Why Should Game-like Learning Be Part of Senior Math Pedagogy?

A Literature Review

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Introduction

The question that inspired the following document is the same as the title: why should game-like learning be part of senior math pedagogy? Research also considered whether well designed games offer alternative experiences that both teach and inspire learners. This paper explores several aspects of currently accepted common and best practices used in secondary school classrooms, and relates those practices to the guiding principles of game-like, or game-based, learning.

Research includes a wide variety of sources, from blogs to scholarly papers, videos to textbooks, and was far from exhaustive. While resources do not necessarily fit the narrow definition of "scholarly", the expertise is abundant and well documented, especially in video and audio format.

The conclusion of this literature review has been that game-based, or game-like, learning has an overwhelmingly positive effect on learning and learners. Including game principles in lesson design embraces many elements of current pedagogical best practices and should, therefore, form a substantial part of the tools employed by educators, including those active in secondary math classrooms.

Games, Play and Human Evolution

According to Ian Schrieber (2009) "a game is a play activity, with rules, that involves conflict". On reflection, one should remember that conflict does not necessarily mean a physical confrontation - as in a battle - but could refer to an internal conflict, or any struggle to make progress. Conflict could be a clash between one's current abilities and the desire to achieve some goal.

Games and play are an intrinsic aspect of human psychology and growth. In fact, in times of extreme duress, role playing and escape to immersive creative constructs can be a matter of survival. Ethel Rogers Mulvany survived three years in Singapore's Changi prison, from 1942 until she was released at the end of World War II. Her story, and the stories of all those others with whom she was imprisoned, is one of extreme deprivation and starvation. One of the ways the inmates of Changi survived was through participation in an imaginary meal. Women would gather daily to take turns imagining and describing a "perfect" dinner, including centrepieces, napkins, china, guests and, most important, the menu. Ethel Mulvaney collected over eight hundred of the recipes created in those gatherings and later released them as a cookbook, proceeds of which went to supporting former prisoners of war (Siegel, 2013).

Listening to the description of the daily gathering, one is struck by how much the womens' retreat into imagination emulates a role-playing game. The immersive nature of role playing allowed participants a brief escape from the difficulties of their actual existence. Play is powerful.

According to Jane McGonigal (2010), as of 2010, about three billion hours per week were being spent on video gaming, while Constance Steinkuehler (2015) suggested that there

may be more people gaming in the total population than otherwise. Games can be used to combat anxiety and depression, and to help prevent post traumatic stress disorder (McGonigal, 2010).

Defining Game-based and Game-like Learning

Gaming is, in general, collaborative problem solving. It allows young people opportunities to engage in real world experiences without real world risks. During a game, players are given immediate and constant feedback, sometimes even experiencing the death of a character - multiple times in various ways. Virtual stakes are high. Assessment is constant (death is an epic fail) but unlike traditional tests, where determining progress takes place apart from the actual learning activity, players are not focussed on the fact that they are being assessed - they are just trying to save the world (Gee, 2008; McGonigal, 2010) .

Game-based learning (GBL) is the process of incorporating game features into lessons as part of a teaching strategy. According to the Centre for Teaching Excellence at the University of Waterloo, in their article regarding gamification and game-based learning (2018), GBL can include designing a story line around which a learning strand is developed, and opportunities to level-up as increasingly more complex problems are mastered. The first level of a game is the tutorial, in which players discover the techniques and rules of the game world. In a well designed game, the process of pre-teaching should not be needed. Completing each level means facing a boss, the point at which all of the learning comes together and is necessary to defeat the bad guy (overcome a hurdle). On the way, players recruit allies (collaboration) and acquire new power ups (skills and coping mechanisms). After they defeat that boss, players have the amazing

reward of - an even more challenging task! Then they are given even tougher hurdles to surmount (Farber, 2013; McGonigal, 2012).

Game-like learning (GLL) is the term used by the Institute of Play (n.d.) to describe a blend of game and learning design they have developed to help shift the constructs of traditional learning to a more play based structure. A third type of gaming implementation used in classrooms is gamification, wherein features of games such as badges, experience points and leaderboards are used to inspire learners and track their progress (University of Waterloo, 2018). The focus of this preliminary research has been on GBL and GLL.

Game-based Learning

Why Games?

Katie Salen (2013) talking about the power of game based learning, mentions one of the concerns parents have around gaming in the classroom: the "addictive" nature of games - once they start playing all they want to do is get better, and better and better, which leads one to ask "Is that a bad thing when it comes to learning?"

