game engine (like a single player game) or by someone who is knowledgeable enough to guide the players, which creates a dependency since an expert must always be in the game for it to work. Designing standalone experiences means that most, if not all, support and all scaffolding (help) must be part of the game engine. Although a community may grow around a video game, this is most likely beyond developers’ control, and dependency on a community for a learning outcome is a very big dependency that could be indicative of a major design flaw. Educational video games to be integrated into a larger instruction experience are also at the mercy of the environment where they will be used, which may include things like class duration, fitting into state standards, the instructor’s comfort with technology, etc. This adds more dependencies that could lead to failure. No matter what type of educational video game the designers intend and which problems the designers accept, however, a model must be at the heart of the design.

An Example Model

Models have structure (Hestenes, 1997; Hestenes, 2008; Hestenes, 2010), and a basic model is presented as an example. The model is *particle moving with constant velocity* (Hestenes, 1992). Particle does not mean an atom or molecule. Particle means an object that can be modeled as a single, rigid (solid) object, where the internal structure does not matter. Although the specification for a model evolved in Hestenes’s writings, a model has the following substructures although not all may be present. Here is a model using a spaceship as the particle in an educational video game for Newtonian mechanics.

1. Systemic Structure: What is the structure of the system?

- a. Composition: The object is a spaceship which we model as a particle.
- b. Environment: The spaceship flies in space. We assume there are no large massive objects nearby, so we do not have to consider gravity (force).
- c. Connections: None. There are no interactions with other objects necessary for the model.

2. Object Structure: What are the things in the system?

- a. Intrinsic properties: Position is the only spaceship attribute (variable) that changes.

3. Geometric Structure: How are things placed?

- a. Location: The spaceship moves on a 2D Cartesian grid with the origin in the left corner.
- b. Configuration: None because no other objects are needed in the model.

4. Temporal Structure: How do things change over time?

- a. Descriptive Structure: The spaceship changes position on the grid, which is a graph.
- b. Dynamic Structure: The only spaceship state variable that changes is position:

$$x = x_0 + vt \text{ for horizontal motion}$$

$$y = y_0 + vt \text{ for vertical motion}$$

Subscript 0 means initial position (when time equals zero seconds).

Time (t) is in seconds. Velocity (v) is constant in the horizontal and vertical directions.

5. Interaction Structure:

- a. None as there are no forces or the forces sum to 0. There are no collisions either.

This specifies a model to describe a particle moving with constant velocity. If we wish to design a game to teach a player about constant velocity accurately, this model describes what the player must learn. Surface details may be changed. For example, instead of a grid, a number line could be used where the player only must consider one dimension. The larger point is that this model puts constraints on the design of the video game. The temporal structure is especially important because it is, in a sense, where the action is. The model, unfortunately, does not give us a prescription for teaching the model. That is for the designer to decide, and there is a wealth of research in modeling instruction and other areas to help with this. (To learn more about the structure of models and implementing modeling instruction cycles, the American Modeling Teachers Association provides a wealth of materials.)

Modeling instruction is a topic worthy of study by educational game designers. For creating deep conceptual change in introductory natural science subjects, it may be necessary. Pedagogy matters for educational game design. Modeling instruction suggests that there may be a scientific foundation for educational video game design waiting to be created since models are objective and imply constraints on game designs. Game designs that use models and emulate the model cycle, the process by which students construct and test models, should have a higher chance for success.

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EcoChains: A Multiplayer Card Game to Teach Food Webs, Climate Change and Systems Thinking

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Overview

EcoChains: Arctic Crisis is an educational multiplayer card game for all ages, focusing primarily on middle school students through adults. It is designed to be a fun, accessible, collaborative experience with a short session length (approximately 30 minutes), playable within the classroom or at home. The game is for 2 to 4 players.

Learning Objectives

Players learn about Arctic ecosystems and the impact of a changing climate as they build and manage food webs based on predator-prey relationships. Various threats to Arctic marine ecosystems arise (e.g., carbon pollution, other impacts of climate change such as invasive species, etc.) that encourage participants try out strategies to build more resilient food webs and reduce environmental stress (e.g., the development of alternative energy).

Players realize the importance of sea ice as they act as stewards over their food webs. As global warming progresses and the area of perennial sea ice diminishes, the range and quality of a player's ice habitat will also decrease, leading to the loss of Arctic species. When their food source is lost, a species first tries to migrate to another player's food web looking for new prey, or perishes if unable to do so. The game is designed to teach players the importance of ice to key Arctic species, and that biodiversity leads to more resilient food webs. In this way, the game promotes systems thinking, an important skill for the 21st century (Gee, 2005).

Gameplay

Players set up a base of sea ice cards and play Arctic species cards to gradually build up marine food webs according to predator-prey relationships. In each round, representing an annual cycle, various Arctic species, "Action" and "Event" cards are drawn. The Event cards have an impact on specific species in the environment, allowing players to see the potential impact of specific environmental stressors on ecosystems. On a player's turn, they may draft Arctic species or Action cards to mitigate the impacts on their ecosystem. In this way, players learn how to build a more stress resilient ecosystem and understand the consequences of pro-active versus reactive responses.



Figure 1: Food webs with a base of Arctic sea ice.



Figure 2: Four students play EcoChains.

Players also draw “Goal” cards and earn bonus points by accomplishing secondary objectives as they build and manage their food web. Goal cards provide additional reinforcement to the EcoChains learning objectives, drawing attention to desirable outcomes such as biodiversity and resilient food webs. The game ends once a player constructs three webs of four or more Species cards or loses all of his or her sea ice. Players are awarded points for every Arctic species that remains alive; the player with the most points wins.

Design

EcoChains: Arctic Crisis is collaborative effort between designers, subject matter experts, and learning scientists. Its success is the result of several cycles of design, scientific content review, playtesting, evaluation, and redesign. There is a need for more accessible educational games that address systems thinking and climate change issues from biophysical, impact, and adaptation perspectives (Reckien, 2013). This is the first of a series of ecosystem-based food web games in response to this challenge that is not only educational in scope but is also entertaining to play. For more information, please visit EcoChainsGame.com.

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Acknowledgments

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Games for Climate Change Education: Opportunities and Future Directions

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Introduction

In this paper, we propose new classifications in order to provide a window into emerging opportunities and innovative approaches to climate change education.

Locus of player action: Where does gameplay take place?

Fullerton and Duncombe (2010) describe the difference between a virtual or digital game (i.e., played on a PC), and a *real-world action game*, which takes place in physical space (the “real” world). For example, in the game *Greenify*, players respond to real-world missions in the form of open-ended sustainability challenges (Lee et al., 2013). Games intended to raise awareness, educate or persuade a player about a particular issue can be considered to be *preparation for future action* (see Table 1).

Locus of action	Key features	Pros	Cons	Examples
Preparation for future action	Simulated or fictitious experience that typically takes place on a PC (virtual space)	Lower cost of participation	May delay physical action	<i>Fate of the World</i> (Roberts, 2011) <i>Climate Challenge</i> (Red Redemption, 2006)
Direct action upon the world	Players complete real-world tasks (physical space)	Personal relevance, Immediate physical impact	Higher perceived cost to participate	<i>Cool Choices</i> (Filament Games, 2013) <i>Greenify</i> (Lee, et al. 2013)

Table 1. Where player action takes place (based upon Fullerton & Duncombe, 2010)

Orientation: Envisioning a Sustainable Future vs. Threat-based Responses

Until now, most climate change games have focused on *survival orientations*: the need to avoid the impending devastating consequences of global climate change. In contrast, an increasing number of games are posited on a *vision-based orientation*, which invite players to consider goal-oriented visions for a sustainable future and practical actions that can build toward a better community and world (Grant, 2012; Meadows, 1996) (see Table 2).

Orientation	Key features	Pros	Cons	Examples
Vision orientation	Vision-based, building towards what is desired	May foster intrinsic motivation, creativity, productivity, and well being; larger in scope	Difficulty to articulate and understand Relatively complex mechanics	<i>Greenify</i> (Lee, et al. 2013) <i>Cool Choices</i> (Filament Games, 2013)
Survival orientation	Threat-based, avoiding a negative outcome	Urgency, simplicity, readily understandable, simple mechanics	Diminishes intrinsic motivation Limited scope Constrained possibility space	<i>The Farmers</i> (Fennewald & Kievit-Kylar, 2013) <i>Antarctica: Global Warming</i> (Zuuring & Zuuring, 2006)

Table 2. Proactive vs. Reactive Orientation (based upon Grant, 2012; Meadows, 1996)

Conclusion

Our review has identified two emerging trends: the differentiation of virtual and digital games from real-world action games, and divergence in survival or vision-based orientations. Based on these trends, we propose the following

key areas for further research: First, there is great potential for expansion on mobile devices, taking advantage of the affordances that mobile technology allows. The use of multimedia sharing, location-aware hardware and social-networking features may be especially beneficial in game design. Second, further study of the function and effects of real-world action games and vision-oriented games compared to their traditional counterparts is needed. The resulting insights may help produce games that are more effective in climate change education and promoting sustainable behavior.

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The PBS KIDS Iterative Design Process For Building a Successful Augmented Reality (AR) Game

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Overview of the Iterative Design Process and the Use of Formative Evaluation

This paper focuses on the iterative design process in the development of a successful PBS KIDS' AR tablet app, *Cyberchase Shape Quest*, targeted at children ages 6-8. *Cyberchase Shape Quest* uses a tablet camera and a printable board game to interact with shapes in five different virtual environments. Students apply spatial memory, visualization, and modeling skills to complete levels. In the first week of release, *Cyberchase Shape Quest* rose to be the #1 free iPad kids app in the iTunes store. The app is also available for Android devices. Development of *Cyberchase Shape Quest* involved an iterative design process. Incorporating formal and external formative evaluation into several of the design cycles proved to add significant value during game development because it helped reduce the uncertainty around a large number of unknowns—AR is a relatively new technology and unfamiliar to young children. This paper focuses on the utility of conducting formal formative evaluation at specific points of game development: 1) early game concept testing and 2) user testing on an alpha build.

Formative Evaluation, Cycle 1: Early Game Concept Testing

PBS KIDS initially proposed several game concepts that used AR. These game concepts addressed several mathematics topics, including tessellations, measurement, and spatial reasoning. PBS KIDS and its producers worked with researchers at WestEd to iterate and refine the initial game concepts into the idea behind *Cyberchase Shape Quest*, chosen because it best used the affordances of AR to address an established need in math education—spatial reasoning. At this point the PBS KIDS team was faced with a large number of game design decisions, such as level design and the design of game controls. Rather than make decisions based on limited knowledge of how children would react to the game concept, the team turned to a round of formative evaluation to guide the design.

Methods: Paper Prototype Testing and Game Mechanics Testing

The formative evaluation used a two-part approach in order to address the large number of questions regarding appropriate game design, focusing on questions related to level design and game controls. First the team, which included PBS KIDS developers, math education experts, and WestEd researchers, sketched a series of possible level designs that used a variety of spatial skills (e.g., 2D rotation vs. 3D rotation), were developmentally appropriate, and which progressed in difficulty. Researchers then constructed 13 physical block-and-tile versions of these levels based on the sketches. These physical versions of the puzzles were used in a variation on paper prototype testing. The goal of paper prototype testing was to collect data on the difficulty of the different types of spatial reasoning problems, document the problem-solving strategies students used to solve the problems, and document the scaffolding techniques used by an in-person adult facilitator. The second part of the formative evaluation was to collect data on the usability of different types of game controls—at the time the game was being developed, there was little published data on the usability of AR games for children. Rather than spending resources developing parts of the game, the team opted to test a variety of controls (e.g., pressing buttons with thumbs, shaking the tablet, ability to maintain AR tracking) from a collection of commercially-available AR and non-AR tablet games. Seven children ages 6-9 (3 boys and 4 girls) participated in the formative evaluation. The paper prototype testing and the game mechanics testing each took 30 minutes, with the order of tests counterbalanced across participants. All sessions were video recorded and analyzed.

