Online Communities Making a *Mass Effect*: From Affinity for Games to Identities for Professionalism

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Abstract: A great many adolescents and young adults participate heavily in online affinity spaces around videogames. Committed contributors spend upwards of 20 hours each week researching, writing, and editing to contribute to wikis, fan fiction stories, and other literacy-rich online spaces. Many of these individuals hope to leverage their work toward careers as professionals in the gaming and publishing industries (Ochsner & Martin, 2013). Through ongoing case study interviews, this study explores the goals and trajectories that these writers form, using Miller and Slater's (2000) *expansive potential* and *expansive realization* as lenses for analysis. As a part of a broader trajectory, the goal of this research is to reveal how educators and industry professionals can support young affinity group leaders as they work to establish and build careers as professionals.

Introduction

Many young people today are more passionate about their interest-driven activities around media such as videogames than they are about their educational experiences and perceived career trajectories (Gee, 2007; Gee & Hayes, 2010; Steinkuehler & King, 2009). Yet activity around interest-driven spaces is not always what we might characterize as all fun and games. Active producers in interest-driven spaces such as wiki and fan fiction websites spend significant portions of their time researching, writing, and editing—skills that are valued both in schools and many professional fields (Steinkuehler & Duncan, 2008). Members of these communities frequently seek out project-based and self-directed opportunities (Lammers, Curwood, & Magnifico, 2012). Some individuals are content to do this work purely for leisure, but others hope to pursue work requiring similar skill sets professionally. However, the roadblocks to gaining a job in the games industry or in writing, editing, and research fields are numerous—including disaffiliation with school, failure to be admitted to competitive post-secondary programs, and a lack of direction upon completing academic programs—and young people find themselves unable to make progress toward accomplishing their career goals. Instead of examining the learning that goes on in schools, in this research I look to the spaces where adolescents and young adults already channel so much energy and effort—the websites and online spaces around popular videogames.

Studying active producers on wiki and fan fiction sites around the popular role-playing videogame franchise *Mass Effect*, I explore how participation in these spaces leads contributors to forge identities that inspire and enable them to pursue professional career trajectories. Identity-formation and skill acquisition (such as becoming a stronger writer or editor) are reciprocal processes, building on one another to support individuals to take active steps toward achieving their long-term professional goals. Instead of making assumptions that these activities are always just-for-fun—or worse, a waste of time—researchers, educators, and industry professionals could work to help young people leverage their literacy work in online affinity spaces toward professional career goals. The recent report from the Connected Learning Research Network cites active participation in online interest-driven communities as one of the digital era's best hopes for addressing growing issues such as the achievement gap affecting African American and Latino populations, as well as increasingly growing gaps between working class and upper income families. Because they foster engagement and offer social supports for interest-driven learning, online affinity spaces are ideal sites for exploring equitable ways to offer better opportunities for adolescent and young adult learners (Ito et. al, 2013).

Literature and Theoretical Framework

Interest-driven online spaces around games and other media—including forums, wikis, fan fiction sites, and others—function as affinity spaces (Gee, 2004) and as sites of participatory culture (Jenkins, 2006), forming a constellation of literacies (Steinkuehler, 2007) and information (Martin, 2011). As affinity spaces, videogame wikis and fan fiction sites provide participatory spaces of information and content exchange for informal learners with a shared interest and willingness to engage in collaborative activity (Black & Steinkuehler, 2009; Gee, 2004). Squire (2011) cites participatory learning spaces as places that encourage the development of unique expertise through peer-to-peer learning and apprenticeship. Gee (2004) poses that interest in the topic that an affinity space is centered around is the primary motivating factor for most participants. However, Jenkins (2007) suggests that it is not necessarily passion for the media franchise that motivates participants, but rather it is the community that matters. On a similar note, Davies (2006) argues that online affinity spaces offer opportunities for *reciprocal teaching* and

learning partnerships where the enjoyment of learning is secondary to the satisfaction people get from engaging in collaborative creation of products that are enjoyed by the entire community. Regardless of the initial and ongoing motivations of contributors on these sites,

In their ethnography of Internet practices among Trinidadians, Miller and Slater (2000) examine the ways in which individuals in the modern age forge their life trajectories. They outline two identity shifts that they observed in their participants based on their online practices. The first they termed *expansive potential*. When experiencing expansive potential, "people glimpse quite new things to be" and the Internet acts "as a mode of imagining the future" (p. 13). Essentially, the Internet acts as the means by which individuals are able to expand on who they believe they have the potential to become. The other phenomena they observed they called *expansive realization*. They describe a process of Internet practice "helping people to deliver on pledges that they have already made to themselves about themselves" (p. 11). Expansive realization can refer to re-attaining a state that had once been realized and then lost, or realizing a goal that was projected but not yet attained. Here, the focus is on an expansion of existing identities, with an emphasis on "finding oneself" and "taking up one's rightful place" (p. 11). Through case study interviews, I identify two aspiring professionals who experience states of expansive realization and expansive potential as a result of the literacy and professional development practices they engage in around online *Mass Effect* communities.

