The Use of Game Dynamics to Enhance Curriculum and Instruction: What Teachers Can Learn from the Design of Video Games

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Abstract

Video games have received an increased amount of attention from educational institutions due to their widespread use and their ability to engage and sustain players in difficult learning tasks for extended amounts of time. Many studies have been conducted on the potential of video games to influence learning. Recently, however, some educational researchers have begun to analyze how the game dynamics embedded in video games are used to immerse students in difficult problem-solving and to support their learning. This article examines the need for public school educators to adapt a game design mentality when designing secondary level curriculum and instruction. Game design is presented as a tool for improving student learning and suggestions are offered for how educators can incorporate game dynamics such as narrative context, explicit interconnectedness, well-ordered problems, control, choice, customization, and co-design.

Human beings are hard-wired to do two things – to learn and to play (Alexander, Schallert, & Reynolds, 2009; Ortlieb, 2010). The first is fairly obvious and has been explored for centuries. The latter, however, is only beginning to come into focus. This may seem odd since games have been an integral part of the human experience for thousands of years. Archaeological research shows that gaming culture was widespread and considered a necessity of ancient life as early as 5,000 years ago (Voorhies, 2012).

In the last century, Dewey (1938) wrote of the cooperative and interactive benefits of games in curriculum and instruction, while Piaget (1962) and Fisher (1992) insisted that play was a precursor for emerging cognitive, linguistic, and social development. More recently, researchers have underscored other key benefits of play that include creativity, learner development, and imagination (Bodrova & Leong, 2003; Ginsburg, 2007; Hirsh-Pasek, Golinkoff, & Eyer, 2003; Zigler, Singer, & Bishop-Josef, 2004).

However, video games are a rather recent development and have only been in existence for about 40 years. The study of game-based learning has only been around for half that long (Pivec, 2009). Video games represent a multi-billion dollar business that will soon rival the movie industry, and it has been reported that between 90% and 97% of United States teens play some type of video game on a regular basis (Lenhart et al., 2008). It should come as no surprise, therefore, that education has recently developed an increased interest in the use of commercial and customized video games and has begun to take a closer look at the game mechanics and game dynamics used by video game designers to support players as they work to solve complex problems (Gee, 2007, 2008; Wastiau, Kearney, & Van den Berghe, 2009). While the two terms
are often used interchangeably, game **mechanics** refers to the components selected by the game designer during game construction, while game **dynamics** denotes the way in which those mechanics are actualized throughout interplay between the player and the game itself (Sedano, Sutinen, Vinni, & Laine, 2012; Tragazikis, Kirginas, Gouscos, & Meimaris, 2011).

**What Students Can Learn from Video Games**

While teachers have employed board games such as chess and Monopoly for decades, it now seems that video games are the ones garnering the most attention. Several studies tie them to increased student motivation and engagement, although not all researchers agree on the basis of this motivation. Some studies find that motivation is linked to intrinsic motivators, such as rewards and goals within games (Amory, Naicker, Vincent, & Adams, 1999; Denis & Jouvelot, 2005; Jennings, 2001), while others attribute increased learner motivation to the narrative context that games often provide (Dickey, 2005, 2006; Fisch, 2005; Waraich, 2004). Nevertheless, the studies tend to agree that motivation is a significant characteristic of learning tasks that are embedded in – or tied to – video games (Dondlinger, 2007).

One key advantage of video games is the extent to which they provide immersive learning opportunities that might otherwise be difficult or impossible. For example, I recently visited a high school health classroom where students were discussing the potentially harmful effects that result from an improper diet and lack of physical activity. Using a free simulation from the University of Colorado at Boulder (http://phet.colorado.edu/en/simulation/eating-and-exercise), the students used avatars to experience and observe the effects of various food and exercise habits. This simulation, one of more than 100 designed and offered by the university, provides learners with crucial opportunities to safely interact with content, to think, to understand, to prepare, and to execute actions (Gee, 2008; Pannese & Carlesi, 2007). Researchers concur that in science and other related content areas, simulations tend to augment students’ ability to learn scientific facts, to apply knowledge, and to perform other higher level thinking tasks (Hattie, 2009; LeJeune, 2002).