People who have engaged in, or participated in, or closely observed others playing, well designed video games are aware of the potential for complete immersion in the virtual world of the game. The real world ceases to exist, and all of one's senses are focused on the task, or tasks, that must be accomplished in order to prepare for, and master the final test - the Big Boss! The intensity of the immersion can be alien to those who have only passing exposure, but to players, it is very real. In fact, when in that state of complete immersion, the real world becomes the world of the game. Everything else, including food and sleep, falls away. This is the state of flow. It is part of what allowed the inmates of Changi to mentally step outside the physical

confines of the prison, and the misery of daily life, to go to a better imaginary place, where they could exhibit some control, and show their abilities with pride and confidence. As an educator, finding ways to harness the uninhibited and enthusiastic nature of flow and direct it to specific outcomes, as in a senior mathematics classroom, seems desirable.

Jane McGonigal, in her video lecture "Truths and Myths in Gaming" (2012) points out that describing video game play as a waste of time is inaccurate. Rather players are learning "resilience, grit, determination, having epic ambitions and the ability to collaborate (sometimes with thousands of others)" (McGonigal, 2012).

James Paul Gee (n.d.) provides thirty six different principles around which game design evolves. Echoing Gee's principles, McGonigal (2019) refers to having a "gameful mindset" which has seven guiding characteristics (list adapted from Gameful Mindset, n.d.).

1. The expectation of constant feedback.
2. Willingness to accept failure as part of learning.
3. The ability to repeat until mastery is achieved.
4. Awareness of "just in time" understanding - learning occurs during play as and when needed, neither before nor after.
5. Grit (self-efficacy): the belief that success will come through hard work and determination.
6. Flow: complete immersion in the task, to the exclusion of all else.
7. A tendency to appreciate play and to want more.

In McGonigal's words, part of having a gameful mindset means being aware that "something good could happen, if you take an action". If you believe that you can succeed, and

are persistent, then - certainly within the gaming environment - progress is made. Furthermore, progress is evident when a player "levels-up", demonstrating mastery of new skills. McGonigal says that research into players with a gameful mindset shows that gamers carry their new skills into the real world; some of these skills include communication, collaboration, determination and problem solving (McGonigal, 2010). Social games, such as Fortnite, League of Legends, or World of Warcraft, where millions of players are interacting, are vehicles for building trust, dependability, collaboration skills and social support networks. Reading wikis and forums shows that connections and skills spill over into real world relationships, where players offer one another help and support in their real lives as well as in their virtual lives. Active participation is a necessary component as, according to McGonigal, if games are played for escapism (to avoid dealing with real problems) then the player sees the gaming as separate from reality and skills learned remain in the game. McGonigal suggests that players seeking escape are more likely to become compulsive players (addicts) (McGonigal, 2019). McGonigal compares the connections between gaming and gambling, especially the belief that you will, if you keep trying, eventually succeed. The big difference is that with video game play, the premise is true. Eventually you will win. Gambling games are designed so that the eventual outcome is overall loss, while video games must be designed for ultimate success. The result, in games, is a positive feedback cycle: "try, progress, improve, develop, win" (McGonigal, 2019).

Modifying, or modding, a game is an important feature of good game-based design. Players should be able to change aspects of a game to explore a different idea or go deeper than the original designer planned. The ability to mod encourages research, trial and error (Gee, 2008; Gee, 2012; Farber, 2012; Institute of Play, n.d.; Marquis, 2012). Designers can choose an

existing game and mod it to adjust outcomes that suit different requirements. Gee's Insider Principle says that in GBL, the learner is not only a player but has an active part in the design process when provided with the opportunity to modify (Gee, n.d.). The Institute of Play suggests that a good way to start using game-like lesson design in the classroom, or to start designing, is to take an existing game and modify it to create a new game (see Appendix A for an example of modding a card game).