Methods & Data

Communities of Study

For my research I chose to study the sites focused around the popular single-player role-playing game franchise *Mass Effect* from developer Bioware. At the time of data collection, the second game in the series had been released and was seeing both commercial and critical success, and the final part of the trilogy was due to come out the following spring, so there was a lot of excitement about the game and the online sites dedicated to the series were especially active. To recruit research participants, I turned to editors on the Wikia *Mass Effect* wiki, the largest wiki resource around the *Mass Effect* series, as well as authors on fanfiction.net, which has the largest compilation of fiction stories around the series.

Case Study Interviews

The first phase of the project consisted of conducting interviews with active editors on the *Mass Effect* wiki and writers who compose novel-length fan fiction pieces about the series. I chose interviewees by means of purposive sampling, selecting only those individuals who were especially active and influential in their respective communities, with specific criteria being number of edits made on the wiki and story word count for the fan fiction writers. All interviews were conducted online, primarily through email correspondence with the interviewees. After conducting interviews with between three and five individuals each from the *Mass Effect* wiki and with *Mass Effect* writers on fanfiction.net, I selected two focal participants, one wiki administrator and one fan fiction writer, to function as the study's primary case studies, enabling me to conduct follow up interviews as they became necessary. Throughout the rest of the paper I call the wiki administrator Erik and the fan fiction writer Raina.

Both of the selected case study participants were willing to provide especially detailed information about their motivations and writing practices, as well as how their writing and editing responsibilities fit into larger life contexts relating to career and family. In choosing to focus on just two subjects, I could gain a more holistic understanding of the individuals under study. I was able to determine their motivations, identify the skills they are developing, and understand how their work in the interest-driven online spaces relates to long-term professional goals. Conducting follow-up interviews for a period of more than nine months after my initial contact correspondence allowed me to gather information and data about the participants' ongoing projects and emerging practices, as well as to follow up on the progress they were (or were not making) toward their stated goals and trajectories.

After completing about five interviews and follow-up interviews with both Erik and Raina, I utilized the qualitative coding software NVivo to code the interview responses in order to identify and categorize the major themes that emerged from my conversations with both participants. Analysis revealed four major prevalent themes: roadblocks to continued progress; why the community worked initially (short term); what the community experience offered over time (long term); and connections to larger goals and overall trajectory. See Table 1 for how data from the interviews with Raina and Erik conforms to the major themes.

Community Supported Progress	Erik: Wiki Editing	Raina: Fan Fiction
Roadblocks to Continued Progress	Could not find job	Struggled to find time for writing
	Excess of unproductive time	Few opportunities to receive feedback on work
	Was not making progress toward long term industry goals	Pressure to create an “epic world”
Why This Community Worked Initially (Short Term)	Deep interest in *Mass Effect*	Games offer inspiration for story ideas
	Knew Wikia sites to be a quality source for info	Pre-existing story universe
	Desire to learn wiki-editing skills	Other readers and writers with similar interests
	Got a laptop, enabling increased participation	Anonymity offered freedom for experimentation
	Had time to commit to wiki	Ability to post stories in mid-progress
	Related to (though vaguely at first) long term industry goals	Ability to focus on desired skills: character, voice, and tone
What the Community Experience Offered (Long Term)	Time management skills	Discovered talent for filling in the “blank pages”
	Experience with mediating conflict	Dramatic improvement of writing skills
	Ability to collaborate on projects	Found like-minded audience
	Opportunity to work as a leader in the community	Got over fears of being good enough
	Plethora of experience with writing and editing	Practice before going out into publishing world

Connections to Larger Goals and Trajectory	Time management, conflict mediation, collaboration, and leadership relevant industry skills	Improved on specific skills, fulfilling long term writing goals
	Writing, editing, and communication skills relevant industry skills	Gained confidence through having an audience that appreciates her work
	Dedication to community helped instill greater commitment to goals for a future in the industry	Enabled her to take the next step in her trajectory—publishing original fiction

Table 1: Major themes based on codes devised from analysis of interview data.

Results & Conclusions

Erik and the *Mass Effect* Wiki

Erik is one of the most active administrators on the *Mass Effect* wiki, putting in between 20 and 40 hours each week. He has aspirations to work in the games industry one way or another, but found himself unable to make progress toward this goal. Unemployed and believing himself to have an excess of free time, Erik began contributing to the wiki because he wanted to do "something productive." And productive his efforts have been—the wiki has put Erik back on track with pursuing his professional goals. He is currently working toward two associates degrees, including one in game design. Erik's wiki work involves mediating conflicts, enforcing and negotiating rules and community norms, and managing his time across multiple demanding activities and projects. His work with the game and wiki has enabled him to find a greater sense of purpose that helps drive the goals that are emerging out of his schoolwork.

