Game Design and Development: Pedagogically Speaking

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Abstract: Teaching students to create video games provides an engaging opportunity to introduce computer programming concepts and computational thinking in a constructionist learning environment. In addition, video game design and development in the classroom teaches valuable skills including design thinking, problem solving, iterative design, and storytelling. Video games embody a type of cultural capital that makes content more accessible and interesting to many children. Currently, there are limited options for students at the middle school level to partake in courses in video game design and development, though research suggests there are benefits to engaging students in this type of design work and participatory culture. We explore the research findings and provide an overview of a public middle school program that has developed a curriculum in game design and development for seventh and eighth grade students, and look at implementation strategies for schools.

Introduction

Over the years there has been much talk in the public sector regarding making computer science instruction more accessible and less daunting. In addition, helping students become producers of content rather than just consumers is paramount to the development of entrepreneurial and creative thinking skills (Morrison, 2013). Even President Obama has recently urged students, "Don't just buy a new video game, make one" (Hardawar, 2013). The growing sentiment is that whether or not students choose careers in computer science, it is important to have an understanding of how computer languages work and for students to learn how to create and iterate on their own ideas as well as learn and work with up-to-date technologies (Swacha et al., 2010). Video game design and development courses provide a tremendous opportunity to gain exposure to computer science concepts as well as other important ideas in learning, collaboration, and design thinking.

One of the advantages to using game design as a way to teach computer science concepts is the inherent cultural capital that video games may supply for young people. Introducing game design into the classroom provides an activity that is fundamentally appealing to many children. 91% of kids ages 2-17 play video games (Reisinger, 2011). In research done by Kafai (2005) younger students beginning to learn game development played games developed by older, more experienced students. The younger students expressed excitement about playing the games developed by the older children and commented on how much they looked forward to the opportunity to participate in the actual game design process themselves.

Game design can provide opportunities for culturally relevant activities for students, not only as an interest area but in terms of a participatory culture. Li (2010) uses the term "enactivism" to describe the type of mind, body, world participatory learning that occurs through the individuals' own actions. Participating in the design of a tangible product that others can engage with requires the application of a different skill-set than a regular classroom setting may provide. The desire to actively participate and create within the gaming environment helps to pull the novice further into the realm of computing (Overmars, 2004). Connecting and empowering novices is crucial, as they feel invested and therefore engage in the act of acquiring new knowledge and further enhancing their skills. Stewart (2013) argues that one of the key elements of which educators must remain cognizant is that

technology is not just a "shiny gadget" but something that can instead be used to empower users. Teaching students fundamental computational, design, and problem solving skills via game development allows them to utilize technology to enhance their learning in ways traditional class-work may not.

Game development allows for the growth of computational skill in three distinct layers as described by Brennan and Resnick (2012): *concepts, practices,* and *perspectives*. *Computational concepts* are those computer science skills students should explore, such as conditionals and loops. *Computational practices* are participatory skill-sets, such as iterating off of others' work or debugging. *Computational perspectives* are viewpoints in which students see the act of designing and programming as a way to create and describe the world. In addition, having the experience not only of creating, but of creating both *with* and *for* others is valuable and provides an interesting opportunity to distinguish between the demands of each type of creation (Brennan & Resnick, 2012). Robertson and Howells (2007) argue that, "learners need opportunities for strategic thinking and reflection about their own learning." Participating in the process of designing a game, considering the objectives of the game and the evolution of actual playability requires a great deal of calculation, planning, and reflection on the part of the student. The three layers of computational skill come together as students develop and refine their games.

Playability is a crucial test of students' thinking and reasoning skills. Being able to identify a problem with their design, either on their own or through the collaborative play of others, allows them to iterate, a key component of computer science. The experience of failure in the design process is vital to learning, as it allows students to struggle and resolve, repeatedly (Li, 2010). The discussions and reflection that must take place in order to iterate and move forward require a collaborative meta-cognitive effort and exploration of the various elements of the games themselves. Likewise, through the iterative design process, students receive feedback and observe others playing their games. This encourages reflection on the distinction between player and designer in an authentic manner.

