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FORUM

Leveraging insights from mainstream gameplay to inform STEM game design: great idea, but what comes next?

Melissa Biles

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Abstract This response to Leah A. Bricker and Phillip Bell's paper, *GodMode is his video game name*, examines their assertion that the social nexus of gaming practices is an important factor to consider for those looking to design STEM video games. I propose that we need to go beyond the investigation into which aspects of games play a role in learning, and move on to thinking about how these insights can actually inform game design practice.

Keywords Videogames · Social networks · Learning · Peer-to-peer interactions · Expertise

The idea of exploring the potential of triple-A video games to provide insights into the educational game development process is a solid foundation from which to approach this new evolving industry. As a gamer myself, I find there are many memes (Dawkins 1989) that can be drawn from games developed by the major game publishers and applied towards improving the type of educational video games that are currently being produced. When a paradigm obviously works effectively to draw millions of players into an immersive game environment and results in a detailed knowledge base around the game constructs; there must be something that can be extricated in terms of the knowledge production process. After all, the various types of learning theories are basically complex ways of conceptualizing processes of knowledge production.

Leah Bricker and Phillip Bell presented a case study of one player, Steve, and the social networks and contexts of his gaming practices. I found this focus interesting because, while the article did not outline any straightforward applications toward game development, the

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M. Biles (✉)
CREATE Lab, New York University, New York, NY, USA
e-mail: mlb414@nyu.edu

idea of creating a community around a game has great potential. Both the apprenticeship model and the collaborative problem-solving structures seen in Steve's experiences while learning to play *Halo* are representative of common socio-collaborative learning paradigms. We can all recall an experience where we learned via observation, imitation, and guidance from an expert mentor.

But how can this type of experience be incorporated intentionally into a video game? The experiences described in the article were largely focused around the game itself. They did not occur within the virtual game space. By dividing the social interactions into smaller specialty networks of technology gatekeeper, gaming partner, and active enabler, Bricker and Bell focused in on the various types of interactions that occurred.

From building games to building knowledge

Steve's parents played key roles as technology gatekeepers and active enablers, both supporting his gaming activities and seeking out further technology and gaming related activities to provide a more enriching experience. This type of support and acceptance of the medium as a valuable tool is important in framing the use of video games. Connecting an interest in games with further education in technology and game design turns a game into a stepping-stone for future learning.

Some mainstream games have incorporated this crafting and building component into an aspect of the game itself. A PlayStation 3 game, *LittleBigPlanet*, incorporates a level builder in which the player can create her own levels, from the simple to the complex, by utilizing a visual type of programming. Likewise, an indie computer game, *Minecraft,* utilizes a deconstructable 3D world in which resources can be harvested and used as building blocks for your imagination. Players have recreated everyday objects from scaled models of real-life edifices (i.e.: Parthenon) to complex machines like a working scientific calculator, all within the game world.

As with any other technology, like videos or simulations, the value of a game comes from how you utilize it. By educating parents about the potential benefits of video games in their child's lives, we can help them to support and extend their child's experiences with video games as a foundation for further learning and exploration. Furthermore, when designing games, developers should keep in mind how their game can support and enable self-directed activities either within or around the game world that help youth to develop a deeper understanding of the subject matter. Whether it is a level builder that teaches children and youth programming basics, or a technology camp that encourages children and youth to think critically about the physics and math inherent in games, there is great potential for thinking about how these types of in-game and around-game experiences can support learning goals.

Social affordances of games

Bricker and Bell's examination of the social network of gaming partners focused on the interactions provided by peer-to-peer teaching, strategy guides, and online forums. These functioned as important supplementary aides to Steve's progression from novice to expert within the game. Creating an environment where peer-to-peer teaching occurs is often as simple as placing youth playing the same game in close proximity within a room. Depending on the familiarity and personalities of the players, it can start slowly with covert comparisons of each other's screens and progress within game. As the youth start to encounter more complex and difficult aspects of the game, the dialog begins. "Psst, how do you get past this part?" "I'm stuck. What did you do?" In the CREATE Lab, during our research on effective learning mechanics in educational video games, we often see these types of interactions evolve naturally without outside prompting.