McGonigal's work showcases the social and personal skills being instilled in gamers, while Constance Steinkuehler and Kurt Squire (2015) connect gaming directly to science and math skills. Connections to science are fairly obvious, given the frequency of science fiction universes as in Half Life, or StarCraft. Some science based games, like Portal, encourage players to develop a greater understanding of physics in order to push their playing to higher levels. Steinkuehler points out that the characteristics of successful game play closely parallel good scientific habits: state a hypothesis, run trials, track data, test outcomes, peer review. In a game, that might look like: find a problem, tackle it, observe results, change something, compare results with peers. Games like World of Warcraft (WoW), a massive multi-player online role playing game (mmorpage), and Portal (a puzzle solving game) lead to the creation of large collaborative communities outside the game, primarily in wikis and forums, where knowledge from inside the game is shared and outside knowledge (frequently requiring deep research and synthesis of new information) is used to improve game play. Analysis by researchers at the University of Wisconsin - Madison (UWM) of the forums of WoW, where players converse while participating in the universe, are showing that players are engaging in model based reasoning (systems analysis and model building), which are aspects of senior mathematics.

Players (and designers) must develop skills in pattern detection, problem solving, analysis and understanding - foundational mathematics. (Salen, 2013; Squire, 2013). Squire also says that video games are useful for getting people interested in generating and working with datasets - more math (Steinkuehler and Squire, 2015). In the WoW wikis, Steinkuehler observed multiple instances of advanced mathematics, especially the use of statistics and probability - including collection, collation and analysis of data. Researchers addressed the possibility that their results were from a small population of very clever (genius?) players, but determined that the group intelligence was actually greater than the learning level of the most advanced group member (Gee, 2008; Squire & Steinkuehler, 2015).

Kurt Squire has been involved with designing games that address specific science outcomes such as: how do viruses work in the human body and how do cells grow? Research concluded that, even using traditional assessment methods, the gamers had an average 11% increase of total knowledge when compared to learners who used traditional textbook techniques (Squire & Steinkuehler, 2015). Other research at UWM is showing that learners who play before they encounter traditional textbook learning are understanding more than those who do the reading before they play, and text and gameplay outcomes are significantly higher than traditional text and diagram outcomes; based on pre- and post- test score analysis

There is also power in player learning communities due to the unstratified construction of teams and guilds. Players form alliances because of similar interests and a desire to build new skills, not due to fields of expertise or age. In fact, successful groups are a heterogeneous mix that Squire refers to as “pro-am” meaning professional and amateur, while James Paul Gee (2008) calls them“passion communities” because they consist of all ages and all skills, united by

their passion. Since age is not a consideration in the online groups, young players are being able to try adult roles in planning, organization and leadership to a degree that could never happen in the real world. Mentoring occurs when it is needed - just in time - and comes from the closest available expert, regardless of real world considerations like age, race, gender or socio-economic status (Squire, 2013).

In a gaming universe, from the moment a player enters the game, they are automatically entrusted with the task of saving that virtual world from some colossal menace, and infused with the belief that, of course, they can do it. Tasks are matched to a player's current skill level so the game's belief in the player's ability is quickly, and frequently, supported - but the challenges are also just tough enough that a player has to respect the game's assessment of their potential. Nor is a player expected to save the world alone, for in a game like WoW, or Fortnite, there are thousands, even millions, of others who are willing to help you to succeed. Through those experiences, gamers become "the best version of themselves", motivated to take action. In game, they willingly help others, are resilient and determined to succeed, whereas in their real world selves, they might meet adversity with cynicism or frustration, become easily overwhelmed or anxious. The result is that players develop a sense of "urgent optimism" - a need to take action, and the belief that one can (and will) succeed. (McGonigal, 2010) .

Given the observed effects of learning while involved in video game play, one might consider the instant option of using existing commercial off the shelf games (COTS) instead of going to the work of building one's own GBL lessons. Using COTS can be a good idea, but should only be considered part of the picture. The problem, according to Kurt Squires (2013), is that COTS games, including ones that are called educational, do not always do a good job of

exhibiting knowledge of content, nor do they necessarily embrace accepted pedagogy. Justin Marquis (2012) says that COTS are lacking intellectual content, but designated 'educational' games are seldom as engaging as commercial games. In order for COTS games to be as effective as outcomes based games, all areas of interest must be involved in their design, including (but not limited to): social skills experts, philosophers, content specialists, players and game designers (Squire & Steinkuehler, 2015). The middle ground, where engagement, motivation and content are all high, is game based learning. It is "more powerful than traditional teaching" and learners can "embrace experiential learning in virtual space" (Marquis, 2012).