The idea that students learn through the very process of constructing and designing a product is a key component of constructionist theory. Constructionism, as described by Papert and Harel (1991), consists of two related processes. The first occurs internally, wherein students construct knowledge from their own experiences in their environment. The second refers to an external process, whereby students learn through the creation of artifacts that can be shared with the world (Baytak & Land, 2011). Video games provide an ideal medium in which this construction can occur. Working in design teams allows students to decide whether they want to focus on character development, graphic design and animation, sound engineering, storytelling, or on programming the behaviors of objects in the game. Students take internal ideas and transform them into a tangible, playable creation to share with the world. In addition, this artifact construction allows for the emergence of various elements of student personality and creativity. In a time period where many students are finding a decrease in their creative opportunities within the school structure, game design and development provide an opportunity for students to express themselves creatively. As one student stated, through the process of game making, "You can let your imagination go wild" (Li, 2010). Allowing creativity to manifest in an actual interactive product that others can use and explore provides a very different type of outlet for students.

According to Salen (2007), allowing students to create digital games actively puts them in the role of game designer. In this role, students are able to build technical, technological, artistic, cognitive, social, and linguistic skills which are valuable regardless of the chosen vocation. Collaborative and communication skills developed through work on shared projects are readily applicable across subject matter. The ability to take control of a project, strategize the appropriate steps in order to move forward, and continually problem solve as issues arise are skills that naturally develop in the game design process. Writing and storytelling are also key components, as students decide on the narrative structure and evolution of story in their games.

The design process includes the creation of a design document centered on articulating the vision for the game (Robison, 2008). An important part of the design document is the development of the characters and the story. This is the first step of the process in the industry and should be in the classroom as well. This aspect of the design process focuses on brainstorming and writing and lays the foundation for the work ahead. Garnering feedback from peers in the brainstorming process allows for constructive criticism and enhanced development of the storyline. This is also an excellent way to shift how the participatory culture in the classroom works. It is not just students participating by answering questions posed by the teacher. Through the process of creation and design, students will also be actively discussing and engaging with one another, posing unique questions (and answers) to the teacher and, in fact, may be able to explain things the teacher struggles to understand (Castaneda, 2013).

Case Study

Video Game Design and Development is offered as a full semester eighth grade elective at William Annin Middle School, a public middle school in New Jersey. Originally it was offered as an anchor course in the after school program for a number of years and then as a unit in the seventh grade gifted and talented program. When this course was suggested as an eighth grade elective, it received tremendous support from the Science and Technology supervisor as well as the building principal. It has since become one of the most requested elective courses being offered. More recently, the seventh grade cycle course that all students take has changed from a fairly traditional computer applications course to a video game design and digital storytelling course. The seventh grade cycle introduces students to the elements of game design and serves as a natural lead in to the eighth grade course. The cycle course is a six-week course and students create a complete game using Gamestar Mechanic.

The goal of the game design and development curriculum is to offer an opportunity for students to engage in the many facets of game design including design thinking, graphic design and animation, sound engineering, storytelling, programming, iterative design, and problem solving. Students work alone and in design teams where they can find their niche and collaborate based on their area of interest while gaining familiarity with all of the skills described. The classroom looks and functions more like a design studio than a traditional classroom. The course is delivered through a Quest-based learning environment (3D GameLab). Students complete projects following the main 'Quest Lines' as well as 'Side Quests' which allow them to extend their learning and apply choice and differentiated instruction while addressing relevant learning goals.