Miller and Slater's term expansive potential—where online practices enable people to imagine new futures—describes Erik's experiences quite well. While previously game design had been an abstract goal for the future, he has begun to take concrete steps toward this end. Pursuing a degree in game design, Erik will be transferring from his community college to a four-year university for a bachelor's degree after just one more semester. He hopes to be able to use both the game design experience and the wiki work to gain a job in the games industry. His involvement with the community has played a major role in helping Erik to shape and articulate long-term professional goals for his life, and then the ability to begin pursuing those goals. Figure 1 shows Erik's progression from simply having an abstract goal out of his gaming identity, hitting roadblocks to prevent him from making progress toward this goal, and then finding ways to use the wiki to mediate these struggles and get back on track with his trajectory.

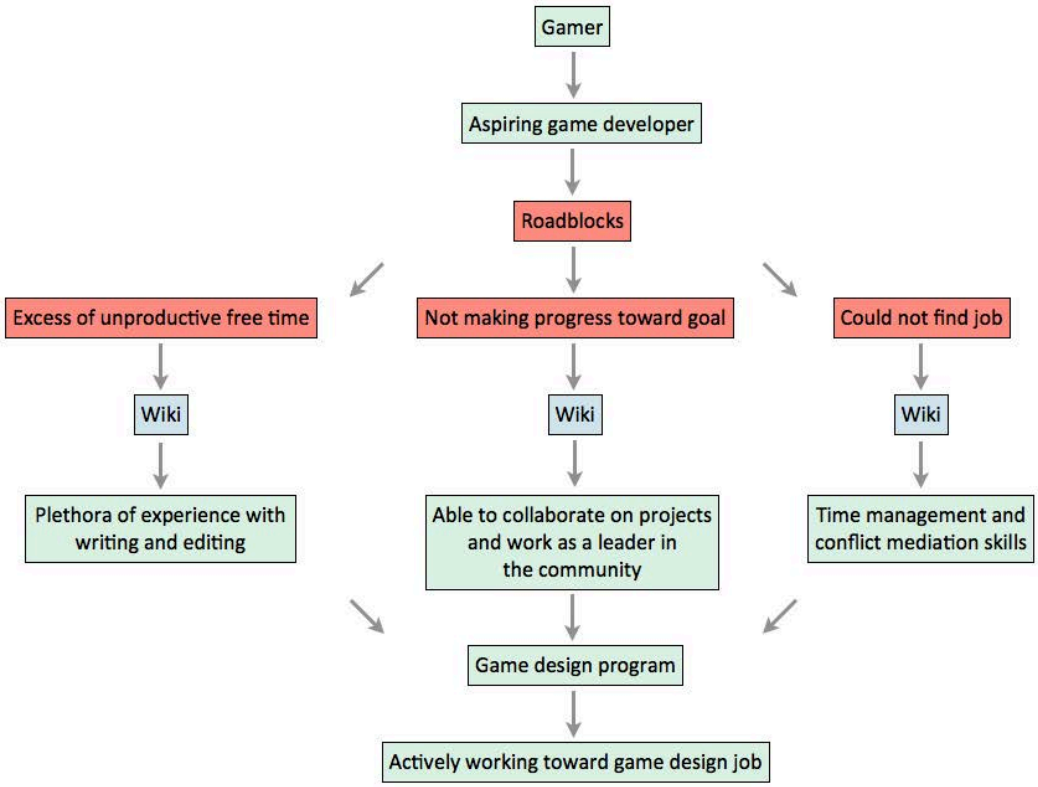

Figure 1: Erik's progression of expansive potential, mediated by editing on the wiki.

Raina and *Mass Effect* Fan Fiction

The second case study for this paper focuses on Raina, a writer who composes novel-length stories set in the *Mass Effect* universe. Raina is a stay-at-home mom who studied creative writing as an undergraduate and graduate student. Now she writes fan fiction as a way to keep her writing skills polished. In school she says she had limited time for working on personal writing projects, a roadblock that has only gotten more challenging as she has become a mom. She describes not being able to write as consistently as she wanted. She says:

> I felt I ought to write to a certain audience and write a certain kind of story. I was having so many issues about how I *ought* to write that I found I couldn't just *write*. [emphasis hers] I was also getting caught up in trying to come up with the epic world I felt all fantasy stories should have (location, backstory, characters, sequel ideas, etc.). And I just couldn't get the first few chapters of the first book down.

This hurdle of creating an entire world from scratch is one that *Mass Effect* was able to help Raina temporarily bypass so that she could focus on improving specific writing skills.

Another benefit that has come out of writing fan fiction is having an audience for her work. After what she describes as "long hours in debate with myself about whether what I had to say was good enough or if I would find a publisher or an audience," with fan fiction she was able to just write and post. She says, "The fact that people like my work and my writing style…made me realize I do have an audience out there." This led her to be more confident: "I realized that by writing the kind of story I wanted to read, the audience found me. I didn't have to change myself to make my stories more palatable."