Squire participated in the design and roll out of Citizen Science, where players are Econauts, an ecological science exploration game where players determine how and why lakes become eutrophic. Participants experience talking to scientists, loggers, developers, and other citizens. Econauts run virtual experiments and collect and analyze data. Post play analysis shows that students who take part in playing the game are demonstrating greater understanding of the science than those who do not have the opportunity to play. Other research at UWM has looked at the effects of gaming on development of language and literacy. After fifteen years of research, the incidental learning effects of non-directed game play is showing exceptional results, especially with English as a foreign language learners. Research at UWM is also finding that players are demonstrating greater interest in pursuing science education and science related careers (Squire & Steinkuehler, 2015).

Squire (2013) points out that games can provide a gateway into complex subject areas. Players engage in critical thinking, observing how they can make change within a virtual reality and then wondering why the real world is at is; questioning political systems and assumptions,

economic systems and social constructs. Squire sees the challenge as one of figuring out how to design games that use the same thinking and interaction of video play, yet also direct players to work toward solutions for real world problems. Gamers already have a growth mindset (see p. 18) and an inclination to want to improve the world around them. Squire advocates a "fundamental re-think of how we do education" in order to incorporate these - and other - characteristics of the game playing community (Squire, 2013).

In summary, according to James Paul Gee, GBL is problem solving that includes lots of opportunities to fail and try again. It incorporates frequent tests, but in a game a test is called a boss level and it's fun. Feedback is constant, and teaching is just-in-time, neither too soon nor too late, and not at all if it isn't needed. The level for demonstrating success is high, lots of feedback is provided but excuses are not accepted. Tasks are not, in Gee's words, "dumbed down" for players, but encouragement, mentorship, and opportunities are provided to guide every player to succeed. (Gee, 2008).

Game-like Learning

Game-based learning is very similar to game-like learning, as discussed in the definition provided earlier. The primary difference appears to be the simpler, more condensed nature of GLL, and the absence of digital technology as a requirement for game-like design. GBL is not dependent on technology, but use of, and reference too, technology is prevalent in the GBL literature.

Katie Salen, executive director of design at the Quest to Learn school in New York, describes one of the goals of GLL as taking the learning that is happening in the digital lives of

students (as described above in GBL) and incorporating that learning into a more school-like environment. The result is a play based learning program for grades six through twelve.

Students are put into challenging situations (missions) with no hope of success at first. The mission is broken into smaller, achievable challenges (quests) that are just complex enough to be engaging, and completion of which will provide necessary skills for tackling the next quest. The result is that learners are always aware of their former limitations, what they now know as a result of their efforts, and what they wish to accomplish - building on processes that learners already know from gaming outside of school. In games, incentives are provided to encourage progress. Incentives can be as simple as bragging rights for what level one has achieved. Each level must be mastered before the next level opens up. At Quest to Learn, curriculum is built on that platform. (Salen, 2013).

The Institute of Play, a non-profit organization dedicated to creating learning opportunities based on both educational strategies and game design, has produced several excellent guides to the GLL design process. From the Games and Learning guide we find that GLL design incorporates seven learning principles (adapted from Institute of Play, n.d.).

1. Everyone is a participant: each player must provide an active contribution, incorporating multiple skills and diverse skill levels.
2. Failure is reframed as iteration: each attempt is a test of the learner's ability and provides an opportunity for growth in order to prepare for the next attempt. The process is fail, fail again, fail better, and eventually - succeed (Q Design Pack, n.d.).

3. Learning feels like play: lessons are centred on the learners, are creative and designed to inspire exploration and curiosity.
4. Learning happens by doing: learning opportunities develop more effectively through experience. As when incorporating scientific method: a hypothesis is proposed and tested. The results direct the learner's next steps.
5. Feedback is immediate and ongoing.
6. Challenge is constant: the opportunity for success should be at the outside limits of the learner's skills, neither too difficult nor too easy.
7. Everything is interconnected: learner's achievements should be published for sharing - within the school community, or the larger community.

In designing both lessons and curriculum, planning should include much the same processes as required to make a successful game-based lesson. In the Q Design Pack (n.d.), lesson designers are advised to engage in "design thinking". Work with a team. At the Quest to Learn school, game-like experiences are constructed by collaborative teams of three experts: a curriculum designer, a game designer and a teacher (Q Design Pack, n.d.).

As with regular lesson planning, be aware of the people for whom the game is being designed. Then, with the curricular goals (ideally derived from BC's new core curriculum) or learning outcomes in mind, design the learning experience.