The primary tools utilized include GameMaker (YoYoGames, Inc.), Minecraft (Mojang, Inc.), and the Portal 2 Puzzle Maker (Valve, Inc.). GameMaker allows students to create and program the objects of their games based on events and actions. Students program the objects using a drag and drop visual interface. The graphical nature helps to provide a concrete context for the programming constructs. Students are incorporating programming concepts including conditional statements, variables, and loops, among others. This approach provides an authentic introduction to computer science in a manner that is engaging and easy to grasp. Minecraft provides a more open-ended, student-driven approach to design based on the sandbox nature of the game. The overarching goal is to create a game in the Minecraft environment while meeting the learning goals of designing a game plan, providing a detailed rule-set, and developing a playable game in the environment. The Portal 2 Puzzle Maker allows students to design and create levels for the commercially successful game, Portal 2. The editor itself is very easy to use, but the skills in designing an appropriately challenging playable, engaging level including key design elements teaches students a great deal about the design process. All of these tools require thoughtful planning, design, creation, computational thinking, and iteration throughout the development process.

The Quest-based environment, along with the instructional videos and resources, makes the course easy to replicate or deliver online. An online version of the course has been developed and has been delivered for the VHS Collaborative for the past five years. The course is one of the most popular offerings, consistently filling five or six sections of high school students from around the world. This spring the Idaho Digital Learning Academy (IDLA) and GoGo Labs, Inc. are collaborating to bring game design and development to the IDLA students. The course includes content from the courses mentioned above in addition to content presented by a number of other prominent educators in the field.

An emphasis on problem-based student driven learning, collaboration, and cultivation of a love of learning that extends outside of school is well served by the addition of these courses. The high levels of motivation demonstrated by students in the game design and development courses are a positive reflection of the instructional design models employed. Student and parent feedback is very positive with students reflecting on the wide array of skills they acquired during the course. Among these, notably, are softer skills such as persistence, collaboration, resilience, and the ability to accept constructive criticism.

A recent parent email illustrates the level of interest and intrinsic motivation described above:

> "I am reaching out to you for advice for my son. He loved your Game Design class and has taken a real interest in game design and development. He has stated time and again that this has been his favorite class

and he wants to do more. We would like to encourage this interest and wanted to enroll him in some summer camps for game design. For me the fact that he is so interested in game design is so very encouraging. I have never seen him so excited to work on homework as he did for your class. I really appreciate your help in this matter and want to thank you for instilling in him a real interest in game design." (Parent, personal communication, February 7, 2014)

Classroom Implementation

Generally speaking, there are relatively few programs that offer students the opportunity to design and develop games at the middle school level. It is the hope of the authors to facilitate the development and delivery of more programs to expand opportunities for students to participate in courses of this nature.

When considering the inclusion of a game design program within an educational setting, availability within the schedule must be considered, although limited availability does not necessarily negate the possibility of successful implementation. While we believe a semester long course would be ideal, there are a variety of ways to bring game design into the curriculum. Work with game development can be included within general technology courses, or incorporated in courses on programming and graphic arts. After school programs, week-long summer camps, and even shorter sub-units within other subjects areas can effectively incorporate concepts from game design (Castaneda, 2013, Bates et al., 2009). The presentation of smaller components or chunks of a game development curriculum is still helpful in facilitating overall learning, and learning game design principles over time may in fact be preferable to learning them all at once. Kafai's (2005) research suggests that in an ideal world, game design courses would run for multiple years in a row, allowing individuals the opportunity to build their understanding of complex skills. Small units here and there throughout several courses can provide ample exposure to relevant skills.

The structure of a program will also impact software selection. Programs with a focus on design thinking without a focus on prior student experience can incorporate tools like Gamestar Mechanic to provide an entry point. Likewise, level editors provide a low entry barrier requiring only basic understanding of game mechanics and computer science concepts. Valve's Portal 2 Puzzle Maker, a level editor, has been used successfully as an introduction to the design process. Sandbox games, such as Minecraft, are often highly effective with younger students providing a basic glimpse into a design environment where students can modify the world and create original content and games. Programs such as GameMaker, RPG Maker, and Scratch take the curriculum further as they incorporate computer programming concepts in addition to the other skills. GameMaker, specifically, was designed to help students gain computer science skills rapidly and in a user-friendly way (Overmars, 2004). The drag and drop programming inherent in the software allows students to experiment with programming in a very basic way while still appealing to a wide array of student skill-levels. More advanced students might enjoy the challenge of exploring some of the more complex game engines such as Unity, Cry, or Source. These engines take students significantly further in-depth and require additional skills with programming and 3-D modelling. Many have free versions that students may utilize and have ample resources online to help support their learning. Several of the middle school level students we have worked with have successfully designed games using the more advanced engines.