Additional perceived benefits for students who use video games are piquing the interest of educators. Studies indicate improved visual and spatial skills, multi-tasking, as well as higher academic achievement and interest levels when video games are well-integrated with other classroom learning activities (Dorval & Pepin, 1986; Kearney, 2005; Stevens, 2000; Wylie, 2001). Research also shows that problem-solving can be improved by video games; however questions abound about how well this ability can be applied outside the context of the game itself (Curtis & Lawson, 2002; Ko, 2002; Kovalik & Kovalik, 2008; Pillay, 2002). Games seem to be a particularly effective form of intervention with students for academic challenges (McKenna, 1991). While video games are widely played by learners of all ages, they tend to have the highest impact on mathematic achievement when used with students in secondary grade levels (Lee, 1990).
What Teachers Can Learn from Video Games

One of the greatest plagues of education is that of student disengagement. As Steinburg, Brown, and Dornbusch (1997) wrote, “So many students are physically present but psychologically absent” (p. 57). They also claimed that approximately 40% of students are merely “going through the motions” (p. 15). Video games may offer a means for addressing this problem. For years, I have been intrigued by secondary students who play Minecraft, Rise of Nations, or World of Warcraft who willingly work at solving complex problems, collaborate, and persist at difficult challenges for significant amounts of time. Gee (2007) noted that the design of these video games has a great deal to teach us about how to facilitate learning, even in domains outside of games. Good computer and video games are complex, challenging, and long; they can take 50 or so more hours to finish. If a game cannot be learned well, then it will fail...therefore good games have to incorporate good learning principles in virtue of which they get themselves well learned. (p. 45)

As educators begin taking a more serious look at video games, we begin to ask questions such as “What is it that makes a video game so motivating?” and more importantly, “How can teachers utilize the learning principles embedded in video games in their own curricula and classrooms?”

Several reviews of the literature on educational games have been completed within the last decade (De Aguilera & Mendiz, 2003; O'Neil, Wainess, & Baker, 2005). Most of these reviews, however, focused on what players learn from video games rather than the potential for educators to work like game designers and utilize the learning principles embedded within video games to improve learning. Yet in the past few years, the literature has begun to reveal a number of distinct game dynamics that could be employed by educators to stimulate desired learning outcomes. These include (a) narrative context, (b) explicit interconnectedness, (c) well-ordered problems, (d) choice and control, and (e) customization and co-design (Dondlinger, 2007; Fisch, 2005; Gee, 2007; Ke, 2009; Pivec, 2009). These game design elements are described below.

Game Dynamic: Provide Narrative Context

Teachers would be wise to start by examining game designers’ powerful use of narrative context within video games. Many video games use story lines and visual narratives to introduce and to build upon learners’ real-world knowledge. A narrative serves as a sandbox, or realistic problem space, where the danger of failure is greatly mitigated (Dickey, 2005, 2006; Gee, 2007; Warren, Dondlinger, & Barab, 2008). Teachers can adapt this narrative aspect of game design into curriculum and instruction by working to construct narrative contexts or stories for situating cognition and contextualizing learning. The goal should be to place educational content at the heart of the narrative as students learn to play and play to learn (Fisch, 2005).
One way for teachers to put the narrative game dynamic to use is to transform existing curricular narrative texts into problem spaces. For example, just before the end of last school year, I visited with a seventh grade language arts teacher whose class was in the process of finishing Robert Louis Stevenson’s *Treasure Island*. But, unlike many other adolescents’ experiences with classical literature, these students were listening and following along intently as their teacher read a few excerpts with them before they started their independent tasks. I noted that the students kept glancing back and forth from the words on the pages to a chart that they had next to their book. All the while they were whispering to each other. Upon investigation, I discovered a simplistic, but well-utilized game dynamic: a contextualized narrative environment for students to make and evaluate choices in order to reach a desired goal.

It turned out that before ever opening the book, their teacher had issued the students a challenge: “Let’s see if you can survive the journey to Treasure Island.” He organized his class into groups and told them that their first task was to “Persuade for Doubloons,” or pirate gold. Specifically, they were to use argumentative writing to convince the King of England, a group of settlers, a company of merchants, or a combination of the three to invest in the risky journey to Treasure Island. Interestingly, nearly all groups resolved to attempt the most difficult option and sought the support of all three of the investors in order to secure a higher number of doubloons to be paid by the teacher. The doubloons were used in the subsequent task to construct a ship, crew, and supplies for the journey across the ocean. Students debated the options with the rest of their group, made their choices, cashed in their chips, and then began reading the book, anxious to see how the voyage turned out for the crew and ready to evaluate their own selections and purchases from the pre-reading activity. The narrative context of *Treasure Island* became a problem-space that engaged students in classical literature. More importantly, it engaged them in higher-level learning.