The main aspects to the game-like design process include goal, challenge, core mechanics, components, rules and space. Goals (learning outcomes), and a challenge (the big picture end result) come first (see Understanding by Design, p. 16)**.** Core mechanics are described through verbs and are the actions that players will take. Components would be defined

by nouns and are the items that a player might use to accomplish tasks. Rules can be broken down to if - then statements, and declarations of permissible or non-permissible actions. Space considers where the game will be played, for example: in a classroom, online, or even in the greater community (Q Design Pack, n.d.).

Learners need multiple ways to access and express their ideas, and opportunities for collaboration. Collaboration allows players to recognize and share their specific expertise and develop their ability to communicate their understanding. Good design will create situations in which co-operation and collaboration are necessary for success. GLL will teach learners to "take charge of [their] own learning and be able to control [their] own learning throughout life (Salens, 2013).

Games should be transferable, not limited to a specific classroom or school, but open for use in broader environs. Break each major outcome into multiple smaller portions which become levels. Each level should have a challenging task at the end to showcase the learner's progress, and demonstrate their mastery of each learning goal. Ensure that the design does not allow the player to proceed to the next learning outcome until mastery of the current skill has been achieved. The beta design product must then be play tested and assessed before release to a classroom.

Beta testing is done by the audience for whom the game was designed: potential players. The testing players should be of varying levels of ability to ensure that differentiation is built into the game, so that students of all abilities can take part. Being chosen as a beta tester could be a reward for accomplishments, achievements, or other desirable behaviours. The beta testers can also become the classroom experts when the game is first implemented.

Constructive feedback must be part of the testing process. Ask players to discuss what they liked best, what they would change, what other features they would consider, and make sure feedback is documented for consideration in the next iteration of the game. The same rules apply to design as to play: expect to fail, and plan to do better on the next iteration. Repeat the process of fail, re-visit and test until the final product appears to be complete.

Designing and implementing a game from concept to implementation will take between four and six weeks. Even after all that planning, the first time a game is used in a classroom setting, play may not proceed quite as expected. Be prepared to make adjustments. Learn by observing, and be flexible. Have students reflect on the game, and record your own reflections on the roll out for consideration during the next iteration or the next game.

Game play can be used as assessment (Gee, 2008), and carefully constructed feedback can also be used as assessment (Q Design Pack: Games and Learning, n.d., p. 35).

For new designers, the Institute of Play suggests that one starts very simply - with a modification of an existing game, or a very simple game. A reasonable goal is one new GLL objective, or modification of an existing game, per year.

Connections to Current Practices

Chunking

Both GBL and GLL require breaking larger goals into smaller tasks, permitting learners to experience frequent, small successes, providing scaffolding and feedback to inspire greater achievement. In traditional classrooms, this is often called chunking. As far back as 1956, George Miller, in his paper on memory and recall, observed that, from a psychological perspective, memory could be considered a matter of coding data into small, easily retrieved,

related chunks. The brain's ability to break up large amounts of information into smaller portions makes it possible for learners to remember more for longer (Miller, 1956). On this basis, and further research, educators began to employ the method of chunking in lessons to help students retain more. "Chunking" is the process of breaking a lesson into smaller, related mini-lessons, permitting processing between chunks, and has become a common practice in learner-focussed classrooms at all grade levels, including secondary mathematics.

Understanding by Design

Also referred to as Backward Design, Understanding by Design (UbD) suggests that the best design starts with the end result as the focus. What do students need to know? From that starting point the designer selects appropriate means of providing evidence of learning and then learning activities are designed that will help students to achieve the predetermined outcomes. UbD is a commonly used approach to instructional design in all educational environments (Pesavento, Macasaet, & Wagstaff, 2015). The UbD theory is based on seven principles (paraphrased and condensed from McTighe and Wiggins, 2014):

1. Learning is enhanced when teachers think purposefully about curricular planning.
2. UbD helps to provide focus on the effective use of content knowledge and skill.
3. Understanding is revealed when students make sense of and transfer their learning through authentic performance. Six indicators of understanding: the capacity to explain, interpret, apply, shift perspective, empathize and self-assess.
4. Curriculum is planned backward from long-term desired results.

5. Teachers are coaches of understanding, not purveyors of content knowledge, skill or activity. Regular review of curriculum against design standards enhances curricular quality and effectiveness.
6. The UbD framework reflects a continual improvement approach to student achievement and teacher craft.

Both GBL and GLL designers refer to backward design, and its importance for effective educational application of gaming principles. The culminating activity, or Big Boss Level in a GBL lesson, has to be the focus of all the previous tasks, since their purpose is to prepare the learner for that final interaction with the material. Considering the six indicators of understanding during the planning process would also be helpful in designing variety and ensuring multiple ways for learners to demonstrate learning.