Computer science concepts that are fundamentally difficult can become much more accessible when explored via game design. Object-oriented programming is one example that involves thinking about and providing commands to indicate how objects interact with each other and to player input. Behaviors are defined in event-driven terms. Game design requires students to utilize computer programming concepts including conditional statements, loops, and variables in a manner that makes sense within the context. Furthermore, students are often willing to invest additional time and energy into the work due to the high interest level games provide. The appeal of working with games contributes to the value of game design and development as an introduction to computer science.

Providing an appropriate context, through discussion and interaction, within the community of learners and asking relevant questions helps to guide student thinking and is a crucial element of the constructionist environment (Egenfeldt-Nielsen, 2007). It takes careful planning and work ahead of time to create a collaborative studio-feel in a classroom environment. Brennan and Resnick (2012) also argue for the vital importance of reflection and discussion in order for instructors to gain a clear picture of learner understanding. Students are sometimes able to

correctly perform actions in-game or in the software design process that they do not fully understand. Through student inquiry, discussion, and large group conversation, misconceptions become more readily apparent. Crookall (2011) refers to this process as "debriefing" and he argues that, "Debriefing is the processing of the game experience to turn it into learning." Making games is not enough. Students need the chance to discuss and reflect on their knowledge. Without the reflective component students may be missing out on key aspects of the learning process.

Interestingly, often studies on game design (Li 2010, Kafai 2005, Lim 2008) examine assignments where students were asked to make "edutainment" games (games designed to teach a particular curricular topic). While we agree that designing games such as these can help to solidify academic skills within a particular topic area, both for player and designer, we argue that the skills inherent in game design are valuable and have worth on their own merit. In our experience, even when students were designing games for the pure entertainment value of others, the work inherent in the design process was extremely valuable. The process of making games engages learners in the active use of a wide array of skills, even without the additional layering of another curricular content area.

Conclusion

Game Design and Development provides middle school students with the opportunity to access and engage with a wide array of learning principles. In addition, as Lim (2008) noted, "It is only when students are empowered to take charge of their own learning by co-designing their learning experiences with teachers and other students that they are more likely to engage in their learning process. One way of doing so is to allow students to be the designers of their own computer games..." The experience of designing and developing games exemplifies a constructionist learning environment where students are creators of content through the application of computer programming, problem solving, and iteration. Artistic creativity also plays a major role as students incorporate graphic design and animation, sound production, and storytelling. The participatory culture developed in the classroom can provide a studio-like environment where collaboration is not only encouraged but required.

Both the authors of this paper and a number of other researchers have observed that when using video games and game design in the classroom, students do additional work and go above and beyond what is required (Li, 2010, Castaneda, 2013, Egenfeldt-Nielsen, 2007). Some researchers have argued that there is no research showing that the additional time spent on games or game design work actually results in increased learning (Egenfeldt-Nielsen, 2007). However, those same authors are quick to point out that the extra time spent might not even emerge if it were not for the games, so it is difficult to understand the full impact on learning (Egenfeldt-Nielsen, 2007). More research is needed to explore the value of the additional time spent on game making activities. Does additional exposure time necessarily result in increased learning? Measuring the acquisition of higher order thinking skills, such as those utilized in the creation of video games, is a challenge in and of itself.