Findings and Contributions to Later Iterations

Researchers analyzed the video data in order to establish the relative difficulty of the different puzzle levels based on the number and age of students who completed each level, the time needed to complete each level, and the amount of scaffolding needed. The video data was further analyzed to generate more detailed data on children's problem-solving strategies, the amount and type of scaffolding required for students to complete each level, children's ability to use different games' controls and to perform the actions required to maintain AR tracking, and how long children could hold the tablet up to maintain AR tracking before experiencing fatigue. As a result of this

first round of formative evaluation, game developers were able to determine which styles of puzzle levels were too easy for the target age group and which styles were too difficult. Game developers were also able to use the scaffolding interactions from the paper prototype testing as models for the scaffolding algorithms into the game. Specifically, the paper testing informed the timing of scaffolding, the progression of scaffolding (e.g., moving from general to specific hints), the wording of scaffolding (sometimes using exact words captured during the study), as well as the modality of scaffolding (e.g., what types of verbal and visual hints to include and when to deploy each type of hint). In addition, the formative evaluation determined that the most usable approach to game control was to have children hold the tablet with both hands and have UI buttons on the edge of the screen. It was also determined that children lose the AR tracking frequently, so providing adequate support for avoiding and recovering from tracking loss would be a critical element for game usability.

Formative Evaluation, Cycle 2: User Testing on an Alpha Build

Following the first round of formative evaluation, the PBS KIDS game developers and producers continued iterating on the game design and produced an alpha version of the tablet game that underwent another cycle of formal formative evaluation. This cycle of formative evaluation was guided by these research questions: 1) What usability problems did the participants encounter when playing the game?, 2) Is the difficulty of the levels appropriate for the participants and do the levels build in difficulty?, 3) What would teachers change about the game to improve the instructional content?. Seven children ages 6-10 (3 boys and 4 girls) tested the game. Additionally, 3 teachers who currently work with this age group tested the game and provided feedback around the game's usefulness as an instructional tool. Each participant played *Cyberchase Shape Quest* for 30-40 minutes (with a break in the middle). Game play was followed by a post-interview to obtain participants' feedback. Observers took note of usability and pedagogical issues that arose during game play. Researchers debriefed after each session to synthesize what they observed in context of the research questions. Observations, interview responses, and researcher debriefs were transcribed and qualitatively coded.

Findings and Contributions to the Final Game

The evaluation confirmed that the game is generally usable and fun, that kids can persist through multiple levels of the game at a time, and that the game is interesting and valuable to teachers. We also uncovered several usability issues that were particularly critical to address in the final game. Users had major problems with understanding the mechanics of AR and perceiving the 3D space—both children and adults tended to sit in one position rather than moving around to view the 3D puzzles from different orientations. This led the developers to create new “tutorial” levels that required kids to physically move, and made them sensitive to the 3D depth of the game. This also led the creative team to amplify perceptual cues in the game (adding shadows, making shapes bounce around). In addition, children struggled to understand the scaffolding provided by the game. As a result, the development team adjusted the scaffolding wording and visuals to be simpler and more direct, as well as adjusting the actions that triggered the scaffolding. Finally, having teachers participate in the evaluation enabled the team to identify more teaching opportunities in the game.

Significance and Recommendations for Future Game Development

Given our experience with *Cyberchase Shape Quest*, PBS KIDS and WestEd have the following recommendations for designing high-quality AR-based educational games: 1) Expect to have many unanswered questions early in the design process, when dealing with bringing technology into a new domain, 2) Explore unknowns by incorporating formal formative evaluation into an iterative design process, 3) Involve different stakeholders and domain experts (game developers, researchers, content area experts) early in the development process, and keep them involved throughout, and 4) Conduct testing early and often, as it is not necessary to have a playable game for testing to add value, and be sure to include teacher participants in the testing of educational games. In conclusion, using formative evaluation was very useful to develop a successful game in a design space with many unknowns. *Cyberchase Shape Quest* launched in January 2014, and was downloaded nearly 250,000 times in its first month on the App Store. It currently averages 12,000 daily active users. Formative evaluation helped the PBS KIDS team understand how children think about spatial problems, and identified new opportunities for teaching and scaffolding. It also helped us design a user interface and game mechanics that are appropriate for the intended age group. The project is funded by a Ready To Learn grant (PR/AWARD No. U295A100025, CFDA No. 84.295A) provided by the Department of Education to the Corporation for Public Broadcasting.

Using a Level Editor's Clickstream Data as a Performance-Based Assessment Tool

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Introduction

Games have great potential to act as assessment tools, particularly for performance-based assessment (Steinkuehler and Squire, 2013). Digital games uniquely enable automated observation of student performance, eliminating the need for video recording or time-intensive observational work. Clickstream data can automate observations if a student's sequence of clicks can be tied to learning claims, for example through an evidence-centered design approach (Shute and Ventura, 2013).

In this study, we will use the clickstream data resulting from a student's use of an in-game level-editor to assess a student's level of persistence and use of the engineering design process (EDP). We will test students both before and after attending an engineering-focused, 12 week after school program. This is particularly relevant as the new science standards emphasize understanding the engineering design process in addition to the scientific method (NGSS Lead States, 2013). The level-editor will be used as an assessment tool, to gauge transference of these two skills from a hands-on, engineering learning context to a digital, game-based assessment context. This is an ongoing study, and we will report on the results from the first round of implementation at the GLS poster session.

The program

We will assess learning in a program called "Be an Inventor," run each spring by Iridescent. In this program, 25 students in grades 3-8 attend an after school program. This program runs for 15 weeks, and meets for two three-hour sessions each week. The program itself alternates between directed lesson on certain skills, like techniques for cutting and scoring cardboard with mat knives or how to mix and pour concrete, with open-ended opportunities for students to practice those skills in projects of their own design. In a sense, the activities performed by students in the program are gamefully designed. Throughout the program, students will be instructed and guided in use of the EDP as a tool to help design and improve their projects. Other than that basic structure, each student is given agency to define and build their own, unique set of projects in the program.

One day at the beginning and end of the program will be set aside for an assessment related task. Students will complete a game-based assessment task. Students will be given a chance to play a physics simulation game created by Iridescent. After getting familiar with the game through open gameplay, students will be challenged to make a well-designed level in the game's level editor (Figure 1) using the EDP. Students will also be given a short survey, to rate their comfort with tinkering and playing games, and a student's use of the EDP will be evaluated through the use of a student journal throughout the program.

Assessing learning goals

The learning goals of the Be an Inventor program are to increase creativity, persistence, and curiosity in students, skills which naturally evolve through increasing a student's understanding and use of the EDP. This study will focus on assessing student use of the EDP and persistence. The authors use the model for EDP provided by The Works (http://works.stylefish.com/files/docs/EDP_final_11x17.pdf).

The Gravity Ether contains a clickstream data collection system. System events are recorded as students play through both the game and the level editor. Large scale events are recorded and time stamped, such as when students enter and leave the level edit screen. Smaller events within each screen are also documented, such as what objects students select and where those objects are placed in the editor, or when control mechanisms are turned on and off in the play screen. In this way, the extent to which students build, test, and refine their levels based on testing will be captured by the system, as well as their persistence in continuing through this process multiple times to eventual success. This can be measured on both a large scale (number of switches between the editing and playtesting screen) and on a small scale (editing and testing the same set of features of a level multiple times). As such, we can score both student persistence and use of EDP in designing their levels.

We plan to analyze the data in several ways. First, we will conduct a preliminary exploratory analysis of student play patterns in the game. Next, we will look for increases from the pre to post scores over the course of the program, in both the hands-on task and game-based task. Then, we will look for correlations in scores between the hands-on work as recorded in the journal and game-based task, to determine whether both tasks are accurately

measuring the same skills. In particular, we are concerned that students with more game-playing experience might perform better in the game-based task simply due to their familiarity with the medium, rather than due to gaining the skills in the program. Finally, the students attending the Be an Inventor program are a mix of new and returning students to Iridescent's programs. Each student's attendance is tracked across programs by an attendance tracking software. In this way, we can test whether students do better on the pretest when they have attended more previous Iridescent programs that have reinforced the skills of interest. Thus, some of the variance in student scores can potentially be explained by prior attendance in the Iridescent's programs.

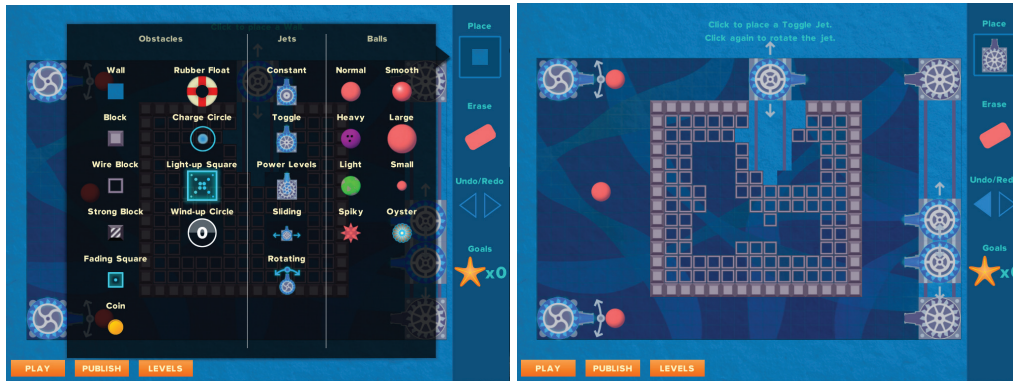


Figure 1: Two screenshots of the game's level editor interface.

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A Framework For Understanding Academic Writing Connections in Fandom Spaces

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This poster session presents a framework for understanding academic writing connections within fandom spaces when coupled with the use commercial-off-the-shelf (COTS) videogames. When students engage in writing in fandom spaces they often do not see the connections with their school-based writing practices or the acquisition of valuable twenty-first century skills such as critical thinking, collaboration, and leadership which we have deemed crucial to investigating adolescents' complex meaning-making and writing development. We posit that, when examined within the Game-Based Writing Framework, students (and teachers) will more readily see connections between literacy practices at home and in school.

Literature Review and Theoretical Underpinnings

Framed within connected learning theory (Ito et al., 2013), this research explores the connections between academic writing and fandom writing through COTS videogames. Connected learning incorporates today's interactive and networked media to make learning more interest-powered, peer-supported, and academically oriented. Connected learning posits that learning environments (a) are populated with people who have shared interests, (b) are focused on production where learners not only produce their own media but also comment on others', and (c) are openly networked to include multiple institutions and groups from popular culture to educational institutions and beyond.

Youth often engage in the creation and adaptation of multimodal literacy practices through videogames and online fandom spaces to further their knowledge in, or about, the game; this is known as metagaming (Consalvo, 2007). Through metagaming, adolescents create paratexts (artifacts and texts that support the main publisher created game) and engage in complex literacy practices, such as fanfiction (Black, 2008; Gerber & Price, 2011; Lammers, 2012; Magnifico, 2012; Steinkuehler, Compton-Lily, & King, 2009). In fanfiction writing, youth create and extend the existing story by either recreating the storyline, extending the plot, or introducing new characters. It has been reported that students may not perceive or understand the connections between their in-school literacy practices and their out-of-school literacy practices when examining videogames and the related writing activities (Abrams, 2009; Abrams, Gerber, & Burgess, 2012; Gerber & Price, 2011).