Backward design emphasizes the role of the educator as coach, while GBL educators admonish teachers to become facilitators, guiding the learning and managing the interaction, but not inserting themselves into the game play.

Grit

Grit is one of the more recent power words in education. It is characterised by overcoming adversity over the longer term, working hard to conquer challenges even when faced with failure. When learners discover that confusion and mistakes, are part of making progress, and are able to develop patience with the time it takes to master skills and concepts, they are developing grit. Grit is one of the leading predictors of success for university students, even more than exam scores (Bashant, 2014).

Growth Mindset

Carol Dweck's work on growth mindset over the last thirty years addresses the differences between "fixed" and "growth" approaches to learning. A growth mindset means the learner believes that they can improve through their own efforts. Success is not dependent on others, nor is failure the result of outside influences, but rather an opportunity to diagnose weaknesses in a skillset, and then to improve. Growth mindset is directly parallel to the GLL idea of iteration, repeated attempts with improved knowledge from past failures will eventually lead to success. Jo Boaler (2016) refers to work by Moser, Schroder, Heeter, Moran and Lee from 2011, in which it is hypothesized that the process of struggle - encountering an almost insurmountable hurdle, and successfully striving to overcome it - causes the human brain to physically grow, forming new neural connections. Thus, having a "growth" mindset becomes a literal truth. In order to achieve growth, challenges can not be too easy, and scaffolding must be minimal. Easy questions with binary answers do not encourage growth, either. Challenges must be hard enough for learners to fail and try again before succeeding. Traditional education with its focus on standards and a "right" way to perform mathematics in particular, interferes with the confidence, creativity and perseverance necessary to grow our brains (Boaler, 2016).

There is a close connection of growth mindset theory to GBL and GLL. In the seven principles of GLL, iteration (the process of failing, and then failing better) and the need for constant challenge are contained in growth mindset (Institute of Play, n.d.), and in GBL a growth mindset means being willing to accept failure as part of learning, and having the belief that success is the result of hard work and determination (McGonigal, 2019, Gameful Mindset, nd.).

Conclusion

Urgent optimism is Jane McGonigal's way to describe the extreme intrinsic motivation that is taking place when a player is fully engaged in a game. She describes it as the desire to respond instantly to a challenge, with expectation of success. Succeeding is not only possible, achieving it is worthwhile, and the time to start is immediately (McGonigal, 2010). Junior mathematicians seldom exhibit urgent optimism in a classroom, and yet many of them are practicing more challenging mathematics at play than they are at school.

Steinkuehler and Squire (2015) show that senior mathematics is already being used in the gaming world, on a voluntary basis, for achieving real outcomes - the benefits of which can be immediately seen in the gaming world. As a math educator, one is acutely aware of the difficulties of making advanced mathematics (an abstract pursuit) into an experiential opportunity. If players are pursuing complex mathematics as a method to solve real problems in a virtual universe, then understanding the necessity of mathematics becomes more real, and ironically, the learning becomes less obvious. Nowhere in the depictions of GBL or GLL in action did the question "when will I ever need to know this?" arise. The next step is to purposefully direct the incidental learning that is already taking place in order to achieve specific curricular outcomes.

The choice to explore both GBL and GLL grew from considering the exigencies of working in a comparatively small, relatively isolated, high school with limited resources. GBL, as noted above, tends to be more directly related to electronic games, which necessitates access to technology. Technology is expensive, and also, while the use of electronic tools is not a

deterrent to this educator, can be daunting for teachers who are not inherently immersed in the computers and devices domain. GLL, on the other hand, includes the characteristics of GBL but opens the GBL design process to include other, equally relevant, methods of play.

One possible limitation of GLL is in implementing the wise advice of the Institute of Play (Game like learning principles, n.d.) that a three person team consisting of diverse expertise (game design, curriculum design and pedagogy) be the core of building GLL opportunities. In smaller schools, having access to all three skill sets is highly unlikely. However, in keeping with Steinkuehler's observation (Squire & Steinkuehler, 2015) regarding the advanced math levels in WoW wikis, the creation of GLL professional learning communities (PLC) might be a solution - the combined abilities of individuals within the PLC would exceed the knowledge of even the most capable participant. Furthermore, Kurt Squire (Squire & Steinkuehler, 2015) advises that building a board game for beta testing is a necessary step in designing an educational video game. The creation of GLL lessons does not preclude a GBL opportunity but rather can be considered a stage in the process if one wants to pursue GBL. Well designed GLL adventures could even be passed on to others for porting to the digital world.