The authors are currently engaged in a survey study involving several hundred middle school students and gaming professionals across the country to further explore their perceptions of game design courses, types of skills acquired in such courses, and the perceived value of those skills. As video games in education continue to grow in popularity it is important that we consider the creative aspects inherent in both the designing and playing of those games in addition to the many concrete skills developers use in the design process. Game design and development truly can provide a wonderful platform to delve into computational and problem-solving processes in addition to the myriad of other skills discussed.

References

Bates, M., Brown, D., Cranton, W. & Lewis, J. (2009). Gaming and the firewall: Exploring learning through play via game design with children. *The European Conference on Game Based Learning.* Graz, Austria: Nottingham Trent University.

Baytak, A. & Land, S.M. (2011). Advancing elementary-school girls' programming through game design. *International Journal of Gender, Science and Technology, 3*(1), 244-253.

Brennan, K. & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. *Proceedings from AERA 2012.* Cambridge, MA: MIT Media Lab.

Castaneda, L. (2013). The "broken rooms" Portal 2 lesson: An exploration of erroneous examples in a classroom setting. *Foundry10.* Retrieved from: http://www.foundry10.org/pdf/The%20broken%20rooms%20research%20paper.pdf

Crookall, D. (2010). Serious games, debriefing, and simulation/gaming as a discipline. *Simulation Gaming*. Retrieved from: http://sag.sagepub.com/content/41/6/898.

Egenfeldt-Nielsen, S. (2007). Third generation use of computer games. *Journal of Educational Multimedia and Hypermedia, 16*(3), 263-281.

Hardawar, D. (2013). Obama kicks off CS education week with Code.org. *VentureBeat.* Retrieved from: http://venturebeat.com/2013/12/08/president-obama-kicks-off-cs-education-week-with-code-org-dont-just-play-on-your-phone-program-it/

Kafai, Y.B. (2005). The classroom as "living laboratory": Design-based research for understanding, comparing, and evaluating learning science through design. *Educational Technology*, Jan-Feb, 28-34.

Kafai, Y.B. (2006). Playing and making games for learning: Instructionist and constructionist perspectives for game studies. *Games and Culture, 1*(1), 36-40.

Li, Q. (2010). Digital game building: Learning in a participatory culture. *Educational Research, 52*(4), 427-433.

Lim, C.P. (2008). Spirit of the game: Empowering students as designers in schools? *British Journal of Educational Technology, 39*(6), 996-1003.

Morrison, N. (2013). Teach kids how to code and you give them a skill for life. *Forbes.* Retrieved from: http://www.forbes.com/sites/nickmorrison/2013/12/27/teach-kids-how-to-code-and-you-give-them-a-skill-for-life/

Overmars, M. (2004). Teaching computer science through game design. *Entertainment Computing*, April, 81-83.

Papert, S., & Harel, I. (1991). Situating constructionism. In *Constructionism* (pp. 1 – 11). Norwood, NJ: Ablex Publishing Corporation

Reisinger, D. (2011). 91 percent of kids are gamers, research says. *Cnet*. Retrieved from: http://news.cnet.com/8301-13506_3-20118481-17/91-percent-of-kids-are-gamers-research-says/

Robertson, J. & Howells, C. (2008). Computer game design: Opportunities for successful learning. *Computers and Education,* 50, 559-578.

Robison, A. J. (2008). The Design is the Game: Writing Games, Teaching Writing. *Computers and Composition*, *25*(3), 359–370. doi:10.1016/j.compcom.2008.04.006

Salen, K. (2007). Gaming Literacies : A Game Design Study in Action. *Journal of Educational Multimedia and Hypermedia,16*(3), 301–322.

Stewart, M. (2013). Let's stop focusing on shiny gadgets and start using tech to empower people. *Wired*, retrieved from: http://www.wired.com/opinion/2013/09/focus-on-people-not-tech-and-ther-impt-lessons-for-interaction-design-and-life/

Swacha, J., Skrzyszewski, A. & Syslo, W. A. (2010). Computer game design classes: The students' and professionals' perspectives. *Informatics in Education, 9*(2), 249-260.