Of particular interest is the examination of supportive roles youth take in fostering their fanfiction writing, the methods and negotiations that they take in the peer collaboration stage, and the subsequent leadership roles and critical thinking in which they engage. Collaboration, leadership, and critical thinking have been noted as vital skills for the 21st century (Gee, Hull, & Lankshear, 1996). Videogames offer many opportunities for players to gain leadership skills (Childress & Braswell, 2006; Collins & Halverson, 2009; Steinkuehler, 2006) and critical thinking skills (Gee, 2007; Squire, 2008) akin to those needed in real-life situations. Additionally, gaming environments offer learners collaborative and cooperative experiences (Gee, 2007; Gerber, Abrams, Onwuegbuzie, Benge, 2014; Squire, 2003). We posit that the elements of leadership, critical thinking, and collaboration can be used to form a Game-Based Writing Framework for analyzing students' fanfiction writing, as well as used as a framework for planning in-school writing lessons, thus creating a bridge between in-school and out-of-school writing activities and providing opportunities for students to develop and enhance vital skills necessary for success in the 21st century.

Research and Discussion Questions

- How do youth perceive the connections between their gaming writing practices in and out-of-school?
- How do leadership, collaboration, and critical thinking enhance fan-related writing activities?
- How do youth perceive these three elements in relation to academic writing?

Methodology

We are in the beginning stages of our collective case studies (Stake, 1995). We will have ten participants age 12-24. Artifacts collected will include interviews and screenshots of fanfiction writing. The qualitative data—as a set—will be analyzed via a constant comparison analysis using the a priori codes of leadership, collaboration, and critical thinking (Glaser & Strauss, 1967) in a form of hypothesis coding (Saldana, 2013). In conducting constant

comparison analysis, the researchers will examine (a) how youth perceive the connections between their gaming writing practices in and out-of-school (b) how the three elements of leadership, collaboration, and critical thinking enhance their fan-related writing activities, and (c) how they perceive these elements in relation to their school writing.

Findings and Discussion

We purport that using the Game-Based Writing Framework (see fig. 1) when planning class writing activities, will allow teachers to more readily understand the depth of how their writing lessons reflect the various levels of leadership, collaboration, and critical thinking, as well as allow them to examine factors such as time and space that need to be reconceptualized to foster connected learning in classroom environments. Further, we posit that when writing lessons are planned within the framework, the connections between in and out-of-school writing practices will become more transparent to students.

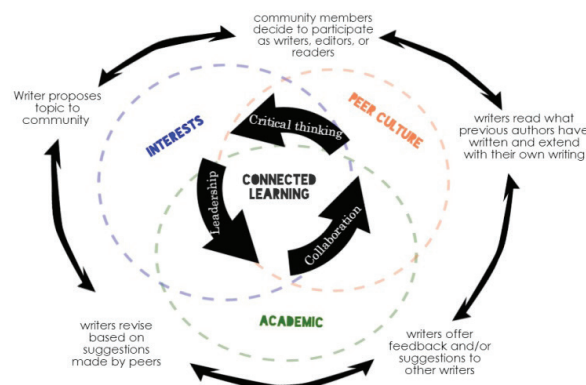


Figure 1: Game-based Writing Framework.

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Analyze This! Examining Mobile Augmented Reality Gameplay Through Analysis of End User Data

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Background

Mobile, location-based augmented reality (AR) games have become viable tools for engaging audiences at informal learning venues (Yoon, Elinich, Wang, Steinmeier, & Tucker, 2012; Lo, Delen, Kuhn, McGee, Duck, & Quintana, 2013; Dunleavy & Dede, 2014). These AR games allow players to participate in active, situated learning (Brown, Collins, & Duguid, 1989) through their interactions with virtual characters, objects and information integrated within a real-world location (Klopfer, 2008). However, as casual visitors play mobile games in a free-choice environment, numerous questions arise: *How many visitors opt into such experiences? How long do typical game sessions last? Is gameplay continuous or divided into intermittent spurts of gameplay and respite? Are some games more “successful” than others in terms of their popularity and/or engagement? In games that include a definitive ending, what proportion of players reach this conclusion? And in games where players make choices, which options do they choose and how does this affect their experiences and learning outcomes?* While survey and interview data can inform many of these questions, data collection can be cumbersome and large sample sizes can be difficult to obtain. This poster describes an alternative approach, a web-based data analytics extension to an existing AR game platform, TaleBlazer, that automatically gathers anonymous end user data to provide a range of game analytics.

An Audience Shift: Moving From Field Trips to Casual Visitors

As part of an ongoing NSF funded research project (NSF# 1223407), TaleBlazer is now exploring ways in which informal learning institutions can leverage AR games to engage new audiences in free choice, on-site visits with the goal of engaging players in STEM learning experiences. Prior to this current phase of research, TaleBlazer had been primarily used as part of controlled research studies or field trips, using hardware loaned to players for the duration of the experience. These experiences were also typically facilitated by staff members and often included whole group introductions and/or concluding discussions. However with the new emphasis on *casual* visitors playing games as free-choice experiences, players now use their personal devices, pausing or stopping gameplay at their own discretion. Given these conditions, understanding players' play patterns becomes particularly relevant. In this way, the data automatically generated by an analytics platform could serve as a valuable tool, potentially used both formatively (to make improvements to games and software) and summatively (to assess the degree to which AR experiences were effective).

Design of Analytics Platform

To gather pertinent usage informational, the authors determined that an analytics component could be added to the existing TaleBlazer AR game platform. When designing the initial scope of this extension, it became clear that different types of end users would have distinct purposes in utilizing the analytics platform and thus different informational priorities. To meet these diverse needs, the design team began by developing narratives that embodied likely usage scenarios for each group. Specifically, narratives were developed for three types of potential analytics end users: host organizations designing games, researchers evaluating AR, and the TaleBlazer platform development team.

Based on these narratives, the design team generated a potential list of analytics features. These lists in turn became the basis for annotated screen mockups which were shown to existing TaleBlazer end users (grant partners as well as individuals who had worked with TaleBlazer to develop games), who reviewed designs and completed an accompanying written survey (n=5). Survey findings, which included feedback on prioritization of features as well as qualitative feedback with additional suggestions, were used to revise the initial designs.

Types of Data Collected & Visualizations

Three primary types of data are collected as part of the analytics platform: (1) generic data, (2) game-specific data, and (3) custom data. The generic data category includes metrics which are valid for any TaleBlazer game. These include basic frequencies (e.g., number of unique downloads and games initiated, type of device/OS) as well as the duration of gameplay sessions. The second category catalogues elements which are specific to a particular game (e.g., how many people played the “scientist” role vs. the “journalist” role?). The last category allows game

designers to tag particular in-game actions (e.g., did the player pick up the *microscope* or the *petri dish*?) in order to determine frequencies of very specific player choices. While generic or game-specific data are automatically captured by TaleBlazer analytics, the game designers must flag a priori the custom actions (using a specific “block” in the TaleBlazer Editor) for which analytics data is desired.

Currently, game analytics are displayed in a separate TaleBlazer Analytics gui for each game individually. The initial default view displays a “dashboard” that provides a quick snapshot of basic data (number of downloads to date, average duration, etc.). Additional screens provide tabular sub-categories of data, allowing analysis of games comparing versions, roles, dates played, etc. For example, a table might display data comparing the average duration of gameplay across two different versions of the same game, demonstrating that the more recent version’s average duration “stickiness” is 120% greater than the earlier version.

Design Challenges

Several challenges arose during the design of the analytics platform. First, the analytics team struggled with determining the optimal ways in which users would want to filter analytics data. While some categories are straightforward (e.g., downloads over time), others are potentially more complex, involving multiple filters and categories (e.g., comparing completion rates among weekend game players across multiple games). The interface which allows analytics end users to filter and categorize game data require additional pilot testing to find the balance between flexibility and usability. Designs will also benefit from added graphical presentations of data, rather than the tabular data currently provided.

A second challenge deals with contextualizing the anonymous game analytics data within additional specific user data. Researchers might want to capture demographic data (e.g., were people playing individually or as a family group?) or survey questions (e.g., players might complete a Likert scale rating their attitudes about science). By linking analytics data with other self-reported data, researchers would be able to explore a much broader range of research questions. Upcoming pilots will explore linking analytics data with player-generated survey responses.

Lastly, the authors quickly realized that they would be incapable of anticipating the many ways in which analytics end users would want to approach the data. For this reason, the analytics platform allows the end user to download a raw dataset as a CSV file for further analysis, enabling the user to have flexibility to follow other avenues of inquiry.

Conclusions and Future Work

Piloting of games for the general public is planned for Summer 2014. These games will utilize the TaleBlazer analytics capabilities to collect initial datasets from real end users.

The authors hope that lessons learned from the development of this analytics platform will inform others who seek to utilize the TaleBlazer analytics platform effectively. Additionally, the authors hope that the outcomes of this pilot project can inform other projects which seek to develop analytics extensions for their own software platforms.

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Geniverse: Science Practices In a Web-Based Game Environment for High School Genetics

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Introduction

With a five-year grant from the National Science Foundation, we have designed and developed *Geniverse*, a game-based environment for high school genetics. Genetics, a core topic of biology in both middle and high school, is difficult to teach and learn (e.g., Duncan & Rieser 2007). The causes of difficulty in genetics include the invisibility of many of the structures (chromosomes and genes); the many different levels involved (genes, proteins, cells, traits); and the difficulty of reasoning across different organizational levels (Horwitz, 1996; Stewart, 1990). Moreover, genetics experiments are difficult to do in schools due to limits on time, facilities, and budget. Multi-generational experiments, the hallmark of genetic science, are nearly impossible in this context. These difficulties can be addressed with computer simulations that bridge the gaps between macro- and micro-worlds, and condense timescales from weeks or years to moments.

Geniverse Narrative

In *Geniverse*, students are introduced to a world where dragons roam, and where a protagonist of their own choosing befriends a dragon that eventually falls ill. Learning of a distant Guild for studying drakes, the model species for dragons, a long and arduous journey with the dragon is undertaken. Arriving at the Guild, the student embarks on a course of study to understand the dragon's disease. Through a series of 32 challenges across four levels of difficulty, students work their way up through the Guild ranks. Each challenge presents the student with an objective to achieve and a multi-level simulation that supports experimentation.

Integrating genetic concepts

Students encounter two different types of challenges in *Geniverse*. In “target drake” challenges, their goal is to breed a drake with specific traits. They can only discover how a trait is inherited by experimenting to reveal the genetic mechanisms at play; then they can breed to achieve the target. They are awarded up to 3 stars based their skill in meeting the challenge, and can repeat challenges to improve their star rating. The game mechanic here represents what Clark and Martinez-Garza (2013) term a “conceptually integrated” game, that is, the concepts of genetic inheritance are integrated into the core mechanic. As we were developing *Geniverse*, we recognized the advantage of engaging players with the science concepts directly and intrinsically, but were concerned that the understanding developed would be tacit rather than explicit. (In this regard, our concern closely mimics the concerns of Clark and Martinez-Garcia (2013) regarding conceptually integrated games.) As a result, we developed a second type of challenge designed to bring tacit understanding to the surface, using scientific argumentation as a means for students to make the targeted concepts explicit to themselves, their classmates, and teachers. We embedded a class-wide “Journal of Drake Genetics” into the game with a CER framework: students post claims supported by evidence (data from their experiments) and connect them with reasoning.

Research design and results

Our research study into the effects of *Geniverse* on student achievement involved 48 teachers: 24 using the *Geniverse* materials, and 24 using their business-as-usual (BaU) genetics materials. In this quasi-experimental design, control group teachers were matched to treatment teachers based on student demographic variables. Outcome measures include tests of students' genetics understanding, open-ended assessments that examine their abilities to engage in scientific argumentation, as well as motivation surveys.