Introducing gaming into senior math classrooms can lead to more engaged, motivated learners. Using design processes provided by the Institute of Play, and seeking out like-minded individuals with whom to collaborate, can improve the culture and quality of learning in a senior math classroom. GBL and GLL incorporate current best practices for educators; the challenge is obvious, the time for change is now, and research shows clearly that there is a reasonable chance for success. Jane McGonigal would ask "What are you waiting for?"

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Appendix A

Modifying Existing Games: An Example

Pyramid Solitaire is played by building a pyramid of cards face-up, starting with one card. Then each row is one card wider, laid overlapping the previous cards until seven cards are in the bottom row. All face cards have a value of ten. Play involves working through the remaining deck, looking at every third card. Every time the player can make a sum of thirteen, the cards used to make the sum are removed from the pyramid. Multiple passes through the deck are allowed until there are no more possible thirteens at which time play ends. The goal is to remove all of the cards from the pyramid. Possible modifications are endless: change the sum, require a product, have students find a difference instead. Make the pyramid bigger, or smaller. Play with a partner, play in teams against another team using two decks and assigning points for each correct pair.

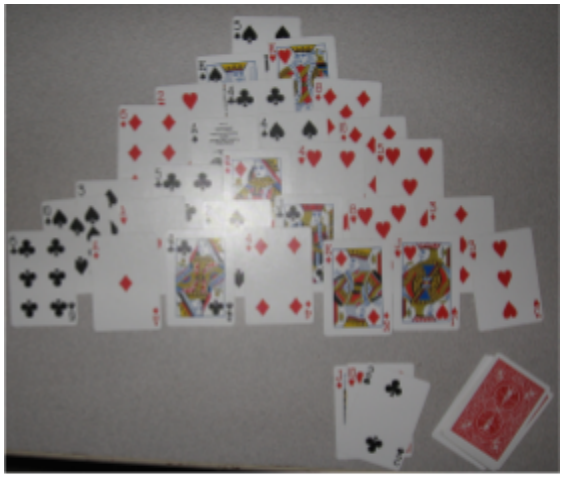


Photo from personal collection.

Addenda: Inclusion and Expansion Items for Next Iteration

Social Constructivism

Social constructivists determined that teaching and learning is a "complex interactive social phenomenon between teachers and students" (Picciano, 2017, p. 170). Leaders of the social constructivist school of thought include Lev Vygotsky, John Dewey and Jean Piaget. One of Piaget's advocates, Seymour Papet, working in computer programming, developed the concept of interactive communities where problem solving involving cross curricular content was the focus. The attention to the interactions between all participants in a learning community becomes particularly important when designing for learners working at a distance (Picciano, 2017).