Raina's experience shares many similarities to Erik's but, since she was a bit farther along in her trajectory to becoming a writer (having already earned creative writing degrees and having more experience), she is more articulate about how fan fiction has helped her to work toward her long term publishing goals. For Raina, writing fan

fiction both helps her to re-identify as a writer with an audience and to look forward to fulfilling her long-term goal of creating original fantasy novel-length stories. She characterizes her fan fiction writing as a practice exercise. Unlike Erik, for whom the wiki seems to have enabled the first steps toward achieving his goals, Raina was able to articulate what she wanted from fan fiction early on, and all along planned specifically to use it to accomplish her professional goals.

Ultimately, Raina's experience contains a bit of both expansive potential and expansive realization. She had realized an identity as a writer in her days at the university, but even then had not been able to work on an original novel-length work. Fan fiction has been a step in a trajectory of fulfilling long-term life goals for Raina—one that enabled her to finally be able to try her hand at writing her original fiction and publishing it online for a real audience. Figure 2 shows how writing fan fiction has enabled Raina to move past some of her writing roadblocks, putting her back on track for writing her own original fiction novels.

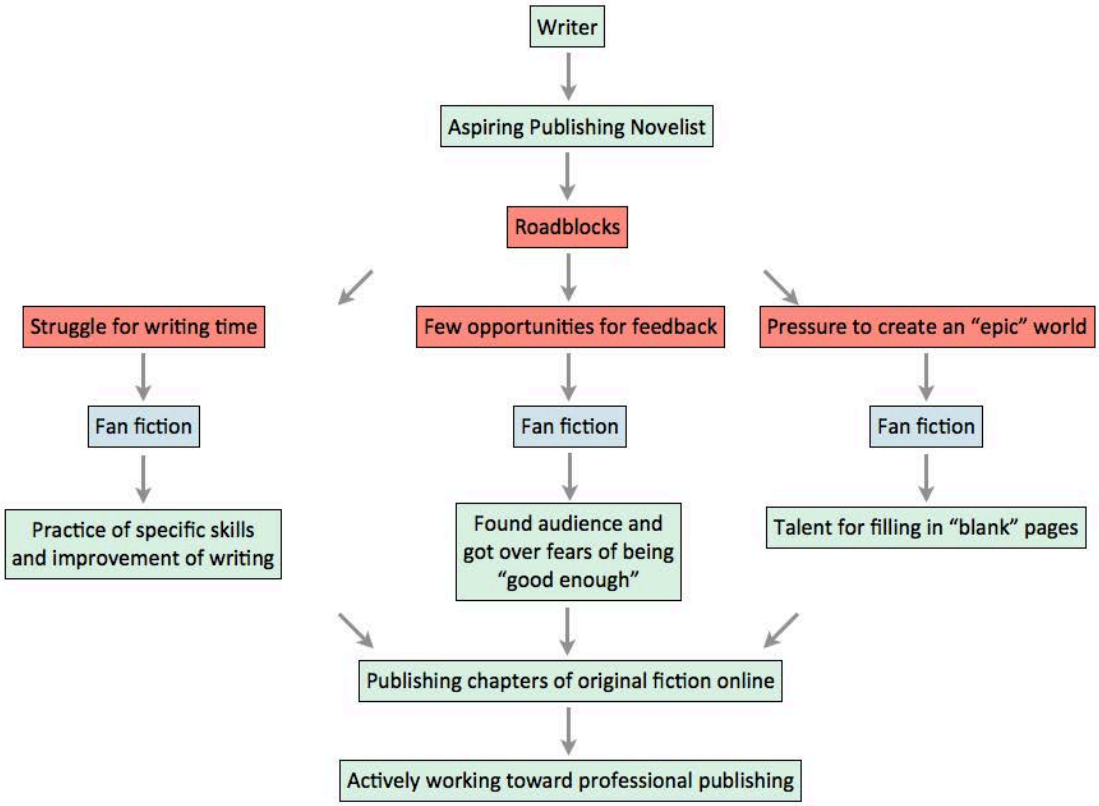

Figure 2: Raina's progression toward expansive realization, mediated by writing fan fiction stories.

Significance of the Research

For participants in these spaces, the work of participation and the practicing of skills turns into a process of shaping and shifting identities. In addition to acquiring useful professional skills, the more active contributors begin to articulate new identities and imagine new futures. Since we live in a world where learning is often confused as being inextricably tied up in school, we need to pay attention to places where people find opportunities to learn voluntarily and work collaboratively to create something they care deeply about. Educators could do a lot for young people through understanding the value of these efforts, and finding ways to help them leverage those skills and experiences toward their professional career goals. Industry professionals could also benefit from being familiar with this work because the results presented here suggest that participating in online affinity spaces around games and other media plays a significant role in adolescents and young adults' preparation to enter professional fields such as the publishing and games industries.