On the science content assessment, our current analyses show significant growth between the pretest and posttest in both groups, however there was no statistically significant difference between the performance of students in the *Geniverse* condition and in the BaU condition. The treatment coefficient is positive in favor of *Geniverse*, but the p-value (.476) is not significant.

For the argumentation research, students in both the *Geniverse* treatment group and in the BaU group were asked to “provide a scientific argument or explanation” for a given specific experimental result. The gains in the *Geniverse* group are higher than those in the comparison group in each of the three aspects of argumentation.

This treatment difference is approaching significance at the total argumentation score level.

Discussion

Annetta et al. (2009) also found commensurate genetics learning gains in a comparison between a teacher-designed digital game and BaU. With respect to content learning across the disciplines, studies comparing game-based and traditional approaches have produced a wide variety of results. Meta-analyses (Clark et al, 2014; Sitzmann, 2011; Wouters et al., 2013) suggest that overall, somewhat greater learning gains can be produced by games than by traditional methods, particularly if the non-gaming teaching style is passive rather than active. Since we did not observe the BaU classrooms, we are not able to assess the degree to which their methods were active or passive.

Previous work on scientific argumentation associated with games has shown evidence for developing scientific “habits of mind” in place-based augmented reality (Squire & Jan, 2007) and specific examples in the forums of off-the-shelf commercial games (Steinkuhler & Chmiel, 2006). Our comparison between BaU and Geniverse shows a strong trend to support the basis for game-based learning of argumentation. However, we note from teacher surveys and classroom observations that the argumentation challenges are perceived by students as less fun than target challenges, and increasingly burdensome as the challenges increase in difficulty. More complete scaffolding of argumentation using principles of prediction, observation, and explanation as suggested by Clark and Martinez-Garza (2013) could support students more fully, but finding a way to connect argumentation to better performance on target challenges may also help to incentivize this aspect of *Geniverse*.

An additional finding that we are currently exploring involves the relationship between how far through the Geniverse materials students progressed, and their scores on the content assessment. Interestingly, students’ progress through the materials as measured by the software was a significant predictor of their achievement, but the teacher’s *reports* of how far classes progressed was not. That is, the further through Geniverse students got, the more they learned, but teachers’ perceptions of how far their students were progressing based on whole class progress were not accurate.

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Socioeconomic Pong: A Social Impact Game about Inequality

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Link to game:

<http://media.capella.edu/NonCourseMedia/mediaLab/socioEconomicPong/index.asp>

(for best results, use Firefox, Chrome, or IE9)

Imagine that life in America is a game. Some players enter the playing field with advantages that make it easier to win. Some players enter with obstacles that make victory a challenge. This doesn't mean that the player with obstacles is doomed to lose, but it does mean that this player may find the game much more difficult to play.

The issue of socioeconomic inequality in the United States has become an increasingly popular topic of discussion and debate. President Barack Obama has placed the reduction of socioeconomic inequality at the center of his second term agenda. Obama recently stated, "The combined trends of increased inequality and decreasing mobility pose a fundamental threat to the American Dream, our way of life, and what we stand for around the globe." (White House, Office of the Press Secretary).

So how do educators engage students in dialogue about socioeconomic inequality—and encourage students to evaluate the American cultural mythos that anyone can "pull themselves up from their bootstraps?" To help educators foster this dialogue, we developed a game called Socioeconomic Pong.

Socioeconomic Pong is a social impact game, or SIG. According to Ray, Faure & Kelle (2013), social impact games "deal with delicate social issues with the primary purpose being that of creating discourse and assisting learners to propose solutions and draw conclusions about issues of concern" (p. 61). Socioeconomic Pong is modeled after the classic Atari arcade game Pong, a simple electronic ping-pong game that features two paddles and a ball.

In traditional Pong, players are each given equally-sized paddles, and therefore neither has an advantage. In Socioeconomic Pong, the size of a player's paddle is determined by socioeconomic factors.

The purpose of Socioeconomic Pong is to demonstrate visually, and through game play, that the socioeconomic advantages and obstacles faced by an individual at birth have a strong impact on the likelihood of that individual's success. Winning the game is always *possible*, regardless of obstacles, but Socioeconomic Pong demonstrates the significant impact of inequality.

Before game play begins, players are asked a series of questions from drop down menus. Players input information about their gender and race, along with their parents' education level, incomes, professions, marital status, and other similar factors. These inputs affect the size of their paddle. Players with low socioeconomic factors are given a smaller paddle, which makes the game more difficult to play, and vice versa.

Players are also asked to input information about the state of the economy. In a strong economy, the ball is larger, which makes the game easier for everyone to play. The opposite is true if the economy is weak.

Scoring in Socioeconomic Pong reflects income disparities. If a player is a White male, he is awarded one point every time he scores. However, if the player is an African American female, she is only awarded 0.7 points every time she scores — because African American women on average make only 70 cents for every dollar that a White man makes. In addition, female players have to play with a "glass ceiling." When a male player's ball approaches the glass ceiling, it travels through as if the ceiling wasn't there; when a female's ball approaches the ceiling, the ball bounces back rapidly towards her side of the game, making it more difficult for her to play.

Statistics and other information about socioeconomic inequality are easy to find. By gamifying the concept through Socioeconomic Pong, we hope to illustrate this important concept in an innovative way and provoke discussion and debate about this important topic.

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Developing Argumentation Skills through Game-Based Assessment

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Introduction

Computer games and simulations have the potential to improve students' interest and performance in many academic domains (Klopfer, Osterweil, & Salen, 2009), and have often been used as learning tools (e.g., Dede, 2007; Shaffer, 2006). One understudied domain in educational game design is argumentation, which is an essential skill for many academic and professional settings (Graff, 2003). Notably, the Common Core State Standards put an emphasis on writing logical arguments, requiring that students demonstrate sound reasoning and use relevant evidence (CCSSO & NGA, 2010). However, many students lack strong argumentation skills, leaving them ill-prepared for college and careers. We developed a game intended to motivate students to develop argumentation skills, and to provide evidence of students' current argumentation skill to support formative assessment. We describe a game-based assessment designed to measure multiple levels of argumentation skill within a meaningful scenario context. We also address the utility of argumentation learning progressions for supporting game-based assessment design, using evidence from a usability study.

Using Learning Progressions to Inform Game Design

To gather relevant evidence about students' argumentation skills, we designed game activities around a set of argumentation learning progressions (LPs; Song, Deane, Graf, & van Rijn, 2013), developed under the Cognitively-Based Assessment of, for, and as Learning (CBAL) research initiative (Bennett, 2011). CBAL aims to design a system of assessments that support K-12 teaching and learning; LPs that specify how skills develop over time are critical to this effort. Informed by cognitive and learning sciences research (e.g., Bereiter & Scardamalia, 1987; Graham & Perin, 2007; Hayes & Flower, 1980; Kuhn, 1991), argumentation LPs describe the qualitative shifts that occur as students reach higher levels of sophistication in four strands of skills: (1) **Appeal building**: understanding an audience's interests, values, and beliefs; (2) **Taking a position**: developing a position and understanding other perspectives; (3) **Reasons and evidence**: using reasons, evidence, and examples to support an argument and to evaluate others' arguments; and (4) **Framing a case**: organizing and presenting an argument logically.

LPs are useful for designing game-based assessments. First, they help determine the targeted skills in the assessment, based on an analysis of critical skills in the domain (Deane, 2011). We have used LPs to inform the design of items assessing five levels of performance (from preliminary to advanced). For example, at the preliminary level, students are expected to classify people's positions as being "pro" or "con" regarding an issue; at the intermediate (4th) level, students should be able to identify others' subjective points of view. Assessment tasks could vary from asking students to categorize opinions, or to identify unstated assumptions underlying a claim. Second, LPs help establish appropriate task sequences. For instance, critiquing an argument is a sophisticated skill that rarely develops before college unless instruction or scaffolding is provided (e.g., McCann, 1989). Thus, we might reserve critiques for later levels in the game, or incorporate scaffolding to support students in performing a critique. Importantly, we have designed activities that present varying degrees of challenge, so that students can play the game regardless of their level of skill. As players progress, the difficulty level of the tasks will increase, emphasizing skills at higher levels of the LPs. The level of tasks might also vary *within* a particular game activity, to support the assessment and development of argumentation skills.

Designing Game-Based Assessment Scenarios: The Case of "Junk Food"

In the *Seaball: Semester at Sea* game, players assume the role of students embarking on a worldwide journey aboard a cruise ship, the *SS Seaball*. As they travel, students will explore other countries, serve on the ship's student council, and work with others to solve problems. Throughout the "voyage," players will demonstrate their argumentation skills by engaging in debates with game characters, recommending policies through the student council, and completing various argumentation tasks.

Players start with two lead-in activities: interpreting the persuasive intent in a poster (Appeal Building, Level 1), and persuading parents to give their permission to join the trip (Appeal Building, Level 2). Once onboard the ship, players join the student council and help make a policy decision: whether the *Seaball* should sell junk food to students. This "Junk Food" scenario consists of five activities of varying difficulty. Players must first gather and evaluate information about the topic from different sources. In the *Peer Interview* task, players interview other students

onboard, and must classify their opinions into ban or allow categories (Taking a Position, Level 1). Next, players seek expert advice by *Selecting a Speaker* to address the students about junk food, such as a physician or a food company employee. Players select reasons in support of their preferred speaker, and reasons against inviting the others. In the *Identifying Arguments* task, players listen to the speaker, and identify the main claim, reasons, and evidence for the speaker's arguments. Players then *Make a Recommendation* to the student council (i.e., ban or allow junk food), providing three reasons for their decision. These three activities assess higher level skills (Reasons and Evidence, Level 2) than the *Interview* task. Finally, players must work to *Establish a Criterion* for what counts as "junk food" by talking with other council members; this involves evaluating other people's arguments, making it the most difficult task in the set (Reasons and Evidence, Level 3).

In a usability study, nine middle school students worked on the game prototype that included an introduction to the theme and setting of the game, the two lead-in activities, and the Interview activity in Junk Food. Students performed well on the tasks and thought that the tasks were relatively easy. They considered the game activities interesting and engaging. We will conduct a cognitive lab study with approximately 20 middle school students on the complete "Junk Food" scenario. The findings will provide partial evidence of the validity of argumentation LPs as tools for designing game-based assessments, and will inform revisions to the design of the game activities, to enhance measurement validity and student engagement.

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Take It All Remix: Engaging Students in Social Psychology Concepts

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Motivation and game research continue to demonstrate that the use of games in education can be engaging, intrinsically motivating, challenging, and fun (Gee, 2007; Felicia, 2012; McGonigal, 2011), precisely the qualities that traditional lectures are perceived by students to lack. So, despite the belief that gamification may be disruptive to higher education values and traditions (Baker, Bujak, & DeMillo, 2012), the use of games in the classroom may provide the characteristics that are sought by those seeking effective educational tools. Thus, it is important that educational researchers investigate students' perceptions of games in higher education. Therefore, we adapted and created a *Take it All Remix* version to teach social psychology concepts related to course content on group processes, and explored student's perceptions of learning, engagement, and enjoyment.

Method Participants

The study was conducted on the campus of a medium size university during the course of one academic year. Forty-eight undergraduate students (overall $M_{age} = 22.27$, $SD = 3.59$) in two different social psychology sections, taught by the same instructor participated.

Procedure

Take It All Remix Game. The original game show, *Take It All* (Wikimedia Foundation, Inc.), aired in December 2012 on NBC for two weeks. The *Remix* version of the game was designed to teach material on the topic of group processes in a social psychology course. A few days prior to class, students received an outline that addressed topics related to group processes and concepts that would be present in the game. This outline included defining groups, group cohesion, factors of arousal, risky shift, social loafing, and the difference between zero-sum conflicts and mixed-motive conflicts.