In content areas that do not traditionally lend themselves to narrative texts, such as science, educators can seek to incorporate the narrative game dynamic by constructing a storyline that helps unify content, lessons, and units. For example, I worked for two weeks in the company of an educator who has authored a unique, narrative-based science unit called *Bio-Hazard 5* for his junior and senior biology students. The premise of the story is that decades from now, the world is on the verge of a series of environmental catastrophes, so a hero has been sent back in time to solve the future’s problems. He needs help from scientists-in-training, or biology students, who are tasked with helping the hero to master biology modules on everything from abiogenesis to zygotic selection. The same content is covered on the Advanced Placement biology exam.

Educators might consider a similar use of a narrative game dynamic in their own classroom, because in video games and in life, humans find story elements profoundly meaningful (Gee, 2007). Therefore, for learning tasks to be meaningful and engaging to students, teachers must think like game designers and provide a strong narrative, or context for testing out new content, skills, and ideas (Waraich, 2004).
Game Dynamic: Explicit Interconnectedness

Another dynamic that can be readily applied in classroom learning is explicit interconnectedness. Unlike some classrooms, games do not go on haphazardly or by a succession of improvisations (Dewey, 1938). Classroom rules are often designed to maintain order and are perceived by students as restrictions (Thornburg, 2008), but in video games, rules are used to help organize conduct and to orchestrate success. Players see – and utilize – the connections between the rules, game plot, challenges, and solutions (Dondlinger, 2007). Players not only know and abide by the games’ rules, but they defend them fiercely when they are violated by other players.

Some may argue that, in contrast, most of what goes on in schools is disconnected and fragmented (Gee, 2004). From some students’ perspectives, much of what they are asked to learn seems to operate in isolation. Information and skills in one class, for example, are often disjointed and disconnected from subsequent lessons and from concepts taught in other classes. Even when content is interrelated and interconnected, some students struggle to see the association. In a video game, these connections are more obvious, and at times, are made explicit to the learner. Early tasks are designed to lead players to develop skills and knowledge in order to solve subsequently more difficult tasks. Consequently, earlier parts of a well-designed game help learners look forward to later parts (Gee, 2007).

Teachers who adapt a game design mindset must find ways to make the relevance and connections in learning activities more noticeable, if not explicit, to students. For example, educators often utilize curricula integration in symbiotic subjects such as language arts and history in order to capitalize on student learning and to establish connections to the real world (Rennie, Venville, & Wallace, 2012). When language arts and history teachers combine efforts to help students research and synthesize different 20th century perspectives on women’s suffrage, instructors must also underscore and clarify how curricula are being integrated. This can be accomplished with teacher-student interaction before, during, and after learning activities in the form of assignment overviews, discussions of standards’ alignment, or opportunities for assessments and projects that address the content of two or more subject areas (Hudson, 2012).

Game Dynamic: Well-Ordered Problems

Teachers can also seek to help students develop greater expertise in a subject or area through well-ordered problems. Game designers consciously orchestrate and sequence learning activities so that they build upon each other and interweave with previous and future concepts. As a result, progressive, repeated cycles of challenges force learners to think again, learn anew, and develop hypotheses that work well for more difficult challenges later on (Bereiter & Scardamalia, 1993). Gee (2008) explained that easier initial problems offer opportunities to respond to problems consciously designed by teachers to facilitate the discovery and encourage the practice of fruitful
patterns and generalizations in regard to the skills and strategies that learners are developing.

In games such as *Halo* and *Pikmin*, for example, players are confronted by challenges that alternate practice with new trials of increasing sophistication, thereby producing an incremental learning curve as the game progresses (Gee, 2007). Teachers seeking to implement a game dynamic of well-ordered problems must design curriculum with a range of challenges that allow students to operate and explore in slightly different parameters (Koster, 2005). In addition, the design and sequence of these problems should force participants to develop the ability to learn, to reflect, and to integrate old abilities with new challenges, rather than asking them to engage in rote memorization or simple comprehension (Dondlinger, 2007; Gee, 2007).

