Facilitating the Discovery and Use of Learning Games

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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. The 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; Galarneau, 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.