At the beginning of class on game day, students were randomly placed into five teams, and the instructor explained the rules to the students. There would be a total of three initial rounds, where each team would randomly select a number from 1-5 on the screen. A prize would be revealed behind the selected number. The goal was to have the most expensive prize, because the group with the least expensive prize would be eliminated each round. Before selecting from the prize screen, each team had the ability to steal another team's prize instead of selecting from the prize screen. However, all teams had one block, which could be used during any round. Once a team's block was used, and a second team decided to steal the first team's prize, the first team would have to select from the remaining numbers on the prize screen. Each round increased in monetary values. For example, round one ranged from \$5,000-\$12,000, and round two ranged from \$15,000-\$25,000. This process was repeated for rounds two and three with one team being eliminated each round until round four, the final round, which included only the final two teams. In the final round, both teams were still in possession of their prizes from all previous rounds. Their total amounts of prizes were calculated giving an overall monetary worth. Then, each team randomly selected but did not look at a card containing an amount of possible extra credit points. The teams were given the final rules which presented a Prisoner's Dilemma situation. They were informed that if both teams chose "Take It All," both teams would end up with no prizes at the end of the game. If both teams chose "Keep Mine," both teams would end up with the prizes they had each collected throughout the game. However, if one team chose "Take It All" and the other chose "Keep Mine," the team that chose "Take It All" would keep its prizes and the other team's prizes. Because the prizes were fictitious prizes, the extra credit points were used as 'real' prizes and created a personal investment in the game. Next, the two teams were told to deliberate with each other and make their final decisions.

Following the game, the group processes outline was reviewed in relationship to game play in order to solidify concepts from the chapter. For example, the concept of cohesion was discussed in relationship to the students' teams. Risky shift was demonstrated within each individual round when students decided to steal from another group and, in the final round, when making their ultimate choice to either "take it all" or "keep mine". Mixed-motive conflict was demonstrated via the prisoner's dilemma that the last round forms between the two final teams. Though these are just a few examples of course concepts within game play, other concepts were evident within the game and classroom. Upon completion of the game and class discussion, students completed a survey assessing perceptions of learning, engagement, and fun.

Student Perspective Measures. A 15-item survey ($\alpha = .91$) assessing students' perspectives was created to

assess three constructs, learning content (seven questions, $\alpha = .93$) (e.g., “did the activity increase understanding of course content?”), engagement (three questions, $\alpha = .82$) (e.g., “to what extent did you feel engaged during the activity?”), and enjoyment (three questions, $\alpha = .92$) (e.g., “did you enjoy participating in the activity?”). All responses were measured on 7-point Likert scales with endpoints 1 (not at all) to 7 (extremely).

Results

Students' ratings within each of the three constructs were averaged to create an index for learning, engagement and enjoyment. Using the 1 to 7 scale as a reference, the mean for learning ($M = 5.72$, $SD = 1.20$) indicated that students perceived themselves as learning while playing the game. This included being a good supplement to lecture ($M = 6.08$, $SD = .99$), incorporating course content ($M = 5.77$, $SD = 1.12$), and being recommended for future students in social psychology ($M = 6.27$, $SD = 1.07$). Similarly, students reported feeling engaged by the game and subsequent discussion ($M = 5.61$, $SD = 1.25$). Also, students reported game play made the class more enjoyable and fun ($M = 6.17$, $SD = 0.96$).

Discussion

Results suggest designing and implementing more game based learning, gamification, into the higher education setting seems to be a worthwhile venture. Research suggests that games promote engagement, and encourage collaboration among peers (Gee, 2007; Kapp, 2012). Playing *Take It All Remix* provides students the opportunity to experience course content in action (e.g., group processes, risky shift, conflict styles) and become involved in learning, rather than be passive participants of hypothetical examples. These results contribute to research that suggesting that games, as a supplement to traditional lectures can be an enjoyable learning enhancement to students (Stansbury & Munro, 2013). Using the game as a supplement to course material provided an opportunity for students to think critically about concepts related to group processes; following game play with a discussion allowed students to apply specific examples of course content (e.g., risky shift) directly to their game play experience. In class discussion, for example, many students reported that if they were playing the game alone, they would have been less likely to steal from opponents and may have been more trusting of other teams motives.

Future research should begin to assess the effectiveness of this increased engagement on students understanding of content knowledge and overall course performance. More specifically, assessing not only whether active engagement with course content increases content knowledge, but also if that content knowledge can be retained over an extended period of time. In addition, assessing student's position in the game and its effect on student's perception of game play and knowledge integration is worthy of future investigation.

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The Empty Comfort of Vanity: Assessing the Effectiveness of an Interactive Game to Increase Skin Cancer Prevention Outcomes

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Skin Cancer Incidence and Tanning Behavior

Skin cancer is the most commonly occurring cancer in the U.S. (CDC, 2010), with more than 3.5 million Americans diagnosed each year (Rogers et al., 2010). UV radiation exposure can come from outdoor sun-tanning and the use of indoor tanning beds (Report on Carcinogens, 2010). One cause of the recent increase in skin cancer incidence is the growing use of indoor tanning facilities (Robinson, Kim, Rosenbaum, & Ortiz, 2008), particularly among younger (15 – 29) females (Herzog, Pappo, Bondy, Bleyer, & Kirkwood, 2006). In addition, sun-tanning remains popular with youth, and eight out of 10 Canadian teens report exposing themselves (Canadian Cancer Society, 2012). Problematically, these younger individuals are also less likely to appreciate the connection between tanning behavior and skin cancer, which often occurs years, if not decades, after continuous exposure. Young tanners are more focused on the immediate, appearance-related benefits of tanning behavior than the long-term health consequences. Youth exposing themselves to indoor tanning largely misperceive their risk of skin cancer. To illustrate, nearly 70% of youth using tanning beds were unaware that this exposure placed them at an elevated risk of skin cancer (Heckman et al., 2008). In short, the motivation to increase general attractiveness is more salient than protection motivation.

Vanity: A Serious Game for Skin Cancer Prevention

In response to this unfortunate reality, a tabletop game entitled *Vanity* was created. In *Vanity*, participants play the role of aspiring actors competing for acting roles. In the beginning, players take turns spinning the fitness, style, outdoor activity, or indoor tanning wheel in order to increase his or her fitness, style, or tan index by one, two, or three. The latter two wheels involve tanning, which requires the player to roll a die to determine whether his or her health risk level increases (between zero and four) as a result. An increase yields a higher chance of developing skin cancer and of losing the game. At any point, an anxious player can spend a turn 'visiting the dermatologist' and reduce his or her health risk by one. When a player thinks he or she has enough fitness, style, and tan, he or she can draw role cards. All roles require some level of fitness and style, and many require a tanned appearance. In order to earn the points associated with a role, players must meet or exceed its attribute levels and then must adjust their current levels to match the role's. The latter requirement forces players to think twice before taking on a role because it requires spending more time building your attributes back up. When a Skin Exam card is drawn from the role decks, it triggers a die roll (of a D10, D8, or D6 respectively for the first, second, and last exam) by each player. If a player's health risk is higher than the number rolled, he or she has skin cancer and must spend at least three turns undergoing treatment. The third exam triggers the end of the game, and the winner is the player with the most points who is not undergoing recovery. The purpose of *Vanity* is to show people that the short-term benefits in attractiveness granted by tanning behavior do not outweigh the sacrifice in long-term safety. In short, *Vanity* was developed to help youth seriously consider the dangers of using tanning beds, and will be a pillar of the Canadian Dermatology Associations anti-tanning bed outreach campaign in 2014. The purpose of the current project is to understand how *Vanity*, and serious games more generally, can influence health-related outcomes. Particularly, we are interested in understanding the mechanism of effect that occurs between exposure to the gameplay of *Vanity* and ultimate outcomes in intentions and behavior regarding tanning.

Entertainment Media and Persuasive Outcomes

Recent entertainment education theories predict that entertainment media have the potential to impact health outcomes by: (1) increasing story-consistent attitudes and beliefs, (2) reducing the formation of counter-arguments, (3) reducing the belief that the source of the message is trying to dictate your behavior, and (4) increase perceived vulnerability to a health threat highlighted in that narrative (Slater & Rouner, 2002; Moyer-Guse, 2008; Moyer-Guse & Nabi, 2010). Although these theories have largely been proposed in the context of television and written materials, there is ample reason to suggest that similar mechanisms of persuasion exist in response to serious games, as there are some studies that suggest that people have similar responses to games as entertainment narratives; largely, identification with characters and involvement with the storyline (Lin, 2013; Peng, Lee, & Heeter, 2010). The goals of the current study are to test three propositions of the entertainment overcoming resistance model (EORM; Moyer-Guse, 2008) that have been shown to facilitate persuasive outcomes in response to entertainment media in the context of gaming and health-related outcomes. In addition, the current study will compare the effectiveness of *Vanity* to a control condition, to determine the extent to which *Vanity* functions as a preventative tool to keep people from intending to use indoor tanning beds.

Methods

Participants were recruited from a mid-sized Southeastern university in the U.S. All participants played either *Vanity* or a separate board game that will function as a control and completed a brief questionnaire measuring their engagement with the game and attitudes, beliefs, and intentions regarding skin cancer prevention and tanning behavior. Success of the project is measured in two ways: (1) using the EORM to determine how *Vanity* influences subsequent indoor tanning outcomes; and (2) comparing the *Vanity* gaming condition to the control condition to determine if playing *Vanity* can function as a preventative tool to keep people from intending to use indoor tanning beds.

Preliminary results ($N = 61$) are inconclusive but promising. The mean score for tanning intentions is marginally significantly lower ($t(59) = -1.74$; $p = .09$; equal variances not assumed) in the *Vanity* condition ($M = 1.19$; $SD = 0.71$; $n = 36$) than the control condition ($M = 1.80$; $SD = 1.63$; $n = 25$), suggesting that *Vanity* may be an acceptable preventative tool to keep people from engaging in tanning behavior that could lead to skin cancer. Data collection is ongoing, and we currently lack adequate power to assess the mediational relationships identified above.

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Addendum

Boys and their Toys: Video Game Learning & the Common Core

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Abstract: Traditional K-12 public school culture seems to be alienating and distancing for many boys today (Martin 2002). Carr-Chellman proposes that this crisis is due to the rejection of boy culture (2011). Gaining acceptance of games in traditional classrooms has the powerful potential to change the culture of schools to one that is more welcoming to boys' ways of being, but most teachers find games without sufficient curricular merit to spend the necessary time learning and utilizing games effectively. This study sought to understand the potential interaction between commercial-off-the-shelf (COTS) video games and the Common Core State Standards (CCSS) as reported by boy gamers. In this study, data was gathered through phenomenologically based semi-structured interviews with boys, aged 10-17. Our results indicate specific connections between COTS and the CCSS, further supporting such theoretical works from Prensky (2006) and Gee (2003).