These types of innate peer-to-peer social tendencies are another factor to be considered when designing the game experience. Depending on the type of educational content, learning might be facilitated by utilizing a cooperative or competitive game environment. While this can be accomplished using computer-generated artificial intelligence (AI) characters, the AI in games is never as unpredictable as another human being. On the flip side, solitary engagement might be a necessary requirement for mastering more complex content. Additionally, the designer should consider if the content is new to the player. If the player is working with content they already know, in a more *drill-and-kill* manner, then the competitive aspects might increase engagement. Whereas if the player is being introduced to a concept for the first time, cooperative or single player modes might be more beneficial by providing time to focus without the distraction of trying to beat a time or a score. In the research literature around mathematics learning, cooperative learning has been shown to have positive effects on factors like achievement, attitudes, and higher-order thinking skills (Jacobs 1996). The type of game design choices you make will govern whether you focus on fostering the social network within or around the game world.

Looking at the history of gaming culture, the production of knowledge used to occur only by word of mouth. The first few generations of video games were designed to be much harder in many respects than those we are used to today. At first, they were only available in arcade form, where there were no save points—one credit would get you a set number of lives and you played until you died. Then the game would either force you to restart from the beginning or you were given a limited number of chances to continue. As games progressed into console form, save points became more common, however, you could only save at certain designated points within the game and you had a set number of lives (usually 3) before you were forced to start all over. For example, the Nintendo (NES) game *Contra* was a side-scrolling shooter in which one hit by an enemy equals one life lost. Since the player only had 3 lives to finish the entire game, this naturally made beating the game quite hard. I remember when someone finally figured out a solution, it came by way of "my friend's brother's cousin heard it from…" that if you press "up, up, down, down, left, right, left, right, B, A, Start" during the title screen that you could get 30 lives instead of the 3. This type of word of mouth information was quite limited compared to the resources we have today.

The widespread arrival of the Internet revolutionized this information communication process. Now, when you get stuck in a game, whether it is a casual game like *Angry Birds*, or a triple-A game like *Halo*, the player can type in a Google query and be instantly provided with thousands of sites from forums to full scale walkthrough videos illustrating every aspect of the game in question. Bricker and Bell draw attention to this type of "networked expertise" via Steve's use of official Halo strategy guidebooks as well as the Internet to discover YouTube videos of item locations that were helpful in increasing his proficiency within the game. By drawing upon the widespread knowledge available from these multiple sources of information, Steve was able to increase his overall level of expertise as a player. Unfortunately, online forums and published strategy guides generally require a larger player base actively interested and engaged in the game in question.

Given the much smaller scope of educational video games, the likelihood of creating such a vast interconnected external social network seems highly unlikely at this point in time. However, on a smaller scale, within a single school district or even within a single classroom, the potential to create a social network that contains the same beneficial properties is much higher. Once a small-scale community has been established, a continuous feedback loop can be created that slowly expands through peer-to-peer interactions to become a much larger network. In this way, schools have the potential to provide a valuable support structure to guide students in their use of technology, like games, in effective and constructive ways.

One game, multiple players, different experiences

A key component of this social process is the ability to support multiple levels of expertise within the same game. Both an expert and a novice must be able to gain both enjoyment and proficiency from the game, despite their different prior knowledge levels. Think of it this way, using a classic board game example, chess. The novice player in chess is still immersed in the game, despite their lack of expertise. They can learn how each piece moves, their effectiveness in certain situations, and how the offensive and defensive moves interact. However, the novice player's strategy and meta-analysis of the game is far different from that of an expert player. An expert player might immediately recognize such classic gambits such as the *Italian opening* or the *Two Knights defense* and use that knowledge to respond with an appropriate counter-strategy.

This division of gameplay into multiple skill levels has clear advantages when using a game as a medium to teach. Besides the natural affordances of the game structure that allow for the range of play levels, video games can automatically adjust difficulty based on the player's actions. This can be as simple as games like *Fallout 3* which increase the number and difficulty of enemies as the player gains more experience within the game or as complex as games like *Left 4 Dead* that track the player's performance factors and adjusts the location and quantity of enemies, ammo, and medpacks throughout the levels. These types of systems have the benefit of scaffolding gameplay to keep players in their optimal zone for learning by providing just the right amount of challenge and difficulty to maintain the balance between fun and frustrating.