The more we understand the processes that people go through as they pursue their interests in such spaces, the more we can help facilitate both improved learning outcomes and opportunities for the participants to be able to utilize their skills and experiences to pursue longer term life goals. Online affinity spaces such as these can offer a lot to their participants, but they also give these contributors a lot of skills and experiences to offer academic programs and potential employers. However, there is work to be done before the majority of such creators will be able to leverage their skills in such a way. The current professional environment values official education credentials over work in interest-driven spaces such as those outlined in this study. However, as we have seen here, work in such spaces combines with formal education in ways that enables participants to more clearly form and articulate their goals and offers some of the motivation and inspiration to make directed, substantive progress toward those goals.

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ADAGE (Assessment Data Aggregator for Game Environments): A Click-Stream Data Framework for Assessment of Learning in Play

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Abstract: A central challenge to educational videogame research is capturing salient in-game data on play and learning. ADAGE (Assessment Data Aggregator for Game Environments) is a click-stream data framework currently being developed by the Games+Learning+Society group to facilitate standardized collection of in-game assessment data across games. ADAGE integrates core game design structures into a click-stream data (telemetry) schema, which is then seeded with context vital to informing learning analyses. These data can be used to identify patterns in play within and across players (using data mining and learning analytic techniques) as well as statistical methods for testing hypotheses that compare play to content models (cf. Loh, 2013; Halverson & Owen, in press). ADAGE assessment structures also inform iterative, data-driven design of GLS games. Overall, ADAGE provides a standardized game telemetry framework with a rich, method-agnostic data yield, efficient enough to have scalability, and flexible enough to use across games.

Introduction and Theoretical Framework

In educational game research, a central challenge is capturing salient in-game data on user experience through the lens of play and learning. A typical approach has been to treat the game as a black box, focusing on data collection via pre- and post- measurements; in relying solely on this, however, we lose the unique characteristics of games as a learning tool. James Gee has suggested that games themselves provide excellent learning assessments. Well-designed games reward players for mastering content and strategies, scaffold player activities toward greater complexity, engage players in organized social interaction toward shared goals, and provide feedback that allows players to monitor their own progress (Gee, 2005). Rather than ignore the motivating and information-rich features of games in capturing learning, designers need to attend to the ways in which gameplay itself can provide a powerful new source of assessment data. This requires thinking of games as both intervention *and* assessment; and developing methods for accessing in-game data with a consistent, versatile, context-rich framework for use in learning analysis.

Well-designed games are examples of situated learning environments in which learning exists *in situ*, inseparable from environment or context (c.f. Brown et al., 1989; Greeno, 1997). Virtual game worlds have been shown to provide a powerful environment for learning, supporting apprenticeship and collective higher-order thinking skills (Steinkuehler, 2004; Steinkuehler & Duncan, 2008). Videogames afford this environment by providing *designed experiences* in which players explore worlds to understand how knowledge and skills interact in a context (Squire, 2006). From a player perspective, good video games include just-in-time information and cycles of expertise that scaffold play experience. The data channels available to the player act as formative feedback displays which inform play. To maintain this immersive context for learning, good games consist of ongoing assessment balanced with engaging mechanics and narrative (Squire, 2006). Games can thus provide an experience which is distinct from – but relies upon – the core design mechanics of the game. Game design icon Jesse Schell is careful to distinguish early in the design process that “the game is NOT the experience” (2008, p. 10; see Figure 1). Salen and Zimmerman assert that “the careful crafting of player experience through a system of interaction is critical” (2008, p. 61). Additionally, in moments of transgressive play, users often interact with the gamespace in unanticipated ways (Salen & Zimmerman, 2008). How, then, can we further explore the connection between design, interaction, and experience? Applied specifically to educational games, how does it then connect with in-game data collection for assessment of learning?

The GLS approach to bridging these worlds is ADAGE (Assessment Data Aggregator for Game Environments), a click-stream (telemetry) data framework that looks inside the black box of educational games. ADAGE identifies key gameplay verbs as occasions for interaction, providing a click-stream data framework for collecting evidence of learner trajectories. In looking at in-game data, we avoid the “Heisenburg” problem of usertesting – that a user experience “cannot be observed without disturbing the nature of that experience” (Schell, 2008, p. 18). As Val Shute notes, telemetry-based assessment can be a “quiet, yet powerful process” through which we can unobtrusively observe player patterns (2011, p. 504). However, with the affordance of subtlety comes the problem of

abundance; log files from digital spaces can produce millions of data points with little to no context (c.f. Baker & Yacef, 2009). ADAGE addresses this core question specifically for educational games: how do we identify, record, and output click-stream data salient to learning analysis?

ADAGE (Assessment Data Aggregator for Game Environments)

ADAGE was designed to transform game-based log file data into evidence of learning. It articulates a bridge between educational game design and player experience, which is then structurally integrated into a framework for an otherwise inchoate mass of log data. ADAGE organizes click-stream data framework that allow developers and researchers to trace trajectories of player experience by tracking interaction with core mechanics in the educational gamespace. It articulates key mechanics for recording (or "tagging") in the game data, and tags concurrent instructional game cues and gameworld context. The ADAGE tagging procedures are developed to create minimal interference with the development process, yet to yield data rich enough to be make inferences about learning. Because it builds on features core to educational game design, ADAGE is flexible enough to use across genres, and is currently implemented in four vastly different GLS games.