This year, I visited an eighth grade classroom that utilized the game dynamic of well-ordered problems. Students pretended to be planetary scientists who were investigating two newly discovered, fictitious planets made by their teacher out of Styrofoam, plaster, clay, and paint. The teacher explained that their class was tasked with determining if human life could be supported on either planet. To make this determination, students were first introduced to actual satellite photos of Earth. They then worked to determine what oceans, clouds, and various land habitats look like from miles above our planet’s surface. The following day, the teacher encouraged the class to investigate the “new” planets’ surfaces. Students worked in teams to formulate hypotheses about whether the observed colors and textures on the new planets might indicate water, forests, deserts or some other type of terrain. In the days that followed, similar, but increasingly difficult, activities were conducted to compare the Earth’s atmospheric composition and temperature with that of the two new planets. Finally, each student compiled a scientific report, supported by evidence collected throughout the week, with a hypothesis of each planet’s ability to sustain human life. Much like a well-designed video game, the Planetary Scientist activity was orchestrated to ensure that students surmounted a series of challenges and that they experienced the degree of success on each subsequent level that proved essential to achieving their final goal (Koster, 2005).

**Game Dynamic: Control and Choice**

Another motivating aspect of games is a user-centered design that arouses a player’s interest to exercise control over the outcome via the choices a player makes (Clark, 2003). Such control is a key to motivating students as they endeavor to direct and evaluate their efforts (Hattie, 2009). While games are designed by developers, they are set in motion in any particular direction by players in terms of affordances or choices offered by the game (Gee, 2005b). Whether they are carrying out a military mission in *Call of Duty*, solving a puzzle in *Tetris*, or harvesting resources in *Minecraft*, players exercise control in order to carry out and achieve their goals. Learner motivation results from an interplay between desire and pleasure – the desire to be competent and the resulting pleasure when one is (Dondlinger, 2007).
In this way, video games have a built-in advantage in the creation of motivation for extended engagement (Clark, 2003). Whether they are in a game or in a classroom, learners are more likely to take risks and try out new skills and strategies when they are able to make choices and exercise control (Harvey & Goudvis, 2000). When applying this game dynamic in the classroom, educators should keep in mind that outcomes are consistently higher when students have some degree of control over their learning (Niemic, Sikorski, & Walberg, 1996). Curricula designers and instructors can utilize a control and choice game dynamic through pacing, time allocations for mastery, sequencing and pacing of instructional materials, and choice of practice items (Hattie, 2009).

Video games also tend to be motivating because the choice of game genres allows individuals to pursue challenges based on their own perceived strengths and interests. Genres include strategy, action, adventure, shooter, sports, puzzle, and role-playing games. People who invest time and money in a game have usually selected it based on a variety of criteria that correspond to their aptitudes and personality (Koster, 2005). Effective instructors could adapt this principle by finding opportunities for students to make choices regarding what they learn, how they learn, or how they demonstrate understanding (Benjamin, 2006).

Curricula designers and implementers can incorporate this game dynamic by creating opportunities for choice and control throughout the learning activities offered to students. In a science class for example, two very similar assignments could be constructed for separate informational texts of comparable difficulty, one on nebulas and another on black holes. Students could then be encouraged to choose between topics, while still completing the same learning objectives as their classmates. Choice could also be extended in the means by which students are assessed. For example, performance assessment, portfolio, or other more traditional formats could be used. As a result, the role of the instructor would become more facilitative and permit the learner to exert more control over learning outcomes (Reynolds & Trehan, 2000).

**Game Dynamic: Customization and Co-Design**

Video games also possess the unique ability to extend control and choice to learners through *customization* and *co-design*. Customization in games means that players are able to adjust the game to accommodate their own interests, style, and objectives. Gee (2007) observed that classrooms adopting this principle would allow students to discover their favored learning styles and to try new ones without fear. In the act of customizing their own learning, students would learn a good deal about their own thinking, reflection, and ways of solving problems.

For example, I recently observed a ninth grade math teacher who started class by asking her students to help her determine how many stars exist in the known universe. She explained that before looking at any formulas or equations used by other mathematicians, she wanted to hear how her students might go about solving the problem and insisted that there were likely several valid approaches. Students were
given the option of working alone or with others, and then they spent time formulating responses. The class period was spent sharing, evaluating, and revising various approaches created by students. The following day, students were asked to self-select a station where they could review the theories of accomplished scientists either by listening, watching, or reading excerpts of commentaries by various astronomers and mathematicians. Students then worked at their stations to discuss and critique the various theoretical approaches. The instructor pointed out that the experts in the field utilized different approaches to solving the problem and that many disagreed on the estimated number of stars. In this way, her students learned that this activity’s design was not to achieve a single “right” answer in mathematics, but rather to pose questions, explore, analyze, and develop the ability to reason. Be it in math or other content areas, teachers can work like game designers to create opportunities for reflective learning, developing strategies, and selecting learning styles appropriate to specific learning tasks (Coffield, Moseley, Hall, Ecclestone, & Hall, 2004).