Background of the Project

We are facing a crisis in education due to the rejection of boy culture and the alienation of boys' ways of being in traditional school experiences (Carr-Chellman, 2011; Martin, 2002). Video games are a large part of boy culture (Burrows, 2013; Watkins, C., 2009; Jones, G., 2008) and may offer a tool to re-engage boy culture inside of traditional school culture (Carr-Chellman, 2011). Many statistics confirm that boys are at higher risk across their educational experiences than their female classmates (Mortenson, 2011). Mortenson's research found that for every 100 girls:

250 boys are suspended from public elementary and secondary schools
335 boys are expelled from public elementary and secondary schools
217 boys are diagnosed with a special education disability
62 American men earn a Master's degree (Mortenson, 2011)

In an ongoing study Petner, Vashaw, and Carr-Chellman, looked at teacher attitudes toward violent video games and found that teachers were banning gaming, writing or talking about gaming, using gaming in art or other traditional school outcomes (Carr-Chellman, 2011). Primary reasons for this rejection included violence, competition, and individualism in the classroom that is associated with game integration. Because of a link between game culture and boy culture, we are concerned that rejecting games could be a masked rejection of boy culture. Understanding teachers' perceptions of gaming is only a part of the picture—we need to also understand perceptions of boys who game as well. We wanted to illustrate the link (if any) between COTS gaming and traditional learning, in the hopes that teachers, administrators, and parents might perceive a stronger justification for utilization of gaming in the traditional curriculum. As a result, this study seeks to document the ways that COTS games contribute to traditional learning experiences, and to map those learning experiences directly onto the CCSS where applicable ("NGA & CCSSO", 2012). This study asserts that use of COTS games, where aligned with traditional learning outcomes, is possible in traditional classrooms and may welcome boys to a re-engagement of their learning.

This is the first phase of a larger interpretivist research project, which extends theories and prior research aimed at better understanding the contribution of video games to boy learning. Studies conducted by other researchers have developed strong theoretical perspectives into the value of video games in multiple learning environments (Gee, 2003; Prensky, 2003; Squire, 2006). Our research question is: How do boys describe their learning within video games? More specifically, this study seeks to explore the extent to which boys who are using COTS games describe learning traditional knowledge and skills from gaming.

Methodology

Participants

All participants were boys at a rural eastern school district, aged 10-17, in middle school or high school. These were typical male students with varying academic backgrounds and involvement in sports. These participants were chosen because they enjoyed playing video games and were willing to talk about their gaming experiences. Through one of the researcher's established relationship as a coach, we were able to identify appropriate partici-

pants for the study that we knew would be available and were embedded in the boy gaming culture. While this is a sample of convenience, it represents relatively average boys in this district.

Design and Theoretical Lens

Because our goal was to understand the lived experiences of boy gamers in relation to their learning, we decided to use a phenomenological approach (Groenewald, 2004, Lester, 1999, Moustakas, 1994). The theoretical lens utilized for this approach was cultural historical activity theory (CHAT) (Roth & Lee, 2007). There has been growing interest over the past three decades for this framework that encourages researchers to consider cultural conditions within a system that can be utilized to improve itself (Roth & Lee, 2007). CHAT theorists consider a variety of concerns such as the poverty or culture of urban students' home lives from conditions of schooling, consideration of the curriculum, problems of learning, or learning to teach under difficult settings (Roth & Lee, 2007). Furthermore, CHAT is essential for designing constructivist learning environments, which are driven by activity (Jonassen & Rohrer-Murphy, 1999). The CHAT framework allows us to examine *activity* through a designed experience (Squire, 2006), which is our direct interest with boys and video games.

Procedure

Data was gathered using individual semi-structured interviews (Drever, 1995; Seidman, 1998). During this exploratory phase an initial interview was collected from each of 12 respondents, 4 in middle school and 8 in high school over a two-day period. Each interview lasted approximately 15–20 minutes and was conducted in a public space at the high school or middle school. All interviews were audiotaped and used a protocol that included student experiences with gaming, and participants' thoughts on learning through the use of video games. There were questions such as, "What games do you play? How much would you say you play games in a week (# of hours)? Do you feel you learn from games? What kinds of things do you learn in gaming? Tell us about your experience gaming." We recognize that our participants may not be able to recognize learning from games. So our protocol questions were designed to allow us to interpret their gaming activity experiences into traditional learning outcomes.

Data Analysis

Data analysis was conducted based on the interview data, which was transcribed from the audiotaped files. CHAT guided the data analysis. Jonassen and Rohrer-Murphy describe activity theory as, "...a powerful lens to analyze most forms of human activity". They go on to say that activity focuses on the interactions between human activity and consciousness within relevant environmental contexts (Jonassen & Rohrer-Murphy, 1999). The Data Analysis took place in two layers. The preliminary analysis was done to identify and codify repeated activity, ideas, and themes surrounding learning. The research team developed a comprehensive coding framework utilizing a CHAT lens in a continuous iterative process. This included the acquisition and use of vocabulary, transfer of knowledge to the real world, or the ability to analyze key ideas. The team applied some CCSS standards to develop codes to identify *products* (e.g. *instances of learning events*) (Jonassen & Rohrer-Murphy, 1999) that occur as a result of the activity of video game play. Using this coding framework the team performed individual open-coding on the data. The team then came together to discuss and consolidate the emergent codes collaboratively, to ensure consistency. Upon completion of the analysis, several reliable themes emerged from the data.

In the second layer of analysis, our goal was to separate learning accounts based on games, and find out the extent to which these accounts overlap with the CCSS. For this portion of our analysis we used a modified Phenomenological Thematic Analysis (PTA) with a focus on bracketing for each game found in our prior analysis (Moustakas, 1994). First we identified each game played per participant then cross-referenced them with the group. This allowed the team to identify the games that were played by the group of participants. We then applied a phenomenological reduction (extracting textural descriptions), imaginative variation (extracting structural descriptions) and finally a synthesis (textural-structural description) for each game found in our prior analysis (Moustakas, 1994). The focus on bracketing allowed for the team to continuously reveal and scrutinize our own presuppositions within our interpretation activity. This allowed the team to deeply analyze the thematic content that emerged by game. Lastly we used the textural-structural data to identify learning instances that mapped to the CCSS ("NGA & CCSSO", 2012).

Results and Discussion

Our findings show that the participants were able to discuss their learning through their discourse illustrating powerful outcomes from gaming. Although some participants were unable to give substantial information on transfer and had difficulty articulating some learned skills, this may be due to their limited abilities to understand how learned skills transfer or because our interviews were limited in both scope and duration. Despite this, the re-

search team saw evidence that learning was indeed happening. The most common skill identified by participants was Vocabulary Acquisition and Use. Leveraging boys' existing interests in games revealed engagement in literacies (Steinkuehler & King, 2009). They described this acquisition as a result of readings from the just-in-time instruction throughout the game and external resources. This further supports the meaning making process considered by Meaning as Action ("Video Games", 2013b). Such is the case with Blake: *"If you don't read it you don't get it. That's you know...in World of Warcraft you are running around aimlessly without knowing what you gotta do. And you have to read every single sentence and tear it apart to figure out every part of the quest."* This points us towards CCRA.R.1 Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text. Boys were able to directly interact with the content as they used it to navigate through gameplay ("Video Games", 2013b). Participants were able to interpret and give detail on various vocabulary words such as obsidian, tariffs, cardinals, as well as community language associated with the military, football and historical accounts. The boys expressed understanding of both real world concepts and community language within the games. One respondent recalls, *"... like well one day my teacher was teaching about obsidian and in Minecraft there's obsidian and I already knew that I already knew that it was like a lava rock"*. Examples like these align with CCSS.ELA-Literacy.CCRA.L.6 Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression. These are but two examples of the kinds of alignment we found in talking with boys about their learning in games.

Mapping to the CCSS

We have found that there are several areas where the COTS learning overlap with areas of the CCSS: (See Table 2). In particular we found ties to the "English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects" standards. The boys discussed their ability to identify key Ideas/themes, analyze key ideas, interpret words, phrases and concepts, integrate knowledge, comprehend and collaborate, verbally present knowledge, acquire and use vocabulary, problem solve, set goals, analyze data through strategic, extended and evaluative thinking, and transfer knowledge into the real world ("NGA & CCSSO", 2012). (See Figure 1) Games Played Included: Assassins Creed (AC), Baseball (MLB), Battlefield (BF), Borderlands (BORD), Call of Duty (CoD), Diablo (DIAB), Driving Games (DV), Halo (H), Little Big Planet (LBP), Madden (MAD), Minecraft (MINE), NBA2K (2K), NCAA Football (NCAA), Phineas & Ferb (PF), Pokémon (PK), Portal (PORT), Skate (SK), Skyrim (SKY), StarCraft (SC), UFC, World of Warcraft (WOW).

English Language Arts Standards >> Anchor Standards >> College and Career Readiness Anchor Standards for Reading	AC	BF	BORD	CoD	MAD	MINE	NCAA	PF	PK	PORT	SKY	STAR	WOW	All
Key Ideas and Details														
CCSS.ELA-Literacy.CCRA.R.1 Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	■						■				■		■	
CCSS.ELA-Literacy.CCRA.R.2 Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	■		■								■		■	
CCSS.ELA-Literacy.CCRA.R.3 Analyze how and why individuals, events, or ideas develop and interact over the course of a text.														
Craft and structure														
CCSS.ELA-Literacy.CCRA.R.4 Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.														■
CCSS.ELA-Literacy.CCRA.R.5 Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.														
CCSS.ELA-Literacy.CCRA.R.6 Assess how point of view or purpose shapes the content and style of a text.														
Integrate Knowledge and Ideas														
CCSS.ELA-Literacy.CCRA.R.7 Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words														■
CCSS.ELA-Literacy.CCRA.R.8 Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.														
CCSS.ELA-Literacy.CCRA.R.9 Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.	■			■		■								
Range of Reading and Level of Text Complexity														
CCSS.ELA-Literacy.CCRA.R.10 Read and comprehend complex literary and informational texts independently and proficiently.														

Figure 1: Learning Mapped to Common Core Standards.

Additional Findings

Additional findings were related to both cognitive and non-cognitive skills, such as grit (Duckworth, Peterson, Matthews, & Kelly, 2007), which may not relate directly to the CCSS, but contributes to learning and development in other ways. Our findings show several areas where these COTS games aid in learning 21st century skills. The following is a segment of a chart, showing some of the learning results identified by game type. (See Table 1).

Games Played	Learning
Assassin's Creed	Theme Identification, Critical Reading, Language Acquisition (Strong Community Language), History, Development of Grit
Diablo	Critical Reading, Strategic Thinking, Strong Community Language
Madden	Development of Grit, Problem Solving, Extended Thinking, Collaboration, Communication, Strong Community Language, Manual Dexterity, Hand/Eye Coordination, Information Literacy
Minecraft	Strategic Thinking, Strong Community Language, Information Systems Technology, Engineering, Math, Resource Management, Information Literacy, Collaboration, Communication, Digital Citizenship
Skyrim	Strategic Thinking & Decision Making, Development of Grit, Strong Community Language, Information Literacy
World of Warcraft	Critical Reading, Theme Identification, Collection of learned skills, Resource Management, Information Literacy, Strong Community Language

Table 1: Learning by Game

More generally, the respondents reported that games gave them the opportunity to accomplish tasks and goals along a performance based learning system as opposed to a time based learning system (Squire, 2006). Gee's *Psychosocial Moratorium* attributes to gamer's ability to perform and explore appropriated risks, in an environment where real world consequences do not exist (2003). The *Psychosocial Moratorium* in combination with support from the *Affinity Groups* (Gee, 2003) built hopefulness and fostered optimistic outlooks towards challenges (McGonigal, 2011). Ultimately these gaming characteristics help support the development of "grit" (Duckworth, Peterson, Matthews, & Kelly, 2007; Gee, 2009) which is an essential element in success in almost all video gaming today (Ventura, Shute & Zhao, 2013) and is being increasingly pointed to as a success factor in traditional learning as well. One participant explains that it frustrates him when he is not successful in game. So he takes a break and still continues to work through, "I get mad that I can't do it. I'm a kid who likes to be able do everything...when they make it so hard that it takes 100 tries to do it by the 20th try I'm just like I'm done I shut off the TV and walk away...I shut it off and come back later" (Blake). Our findings indicate that there is evidence of boys developing grit through gameplay which we feel warrants future research as businesses increasingly seek future leaders that can demonstrate such characteristics (Beck & Wade, 2004). Our findings suggests that failure can be used as a motivating factor towards problem solving strategies in gaming, but is seen as punitive for most boys in traditional classrooms. The data showed that problem solving skills, both individual and collective, were the second most commonly described learned event among these young men. Game success was not possible without the intentional and thorough processes included in problem solving (Prensky, 2006). According to our respondents, they like to be challenged, both mentally and physically within the games, which is consistent with findings of others (Lawry, et al., 1995). The following participant describes how he handles failure and develops strategies for problem solving using information literacy practices.