Below, we will identify and describe ADAGE assessment mechanics and telemetry features. Together these layers create context-rich raw click-stream data that can be filtered and processed data into sequential blocks or performance indices, facilitating the feature engineering process vital to later analysis.

Assessment Mechanics

Assessment mechanics are structures built into the game that allow for research on play and learning. Understanding game-based learning requires two levels of assessment mechanics: one to trace the paths players take through a game, and the other to access the player experience of game play (Schell, 2008). Squire asserts that games as designed experiences (2006) provide endogenous engagement (Costickyan, 2002) for the player through "roles, goals, and agency" (Squire, 2011, p. 29). Thus, in learning games, there can two core kinds of designed mechanics: one set related to progression through the gameworld (as an engaging learning context [Gee, 2007; Salen & Zimmerman, 2008]); another may be designed as more direct measures of the content the game is trying to teach (e.g. Clarke-Midura et al., 2012). Ideally, these also 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).

The ADAGE framework identifies underlying game mechanics for which serve as core occasions for player interaction. There are three base types of Assessment Mechanics: *Game Units* (capturing basic play progression), *Critical Achievements* (formative assessment of content), and *Boss Level* (naturalistic summative assessment). As "Assessment Mechanics", they serve as data-collection (or assessment) anchor points, which yield data informed by core educational game design structures. This terminology also parallels concepts of formative and summative assessment in formal learning environments (Harlen & James, 1997), and formalizes them as powerful elements of game design (c.f. Gee, 2012).

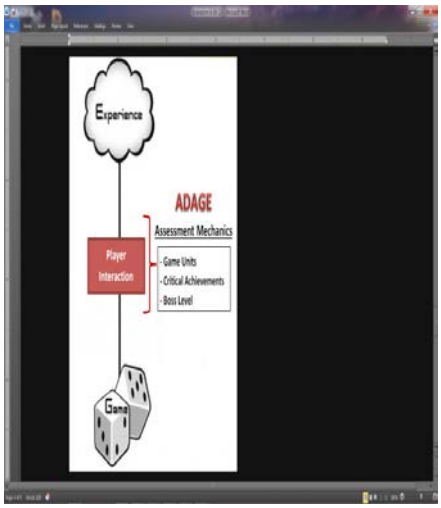

Figure 1: Schell's distinction between player experience and game design (2008, p.23); ADAGE assessment mechanics as bridge between.

Through Assessment Mechanics (AMs), ADAGE operationalizes player interaction (Salen and Zimmerman, 2008) as the vital link between experience and game design (Schell, 2008; Figure 1). These three core AM types can easily overlap within a gameworld; they are not mutually exclusive, though they have distinct categories. Additionally, every game does not have to have all AMs in order to use ADAGE. In this section, we will describe each mechanic, and connect it to ADAGE's underlying telemetry structure.

Game Units. The game Units represent the core progress mechanic of the game. For example, in a game like *World of Warcraft (WoW)*, the core unit is quests. By definition, game units have the property of being a repeating, consistent vehicle for making progress through the gameworld. Units can also be part of a hierarchy – for example, one set of quests may make up a particular map area, and completing all the maps means finishing the game. Thus, from broadest to smallest, game Unit hierarchy might be: game-map-quest. The idea behind Units is that they are flexible enough to work across genres; for example, in Tetris, the core Units are level completion and placement of shapes (different from *WoW*'s quest structure). Currently, ADAGE Unit structure is applied to five different GLS games (*Progenitor X, Fair Play, Anatomy Pro Am, Tenacity,* and *Crystals of Kaydor*) each with different genres and Unit types. The concept of Unit is logistically integrated into ADAGE's telemetry, with the term specifically connected to click-stream tags in ADAGE's API. The Unit AM informs user experience in setting base interaction with the game environment, a "vital component of design and interaction" (Salen & Zimmerman, 2008, p. 51).

Critical Achievements. Critical Achievements (CAs) in ADAGE are direct formative assessment slices of the content model (what the game is trying to teach). They are moments of direct content measurement within the context of normal gameplay. Seamlessly woven into the fabric of the game, CAs use naturalistic game mechanics to measure underlying educational content. For example, *Fair Play* is a GLS game which teaches about implicit bias in graduate education settings. In one *Fair Play* CA, the player needs to correctly identify a given bias to another character in order to progress. This is a direct demonstration of bias knowledge (as opposed to indirect movement through the learning context, like in game Units). Evidence Centered Design (ECD) is an analytic framework which focuses entirely on CA-like structures – direct demonstration of content knowledge (Mislevy & Haertel, 2006), recently applied to virtual spaces (e.g. Clarke-Midura et al., 2012; Behrens et al., 2012). For this reason, the CA data structure aligns very well with ECD-specific analyses. CAs (analogous to the "task model" in ECD) are intended to be one kind of direct content assessment embedded in gameplay, looking at selected moments of performance as learning measures. These moments can be compared throughout gameplay to give one snapshot of learning growth; moving beyond a task model, they can also be triangulated with ADAGE mechanisms like broader gameworld interaction data (Units), boss level performance, and pre-post learning measures. Although CAs are a great educational game design feature that lends to robust learning analysis, games don't have to contain CAs to use the ADAGE framework. The concept of CA formative assessment is manifested logistically in ADAGE's click-stream data structure, with CA-specific terminology in the API. Ultimately, CAs are a unique feature of educational games, and capture both learning AND play dynamics in the user experience.