Video games also utilize the game dynamic of co-design to ensure that players feel like active agents and not just passive recipients (Gee, 2005a; Li, 2012; Olsafsky, 2006). Effectively designed games provide players the opportunity to create, to author, and to shape (Koster, 2005); their choices and actions have a significant impact on the direction and outcome of challenges placed before them. In a classroom, co-design could take the form of students’ ownership, buy-in, and engaged participation. Students would come to understand the design of the domain they are learning so that they might make choices to improve what and how they learn (Gee, 2007). This comes in stark contrast to the frequent intellectual dependency that is too often found in classrooms in which students must wait for teachers to tell them what to do (Gatto, 1992).

**Game Dynamics in Schools**

While the use of games and game dynamics in schools appears to have a highly positive impact on student learning (Ke, 2009), a few cautions and considerations must be kept in mind. The first is that there is a tremendous lack of knowledge amongst the majority of educators regarding how to best utilize games and game dynamics (Mishra & Koehler, 2006; Pivec, 2009). Even when teachers are willing to incorporate game design into their lessons, research, techniques, and suggestions are rarely published in journals commonly read by educators (Pivec, 2009; Sprague, 2004). Gaming and education tend to operate independent of one another, but future collaboration between the two is likely to have a positive impact on our students. As a result, it would be wise to consider ways to foster more strategic, disciplinary, and collaborative research between game designers, curriculum developers, and curriculum enactors (Tzuo, Ling, Yang, & Chen, 2012).

Unfortunately, despite recent interest in game-based learning, teachers are most often trained in methods that traditionally focus neither on games nor game design as a part of the curriculum. As a result, it is mostly researchers and a handful of innovative educators who are willing to utilize games and game design (Pivec, 2009). Even when games and simulations mesh well with curriculum, studies continually underscore the
need to use video games to supplement traditional lessons, rather than to supplant them (Egenfeldt-Nielsen, 2005). Mitgutsch (2007) further argues that it is not the game itself, but the interaction surrounding the game that truly promotes learning. Therefore, it is imperative that teachers and curricula designers embed games and game dynamics as part of larger experiences and constructive activities, often through dialogue, reflection, and debriefing (Garris, Ahlers, & Driskell, 2002; Koster, 2005). It must also be noted that research regarding the use of games and game dynamics in schools is fairly new and extremely varied – sometimes even contradictory – in design, methodology, context, and results (Druckman, 1995; Egenfeldt-Nielsen, 2007; Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Much more robust, empirical research is needed, particularly studies that attempt to narrow down the types of game dynamics that prove to be the most effective with certain types of learners and in certain contexts.

Despite these concerns, the question is no longer if games impact learning, but rather how they do so. More importantly, how can those of us designing and implementing curricula affect learning? The answer most likely centers on game dynamics: the heart and soul of game design (Tobias & Fletcher, 2011). Getting inside of a game – how it is designed and executed – could be a key to engaging students and sustaining their learning. Lately, in an attempt to glean from the learning principles embedded in video games, I have brushed away some of the cobwebs and tried to play some of the video games that are the most popular with my students; then I worked to compile a list of strategies employed by the game itself that helped me “learn” to play. At times, it seems that game designers may be more adept at supporting learning than some teachers. Game designers appear to recognize that learners, or players, persist longer in learning tasks, even difficult ones, if they are enjoying the challenge at hand.

Teachers and curricula developers might benefit from thinking like game designers and considering the nuanced features of games (Khoo & Gentile, 2007). By consciously interweaving game dynamics – immersion, narrative context, explicit interconnectedness, well-ordered problems, control, choice, customization, and co-design – teachers might successfully transform the interest of a learner into motivation, problem-solving, and critical thinking. In the classroom, stakes for learning are higher than ever (Friedman, 2005; Lipman, 2003); yet, right now, too many students fail to learn and, eventually, learn to fail. There is currently an unfortunate distinction in schools between games and education. Humans are wired for learning, but they are also wired to play (Alexander et al., 2009; Ortlieb, 2010). As educators, we should consider game dynamics as a way to help our students do both.

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