Interviewer: What do you do when you fail or you don't succeed at a goal in the game?

Respondent: um it can be very

Interviewer: Besides get mad

Respondent: yeah, its aggravating but sometimes I'll just turn off my Xbox like I don't even want to play anymore that's how bad I can get, but you feel let down kind of its almost seems impossible sometimes and you never can find out the answer just makes you upset. Its.. Its aggravating.

Interviewer: So when you come upon that situation and its aggravating um and you decide not to turn off your Xbox what do you do?

Respondent: oh I look f...

Interviewer: Do you scream? Do you shout?

Respondent: yeah..um

Interviewer: Do you throw things (laughing)?

Respondent: hmm yeah I definitely can I kind of just like groan at it like just and I try to find other ways to find out what how to surpass that whether or not that be in the video game like YouTube and stuff but yeah you can emotionally it can hurt like you go crazy sometimes depending on how bad the situation is (Austin).

This exchange between Austin and our interviewer clearly displays the frustration that a gamer goes through during gameplay. Austin even demonstrates emotional attachment when he mentions, “you feel let down kind of...”. This shows that he is emotionally vested in this gaming activity. Although this activity is so frustrating that he wants to throw things and even scream his investment in the activity forces him to continue which demonstrates both persistence of effort and consistency of goal (Duckworth et al, 2007). With examples such as this we have seen that through this type of development of grit, the our participants have found ways to cope with frustration and maintain consistent goals by utilizing embedded support systems such as YouTube or friends. Learning how to develop grit in this way may help video gamers in the business world. According to Harvard Business School, video gamers are committed to professional excellence, have a strong sense of competence, are comfortable taking measured risks, don’t count on fixed organizational structures, and expect themselves to actually deliver among others (Beck & Wade, 2004)

The second type of problem solving that was discovered described participation in affinity groups (Gee, 2003) and required a collective effort of problem solving. One respondent enjoyed playing Minecraft and reported, “*Minecraft, I play that too. Um, I, I play like with friends on a, a, like a multiplayer server and we talk about like how to survive the longest, and like what to do, things like that. I do strategize a lot with my friends*” (Brad).

Researchers suggest that educators could use video games as a model for improving learning environments (Sandford, R., Ulicsak, M., Facer, K., & Rudd, T., 2010; Shaffer, D, Squire, R. Halverson, R. & Gee, J., 2005). While games may offer an important tool for creating a more boy-friendly school culture, it remains important that games are used judiciously and primarily where content is aligned with the gaming learning outcomes. Using a game purely for motivational purposes would be a misuse of the media affordance of gaming. However, using a game to change a culture, build grit, and further specific traditional learning goals, when well aligned, is a powerful and important step toward re-engaging boys in their own learning.

Conclusions

In agreement with other scholars and theorists, we feel it is important to understand the gamers’ perspectives in revealing meaning making and learning outcomes from gameplay (Squire, 2005, 2006; Squire & Jenkins, 2003; Gee, 2007). Our findings indicate a wide variety of learning outcomes can be gained from COTS video gaming. This confirms much of the theoretical work, which posits that gaming can lead to specific and significant learning gains (Gee, 2003, Prensky, 2006; Steinkuehler & King, 2009). Problem solving elements are unavoidable while participating in game play (Steinkuehler & Squire, 2012). Players must gather and implement intentional methods and strategies to participate successfully in game play. This requires players to access a variety of resources including, a community of learners, a shared language and problem solving skills. We believe that based on the perspectives these boys have shared with us, COTS deserve further attention and research as a viable addition to the traditional classroom experience. While we recognize the reluctance of teachers to engage in COTS games in the classroom as Petner, Vashaw and Carr-Chellman’s research suggests, gaining a deeper understanding of these boys’ perspectives may help to overcome some of their objections and further diffuse this powerful innovation. While more research is needed to gain deeper understanding of the potential impact of the inclusion of gaming as an educational tool; we believe that COTS gaming has the potential to meet educational aims while including and engaging boy culture in the classroom.

As we are still in the process of learning about the kinds of educational experiences that COTS offer learners, we recognize that there are limitations to this study. This remains exploratory, interpretive work at this point, and with a limited sample. We hope, next, to examine students’ specific responses to COTS games that may be seen by some to be more “educational” without being truly educational games by nature (e.g., Minecraft). As we observe this gaming experience for learners, and ask them to “think aloud” as well as reflect on their game playing, we anticipate learning much more through richer data about how these experiences can be mapped onto the CCSS. Despite these limitations, the work stands as an important contribution to the understandings of boys’ ways of gaming, their learning within gaming, and their ability to use that learning within their own educational experiences. We hope that this may help teachers to more readily accept COTS gaming in their classrooms as a way to embrace boy culture.

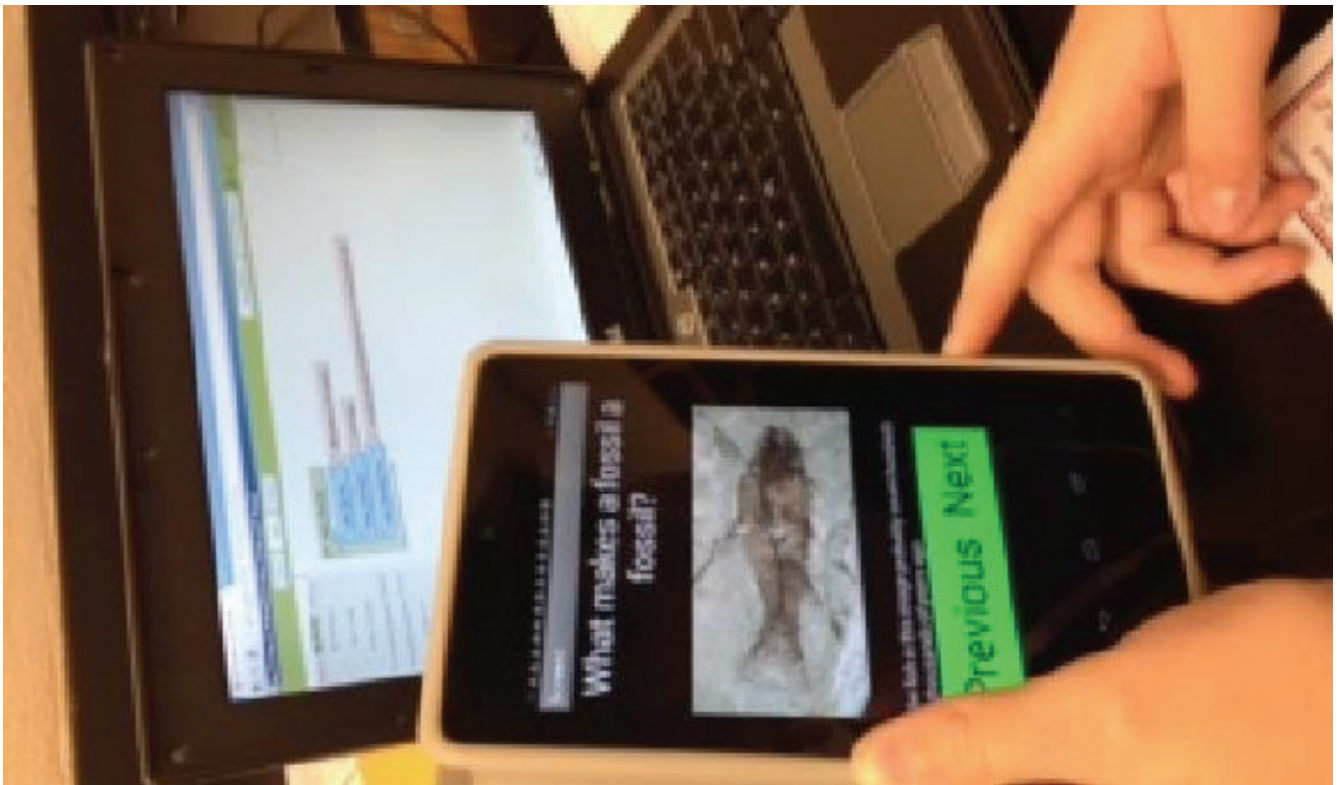
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Adolescents and App Development in Middle School Classrooms

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Example URL: <http://www.workingexamples.org/example/show/630>

Our research involves investigating the viability of teaching computational thinking (CT) to middle school students through application (app) development. Computational thinking is a way of devising, decomposing, and designing ways to solve problems. Many computer scientists and educational researchers consider CT foundational skills for everyone, believing they complement core elements of computer science, and attend to human-computer interactions involving creativity, innovation, collaboration, aiding in structuring and solving problems efficiently (Papert, 1996; Wing, 2006). New guidelines for computer science now include measures to consider CT. Computational thinking has no firm definition, but it is broadly defined as a set of thinking practices characterized by conceptualizing ideas, engineering solutions, and thinking at multiple levels of abstraction (Wing, 2006). It is supported through teamwork, creativity, human interaction with computers, increased visualization, and it aims for global impact – to make a difference in the lives of others (The College Board, 2011). For this research, we draw on Barr and Stephenson's (2011) definition of computational thinking as a set of techniques that include: problem decomposition, pattern recognition, pattern generalization to define abstractions or models, and algorithm design. These skills are markedly different than traditional computer science skills of decades past that were narrowly focused on knowledge and skills related to technical programming (CSTA, 2005).

The fundamental need for computer science knowledge in an information-based society is being reframed as a need for everyone to learn computational thinking (Yadav, Mayfield, Zhou, Hambrusch, & Korb, 2014). Ostrachan (2012) portrays coding as a metaphor for computational thinking, detailing the ways writing and interpreting code is integrated in everyday life. Coding has recently gained popularity as a way to encourage computational thinking (CSTA, 2012), as evidenced by large-scale initiatives such as Code.org which hosted CS Education Week (<http://csedweek.org/>) in December, 2013, introducing code to more than 31 million students.

The App Development Platform

MIT App Inventor (<http://appinventor.mit.edu/explore/>) is an open source, visual programming platform that al-

lows users to create Android apps by snapping blocks in place. Conceived as an easy entry into intuitive, incremental and logical programming, it consists of two main elements: a Design view used to select components of an app, and a Blocks Editor to program behaviors (Pokress & Veigra, 2013). Google originally developed and maintained the software in 2010; it is now hosted by Massachusetts Institute of Technology (MIT).

MIT App Inventor (also referred to as “App Inventor”) was created with educators and learners in mind, with a goal of increasing interest and skills in computational practices (Pokress & Veigra, 2013). It is novel, and thus has limited but growing research exploring its capacity in college classrooms (Wolber, 2011; Abelson, Morelli, Kakavouli, Mustafaraj, & Turbak, 2012) with teachers in summer camps (Hsu, Rice, & Dawley, 2012) or its potential to bring computational thinking (CT) to K-12 students (Morelli et al., 2011).

Seed

Tell us about your idea or project. What’s your vision?