Boss Level. The Boss Level is a final stage of a game that is a culmination of skills learned in gameplay. It is a naturalistic summative assessment, and can include both learning and progress mechanics (like CAs and Units). Gee notes that powerful embedded assessment occurs in "boss battles, which require players to integrate many of the separate skills they have picked up" throughout the game (2008, p. 23). Games are an ideal medium for this summative assessment, he asserts, since they can provide just-in-time performance feedback with low cost of failure (Gee, 2007). Thus, summative assessment mechanics in games can give us an unobtrusive measure of performance (c.f. Shute, 2011) in an agency-inspiring context (Squire, 2011) in which players receive instant feedback and appealing opportunity to improve (Gee, 2007). By formalizing the Boss Level as an Assessment Mechanic in ADAGE, we encourage deliberate inclusion of summative assessment in game design, and provide corresponding telemetry API structures for implementation. Interaction in the Boss Level shapes user experience as a culminating game encounter, and has also proven significant in ADAGE studies on gameplay progression and learning. For example, in *Progenitor X*, a GLS game about regenerative biology, strong performance in the boss level was predictive of learning gains (Halverson & Owen, in press).

Telemetry Framework

The Assessment Mechanics, informed by game design and assessment research, create a conceptual framework for identifying interaction data. The next ADAGE step moves us from concept (AMs) to implementation (telemetry). The telemetry framework hinges on the AMs to create a schema of context-rich data tags for implementation in the game code. Interpretation of student interaction often hinges on the context of the learning environment (in this case, the designed gameworld). The telemetry schema addresses this need by seeding the AM interaction data with vital contextual information.

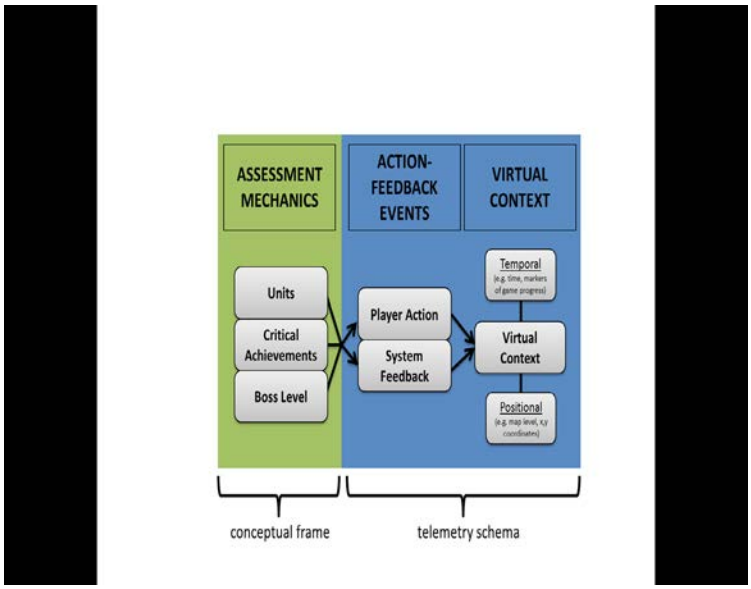

Figure 2: ADAGE Assessment Mechanics and telemetry schema.

The telemetry schema has two layers: an action-feedback layer, and a Virtual Context layer. First, for each Assessment Mechanic, it identifies two sources of direct interaction: user action, and system feedback. It articulates the vital action-feedback loop (c.f. Salen & Zimmerman, 2008) that comprises interaction between the player and the game. The second layer, called the Virtual Context, attaches important contextual information to each action-feedback event. The Virtual Context can include things like timestamp, map level, and screen x,y coordinates. These two layers work in tandem to provide context-rich telemetry data on AM-based gameplay trajectories (Figure 2).

One example of the applied telemetry schema is in the game *Progenitor X*. *Progenitor* is a puzzle-based zombie game about stem cell biology (playable from the footnote link). The core Units of the game are cycles of cell, tissue and organ creation. Table 1 applies the telemetry framework to a single cycle. In column 1, we identify the Assessment Mechanic – a Unit, specifically the first game cycle. Column 2 asks: for the start of that cycle, game cues are going on? To help the player begin, the game makes the start button flash. The feedback event becomes "Start button flashes". Next comes the corresponding player action for Column 2, which is "Player clicks 'start' button". Lastly, for each of the action-feedback events, we define the contextual information we need (column 3). To understand player progress, we attach information about which map the player is on, and elapsed time. Location of click is also recorded, in case heat mapping or place-based performance analysis is desired. The resulting Virtual Context is "Timestamp," "Map Level," and "x,y Coordinates."