Experiential Learning

Instructional Design For Blended Learning

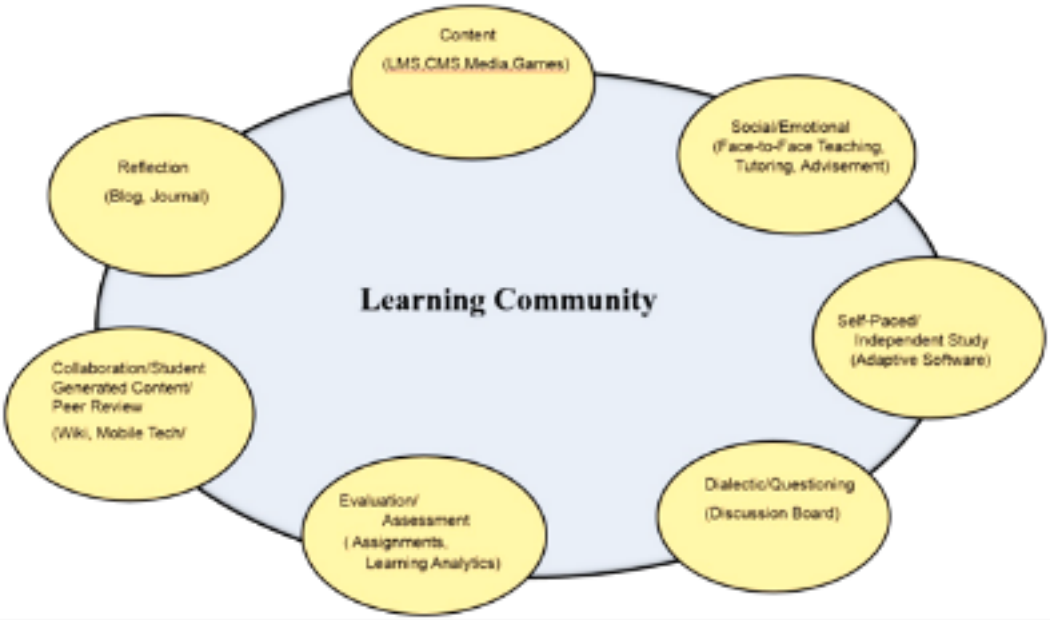
The Multimodal Model

In 2011, Terry Anderson provided the basis for a model of instructional design specifically for online learning. He hypothesized a layout that was community centred, knowledge centred, learner centred, and assessment centred, with some similarities to Amy Garrett Dikkers' work on the social aspects of K-12 learning (Anderson, 2011; Garrett Dikkers, 2018). Picciano (2017) built on Anderson's work to create a framework that could specifically be used for instructional design in a blended environment. Picciano's model is modular,

allowing for the instructor/designer to include and exclude, or adapt elements depending on the mode of delivery, from a completely traditional face-to-face classroom, through varying degrees of digital inclusion, to an entirely online course. The result is a highly flexible, non-prescriptive approach to design that allows the person developing the course to incorporate whichever elements meet their requirements.

The multimodal model is driven by pedagogy and content. Each module is independent, and the modes of presentation can vary. For instance, the reflection module could be an online blog, or a private pencil and paper journal. Collaboration can be done online in a classroom community or forum, or as small group work in a classroom. Picciano's work provides a highly flexible model on which to design any course, including blended or online delivery.

Figure 1: Multimodal Model for Online Education (Picciano, 2017)



Rapid Prototyping Model

The rapid prototyping model of instructional design is also modular, and could almost be considered a best practices addenda to the multimodal model suggested by Picciano (2017). The rapid prototype design is progressive and, as recommended by cognitivists, learning and design is broken into small portions. The designer is then able to design, reflect and re-design each portion before working on another section. The process of small module refinement is especially appropriate for classroom instructors who are desirous of moving some, or all, of their face-to-face courses into a blended or online model (Pesavento et al, 2015).

Either, or both of these models would work well for adapting GBL or GLL strategies to a blended classroom. When breaking down a project into smaller chunks, a designer could choose whichever aspects of the learning community would best serve the design and purpose of the game.

Possible Negative Aspects of Video Gaming

question: if negative aspects of video gaming show after x hours of consumption, would including video games as a part of learning be adding to the possibility of problems. If three hours per day is a borderline issue, and a class takes an hour - is the student then likely to curtail home use? Probably not.

observation: the difference between video gaming and social media should be considered. See slide show from OLTD 508

Addiction:

More about what games offer that the real world is not providing than it is about the quality of the game:

  - Caused by sense of satisfaction,
  - ability to SEE outcomes (instant feedback)
  - Opportunities to improve, chance to succeed, achieve mastery.

- Research showing that even when strategy games including co-operation are violent, the take away is the co-operation skills, not the violence. Players can differentiate between virtual violence and real, collaboration and social skills adapt readily to Real World. From alie ward podcast: Violence/attack style games on their own can be socially negative, need socially interactive component to counteract.
- Players return to real world with more ways to solve problems, collaborate on real world problems.
  - McGonigal, J. (2012, June 2). *Truths & myths in gaming* [Video file]. Retrieved from https://www.youtube.com/watch?v=ZJ7uaDlYVmo
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- Light users: play less than 1 hour per day "higher life satisfaction and prosocial behaviour" "electronic play [] functions similar to traditional forms of play"
- Heavy users: play more than 3 hours per day -Lower life satisfaction and less prosocial behaviour
  - Przybylski, A. (2014) Electronic gaming and psychosocial adjustment. Pediatrics. 134(3). doi:10.1542/peds.2013-4021

Social Isolation: data and references from Gaming and Social Skills slide show

- "the average gamer is not socially isolated, with more than 70 percent of gamers playing with other people either online or in person"
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Gender Bias

- boys play more than girls (but girls DO play!) (steihnkuehler and Mcgonigal)

Violence:

- Most games not excessively violent, racist, mysoginist etc. like GTA, but those get the most press time. (Steinkuehler,

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