Four prevailing realities inform our vision: (1) the current demand for those skilled in computer science and CT outpaces student training and graduates by roughly 2:1 (US Department of Education, 2012); (2) middle schools typically do not offer computer science curriculum due to low student interest and lack of resources (CSTA, 2011, p. ii.); (3) recent guidelines have shifted to include CT practices supported through teamwork, creativity, human interactions with computers, increased visualization, and societal impact (The College Board, 2011); and (4) outside of school youth regularly participate in media-rich production spaces emulating some of the abovementioned CT practices (Jenkins et., al, 2006). Additionally, a wealth of research supports programming and designing with games and apps as a means to foster complex problem solving, logic and reasoning, systems thinking, and creativity (Gee, 2003; Ketelhut, Dede, Clarke, & Nelson, 2006; Klopfer, Osterweil & Salen, 2009; McClarty et al., 2012; Williamson, Squire, Halverson, & Gee 2005).

Providing and researching opportunities for students to hone CT, and for teachers to develop ways to embed CT practices in curriculum, offers a way to meaningfully address this need.

What problem are you trying to solve and why does it matter?

Our goal is to offer middle school students an avenue to practice CT while investigating the following questions:

- (1) What are teachers’ perceptions regarding app creation to teach computational thinking?
- (2) What are students’ attitudes and beliefs about computational thinking? Do they change after participating in app-design curricula?
- (3) What evidence links app development to the CT skills of problem decomposition, pattern recognition, pattern generalization and algorithm design?

Project collaborators include professors of Digital Media and Learning and Computer Science, and participating classroom teachers across three school districts. The final phase our project (detailed below) will include researchers from the Educational Testing Service (ETS). Our initial challenge is navigating the demands and logistics of schooling while providing a worthwhile experience, and collecting meaningful data to inform our project moving forward. This working example will discuss both the process and challenges of our endeavor.

What challenges might pop up?

Working Examples: Feedback and Support from the Community

We seek feedback from the community regarding the viability of this enterprise. We anticipate challenges creating game-like assessments (see Phase 3 in Sprout) and appropriately defining “indicators” to measure CT practices. Thus, we are especially interested in feedback and support from those who have experience in CT and app development, or have created in-game assessments.

Using the “Worked Example” model (Gee, 2010) we present media-rich (video, images and hyperlinks) curriculum examples, data, and our early findings. We propose conditions necessary to garner support when implementing app-based curricular platforms in school by revealing processes, successes, barriers, and failures. It is in “building plausibility arguments via proof-of-concept implementations” or exemplars, that a broad interdisciplinary discussion can ensue, and serve to unify and inform research and practice (Barab, Dodge & Gee, 2009, p. 18).

Sprout

Tell us about your process and how your idea is evolving throughout the project.

Three phases encompasses our goals in this project.

Phase 1: A pilot project was conducted in two at-risk 8th grade classrooms helping us better understand the viability of using MIT App Inventor in schools. Technical requirements, logistical concerns and curriculum integration were addressed, and data were collected to gauge teacher and student perceptions of the experience. Measures included pre and post-test surveys from 17 boys, 18 girls, and 2 participating teachers, observations, focus group interviews, and student artifacts. Data were analyzed and triangulated describing teacher and student perspectives and practices. The pilot experience suggested (1) students' had limited knowledge of CT before the intervention; (2) students' understanding of, and attitudes towards, CT improved after the unit; (3) students' believed the unit motivated them to continue developing apps, and (4) boys showed greater gains in understanding and attitudes. Teachers' perceived the unit as valuable and intend to offer additional classroom opportunities. They suggested teacher training, scaffolded lessons, and addressing logistical concerns are necessary for effective practice.

Rethinking challenges and failures. Two challenges and "failures" surfaced during this phase. The working environment for students posed numerous challenges including network issues related to Wi-Fi and dated school-owned laptops. Behavior issues were exacerbated by the room configuration and additional distractions created waiting for technical issues to be resolved. Our team, and participating teachers, agreed the curriculum needed revision to better scaffold lessons. Students struggled moving from simple to complex app creation. Simple apps involved fewer components and design elements, complex apps typically had a number of variables requiring increased decomposition, pattern recognition and logic in coding. To address the challenges moving forward, we spent more time on the "back-end", ensuring technical support, specifying minimum hardware and software requirements and testing connectivity. Many of our challenges were remedied by better communication. We also re-thought scaffolding between difficulty levels of apps, adding components and variables at a gradual pace.

Phase 2: The second, in-progress, phase is being conducted in two regular education classrooms. It entails examining 8th grade students' and teachers' perceptions of CT before and after an intervention designing apps, and further studying whether evidence exists linking four pre-determined CT to student learning. Specifically, we are investigating indicators of CT by student engagement in problem decomposition, pattern recognition, pattern generalization to define abstractions or models, and algorithm design. Indicators of CT are currently being coded and mapped to themes from pre and post-test surveys, focus group interviews, observed activity, and student artifacts our research team independently to reach consensual validation (Eisner, 1991, as cited in Creswell, 2007, p. 204).

Describing the current intervention. Within the 4-week, daily fossil unit App Inventor was taught 3 times per week. Students used their fossil research to plan and design a story-telling app including pictures and text supporting their essential question, with buttons programmed to move from page-to-page on the app. A desktop sized mat emulating the various panels and components in App Inventor was used to plan and storyboard learning. A typical class period included a 10-20 minute mini-lesson using the mats or other learning resources, followed by 25-30 minutes of students working in App Inventor at their individual computers. Towards the end of the unit, students spent a majority of their time at their computers working on coding, playtesting, and problem solving. All (n=57) students completed a working app. Figures 1 and 2 depict representative student work.

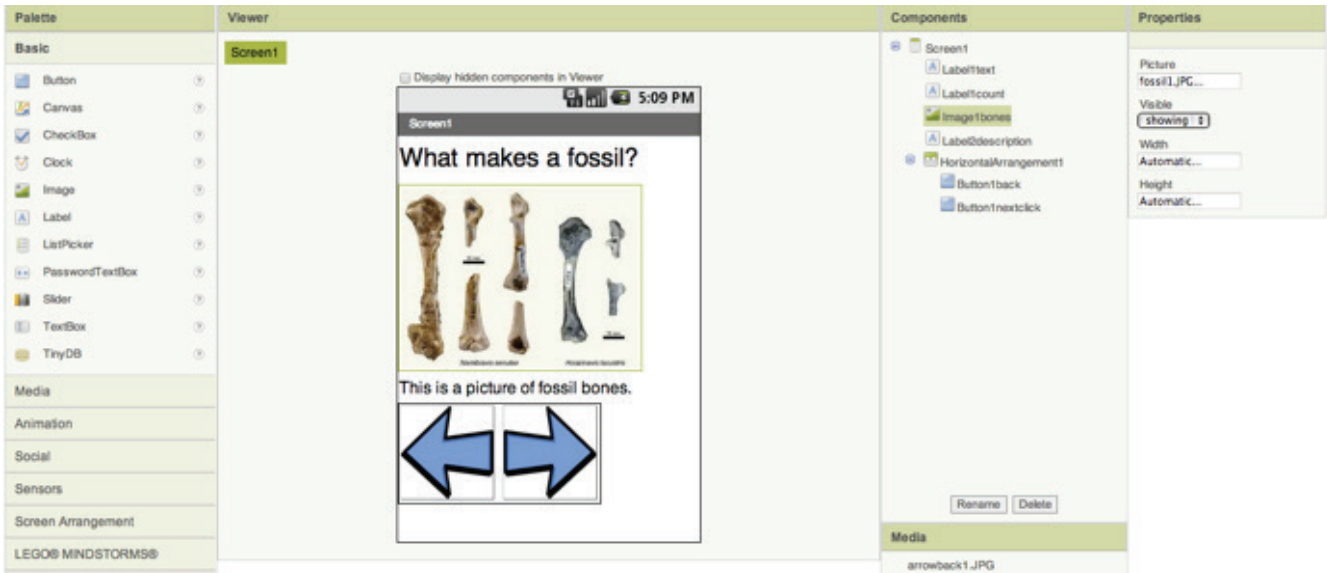


Figure 1: Screenshot of student’s app in Designer view using MIT App Inventor

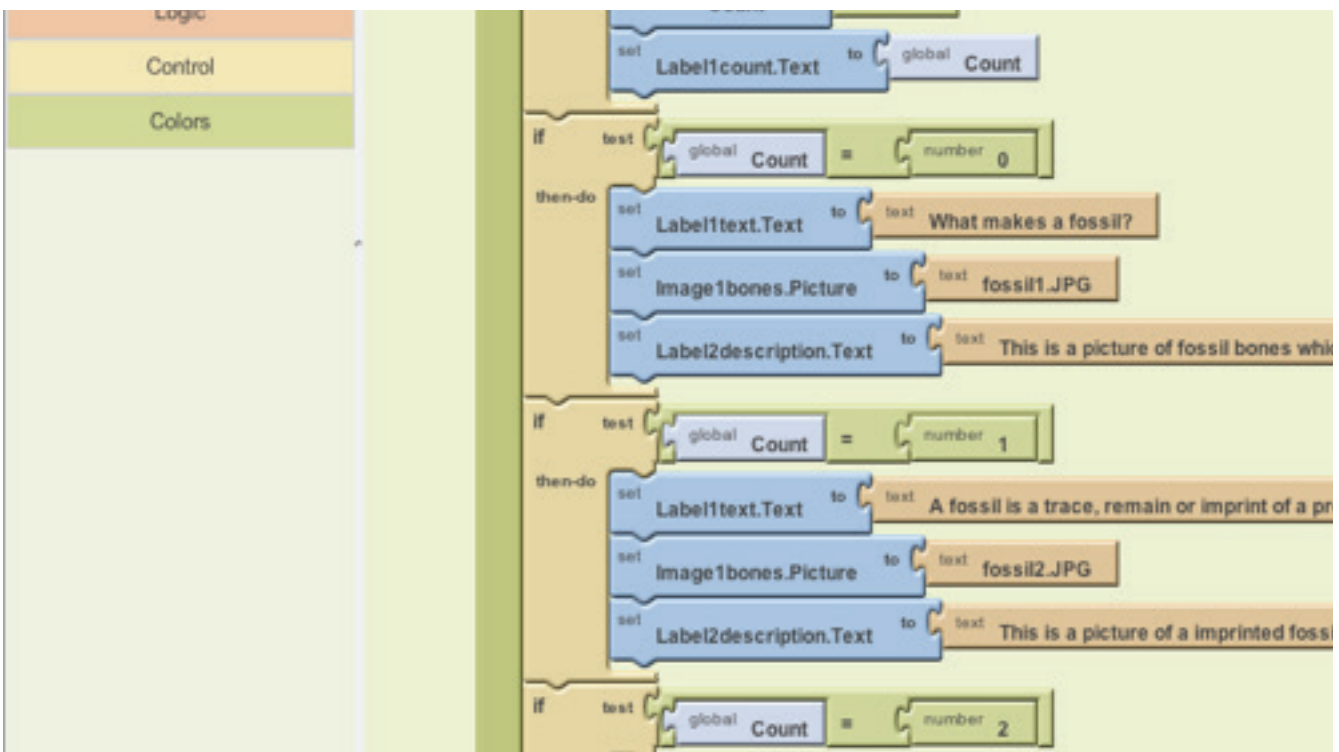


Figure 2: Student coding in Blocks Editor view of MIT App Inventor.

Phase 3: The third phase will consist of expanding app development units to include an assessment measuring CT using a game-like platform. We are partnering with research scientists from ETS, and pursuing external funding; our research proposes creating a game-like model with an embedded test administered before, and then after, students participate in an app creation unit.

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In this context, the curriculum design provides a model towards app design to further CT practices in school. This invitation for scholarly conversation and critique of curriculum components, its appeal to youth and potential next steps - including studying achievement indicators within the curricular interventions using game-like assessments, create a common foundation for collaboration across disciplines adding to the plausibility of the thesis.

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