This idea of creating an optimal level of challenge is reflected in Bricker and Bell's observation of Steve's modification of a mathematics tutorial to include the element of time. By self-imposing a time limit, Steve was increasing the level of difficulty within the math assignment to reflect an appropriate level of challenge. By designing STEM games that keep track of the player's in game actions and strategies, the game can be designed to present problems in a manner that provides the optimal level of challenge for the player. This act of tailoring a user's experience to promote learning is not a new concept. Whether it is a teacher observing and understanding their students, or the use of computer programs to effectively communicate knowledge (Shute and Psotka 1994), the end goal is the same—knowledge production. With the advent of more advanced computing technology, great strides have been made in the fields of Intelligent Tutoring Systems (ITS) and Data Mining. These areas of research can be used as inspiration for designing effective educational games.

Computational and analytical potential

Intelligent Tutoring Systems were originally conceived as a substitute for a human tutor, creating a way to individualize instruction on a larger scale (Shute and Psotka 1994). They have the ability to provide customized feedback based on a student's answers and actions within the tutor interface. Each task is divided up into different steps that must be taken to reach the goal (i.e.: multi-part algebra problem). The incorrect or erroneous assumptions that a student can make are identified and linked with specific feedback designed to draw attention to the error and promote critical thinking about the correct response.

Now, think of this within a game context. Each action within a game can be instrumented and quantified. Certain series of actions such as solving a puzzle the wrong way repeatedly, can trigger a game prompt that provides the needed feedback. Alternatively, the game could alter the game state in a way that either simplifies or guides the player toward the learning objective. For example, in a Geometry puzzle game designed by the CREATE Lab called *Noobs vs. Leets*, players have to solve angles in order to unlock lines to get through the maze to rescue a fellow *Noob* (Hayward et al. 2012). By placing an enemy character on a line, it creates a barrier that forces players to avoid that line in order to be successful in solving the level. These enemy *Leets* can be positioned so that players are forced to figure out how to use more complex angles, a learning goal of each chapter.

Data Mining is the use of different methods to analyze data in order to better understand the user and their actions. Many triple-A games have used data mining procedures during their development process to examine issues such as balancing, engagement, and player behavior. When developing Halo 2, Microsoft Game Studios tracked information including where on the game map players were dying most frequently and which weapons were used most often and where (Schuh et al. 2008). This knowledge allowed developers to tweak the gameplay factors such as visibility and placement of items (usability) and number and strength of enemies (difficulty).

Educational Data Mining (EDM) takes the same analytical principles and applies them to the process of learning (Romero, Ventura, Pechenizkiy, and Baker 2011). When developing a learning game, which has specific learning goals, it becomes even more important to discover whether players are making the same mistake over and over again, or completely missing a key button. Figuring out whether it is a usability issue or if the player just does not have a grasp of the knowledge being solicited is important in designing the type of feedback that the game provides.

Since the design of STEM video games is a rapidly developing field, it is very important to examine what exactly is being created and to think critically about what affordances of the video game medium can best be used to support learning goals. Bricker and Bell approach this idea from an introductory standpoint, endeavoring to lead the reader on a journey toward the conclusion that there is a necessity to examine social gaming practices when designing STEM game learning experiences. There are definitely lessons to be learned from the social aspects of mainstream gaming, but why stop there? Videogames can provide a rich source of inspiration for enhancing learning, but how do we apply those insights to create actual game design principles? But that is not our only hurdle. Once well-researched and thoughtfully designed games are available, how do we create and promote an understanding of the value of these types of experiences both inside and outside of school?

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Author Biography

Melissa Biles is a doctoral student in the Educational Communication and Technology Program at NYU. Her prior experience includes summative and formative research for educational children's television shows such as Little Einsteins, Super Why!, and Word World. She has also been involved in research projects examining usability and learning outcomes for the Ready-to-Learn Partnership, Disney, United Laboratories, and the Music Together program. Currently, she is involved in ongoing research on game design with projects such as *Noobs v. Leets*, a geometry puzzle/strategy game for middle schoolers, and the analysis of large data sets from *AppInventor*. Her research interests include learning mechanics, game theory, executive function, decision-making, and the use of educational data mining and psychophysiological (i.e: eyetracking, EEG, fMRI) measures in games research.