Unit	Action-Feedback Events	Virtual Context
1st Cycle	Start button flashes Player clicks "start" button	Timestamp Map Level x,y Coordinates

Table 1: Telemetry schema example: *Progenitor X*

In implementing this framework, this process is completed for every sequential Assessment Mechanic in the game. In other words, each unit, critical achievement, and boss level section is laid out sequentially, then mapped to action-feedback events and Virtual Context. More detailed process information and templates are laid out in ADAGE's DevDoc, a working document for connecting ADAGE with new games. However, ADAGE's core telemetry structure is presented here, centered on the AM sequence, the action-feedback events, and the Virtual Context. Each of these elements has a counterpart in ADAGE code, mapping conceptual AMs to click-stream structures of user actions, system feedback, and the Virtual Context around each.

Raw Data. Essentially, ADAGE identifies core game design features that provide occasion for interaction. It then delineates a framework for tagging this data in the massive influx of click-stream input, and attaches systematic contextual information to each data point. This, in turn, produces an abundant stream of telemetry data informed by the game design structures. Raw ADAGE data contains all action-feedback data of each AM in the game, enriched with the telemetry structure's Virtual Context (Figure 3). The beauty of this rich stream is that it gives contextual data raw enough to be used in almost any analysis.

ADAGE Data Filtering

After the raw data from the telemetry schema is tagged, ADAGE features additional processing and filtering affordances. It can build in information about Unit bookends (e.g. the beginning and end of cycles), as well as create performance measures like AM success, failure, and repetition. Performance measures can be tailored to the research question; for example, one might be interested in Critical Achievement performance (for use with ECD), Unit progression (gamespace trajectory projection), or Boss Level success (in triangulation with a pre-post assessment on learning gains).

Feature Engineering & Analysis Lenses

ADAGE's context-rich data make ideal building blocks for feature engineering. Features are essentially variables of interest in the data, which can range from simple click locations to complex measures like accuracy over time. Features of interest across a variety of methods can be generated from ADAGE output, including evidence model performance (ECD), quantitative ethnographic data (c.f. Efferson et al., 2007), or sensor-free affect detectors (Baker et al., 2012).

The features constructed, in turn, can be used across a broad range of analysis techniques. Data lenses can include descriptive statistics, hypothesis-driven applied statistics, and machine learning techniques. For general descriptive stats, ADAGE data can be used for simple aggregation of behaviors in the gamespace, including figures of average elapsed time, number of units completed, time per level, etc. Hypothesis-driven applied statistics (used in methodologies like ECD) can use ADAGE data as dependent variables, independent variables, and covariates for use in associative or predictive modeling. Specific to educational games, this often means testing hypotheses that compare play to content models (cf. Loh, 2013; Halverson & Owen, in press). Lastly, ADAGE data lends itself to learning analytic techniques often used with big data sets. Recent "State-of-the-Art" reports in Educational Data Mining (Baker & Yacef, 2009; Romero & Ventura, 2011) articulate various machine learning analysis techniques used with log file data. These include Social Network Analysis, classification and regression trees, cluster analysis, Markov chain modeling, and Bayesian networks. GLS researchers have also utilized ADAGE data to create heatmaps of most frequently visited in-game areas.

Design Implications and Conclusion

By capturing trajectories of player experience via context- rich interaction with core mechanics in the educational gamespace, ADAGE connects design and user experience. It then extends that connection to a standardized framework for collecting salient click-stream data on play and learning. These data can be used to identify patterns in play within and across players (using data mining and learning analytic techniques) as well as statistical methods for testing hypotheses that compare play to content models.

ADAGE assessment structures also serve to inform iterative, data-driven design of GLS games. The articulation of formative and summative Assessment Mechanics inform core educational game design. ADAGE AM data are also utilized as well in the iterative data-driven design process. In the recent GLS Tenacity project, a collaboration with the Center for Investigating Healthy Minds, early usertesting telemetry informed design refinements during game development (Owen et al., 2013). Additionally, ADAGE data output can be used to inform adaptive tutorial help overlays, potentially providing pivotal support for learners in hotspots of game dropout or failure.

ADAGE bridges design and experience, while creating a standard framework for producing salient telemetry data of play and learning. It encourages best practices in iterative game design, specifically around integrated formative and summative assessment mechanisms in gameplay. Overall, it provides a standardized game telemetry framework with a rich, method-agnostic data yield, efficient enough to have scalability, and flexible enough to use across games. Through integration of content, design, and interaction data, design efforts like ADAGE model technology standards for transforming click-steam data into evidence for learning analysis.

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