Handbook of Research on Mobile Technology, Constructivism, and Meaningful Learning

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Chapter 1
Inside, Outside, and Off-Site:
Social Constructivism in Mobile Games

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ABSTRACT

Well-designed mobile games that require player agency and meaning making are excellent examples of constructivist learning. Mobile games can generate a myriad of different learning experiences such as discovery learning and contextually based learning. One of the most powerful affordances of games is promoting social learning, or social constructivism; collaborative games provide plenty of opportunities for peer scaffolding and collaborative discourse. This chapter details three mobile augmented reality games designed to afford constructivist learning through collaborative interactions: one inside a school, one on and around school grounds, while the last one is located at a working farm. We hope to demonstrate that collaborative mobile games represent a flexible approach that can promote meaningful learning across subjects, ages, and even environments. Game-based learning (GBL) can, does, and should continue to occur in class; however, GBL can also be effectively implemented outside and even far away from the classroom, off-site.

INTRODUCTION

Today's young students learn differently—they want active, exploratory learning. Don Tapscott (2009), an expert on the transformative power of the digital age, believes that young students who are growing up digitally connected actually learn differently; because their brains have developed differently through their media interactions, their brains process information differently. This *different* style of learning is largely why students are often disengaged at school (Goyal, 2012). Curricula struggle to support

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tech-savvy students because a tension exists between traditional, didactic teaching approaches and the distributed, decentralized nature of today's media (Roschelle & Pea, 2002). To get students engaged at school, content mastery needs to be replaced by learning mastery (Richardson, 2012).

We believe that mobile augmented reality (AR) games represent a unique opportunity to create active, exploratory learning environments that engage students and offer more meaningful learning experiences. Today's students have the opportunity to learn in different ways, largely because of the technologies that surround them outside of school (Ito, 2010). One medium that dominates a young student's out-of-school time is gaming and it starts from an early age. In fact, "gaming represents the central form of early computer experience for kids" (Ito, 2010, p. 196). By middle school, students are high-frequency users of video games and web-based games (Spires, Lee, Turner, & Johnson, 2008). More importantly, students value the use of games for learning (Goyal, 2012; Project Tomorrow, 2010). Nikal Goyal (2012), who published his student perspective on the state of education, stated "I have learned so much more about math by playing games…than by hearing lectures and doing textbook problems" (loc. 5400); he goes on to clearly state that he wants to see games used in the classroom. He is not the only student voicing this opinion. Students in the *Speak Up* study—approximately 300,000 students—also advocated for games in the classroom because games can get them more engaged with the subject matter, help them to work in teams, and provide an easier way to understand difficult concepts (Project Tomorrow, 2010).

If games are worthy of exploration from an educational perspective, then what is the best way to deliver game-based learning? We believe that the digital medium that warrants the most potential at this moment is mobile technology, because we are at a tipping point. For over a decade, mobile phones have been a vital part of teenagers' social lives (Katz, 2006); young people live in a mobile world and their devices connect them to it. Mobile technology has had time to incubate outside the K-12 system; now, it is ready to be a "disruptive innovation" (Christensen, Horn, & Johnson, 2008). More and more schools are inviting students to *bring your own device* (Norris & Soloway, 2011) and many schools have invested heavily in providing both students and teachers with devices such as iPads, Chrome Books, and other 1:1 technology. We need to create and enact curriculum activities that ensure students will garner important skills and benefit from the unique affordances of mobile technology—no more business-as-usual. We believe that mobile AR games can serve as an effective solution. In this chapter, we will present three mobile AR games that we designed and developed. We intend to demonstrate that well-designed mobile games represent a flexible, constructivist approach that can promote meaningful learning across subjects, ages, and even environments.

BACKGROUND

The games discussed in this chapter draw on a vast body of literature from foundational educational theorists such as Piaget and Vygotsky to today's top thinkers in the games and learning field such as Kurt Squire and Eric Klopfer. Since all of the games discussed in this chapter are collaborative, we start off with some background literature on social constructivism. Then, we will bring you up to speed on some of the literature pertaining to games and learning. Lastly, we include some of the foundational research on collaborative mobile games that helped us to set up our game designs.

Constructivism and Social Learning

Social constructivism is a learning theory mainly associated with Vygotsky, although it draws influences from Piaget. Piaget believed that children construct knowledge through personal experience; Vygotsky believed that children begin to understand new concepts as they converse with each other—Vygotsky put importance on children's interactions with each other (Mooney, 2000).

Vygotsky theorized that within these interactions, social and cognitive development could work together, build on each other, and promote learning. Although Vygotsky would certainly endorse conversation among learners, talking was not enough; sociocultural learning was an interactive experience requiring shared power and authority (Driscoll, 2005). For a collaboration to be an effective learning interaction, it needed to have intersubjectivity: learners must "co-construct the solution to a problem or share in joint decision making" (Driscoll, 2005, p. 258). Aronson and Patnoe (2011) explained why interdependence improves learning for those present in the group:

Learning from each other gradually diminishes the need to try to outperform each other because one student's learning enhances the performance of the other students instead of inhibiting it, as is usually the case in most competitive, teacher-oriented classrooms. (p. 10).

Piaget (1985) posited that such interdependent exchanges present opportunities for intellectual growth as children experience disequilibrium between their own beliefs and those of their classmates. Growth happens because children seek new directions of thought as they try to restore cognitive equilibrium.

Essentially, social interdependence is a way to promote effective group learning. Annemarie Palinscar (1998), an expert on social constructivist learning, explained that studies show students gain benefits from instructional discourse with peers; however, "the benefits depend upon the types of talk produced… it is important to attend to the structure of group activity so that responsibility is shared, expertise is distributed, and there is an ethos for building preceding ideas" (p.365). The types of talk necessary for group learning is reliant on social interdependence.

Learning in Games

Games are a form of play for today's youth. The benefits of play have roots in social learning theory. As summarized by Mooney (2000), Vygotsky connected children's play to their social learning; as children listen and speak to each other, their social interaction directly contributes to their knowledge construction, and they learn from each other. In addition to promoting a child's social development, Vygotsky (1978) posited that play is an opportunity for children to develop abstract thought. Overall, Vygotsky (1978) believed that a child in play can achieve great things; he concluded that "play creates a zone of proximal development of the child" (p. 102).

While explaining why constructivist learning was a natural learning process, Jonassen, Peck and Wilson (1999) used the example of children playing the game of sandlot baseball; "children who consistently hit foul balls will adjust their stance or handgrip on the bat continuously to manipulate the flight path, and they will observe the effects of each manipulation" (p. 8-9). In a well-designed game, players are presented challenges that also require trial and error problem solving. While the action may not be as physical as a baseball game, the mental process is the same. This informal process of experimentation, reflection, and problem solving is being done without conscious thought and yet is clearly a learning activity and more specifically, a constructivist learning experience.

Given the importance of play and its learning benefits as suggested by Vygotsky (1978) and others, it is no wonder that more and more educators are beginning to recognize the potential of games for learning. Several researchers have successfully shown that games can improve the learning outcomes of students (Prensky, 2006; Steinkuehler & King, 2009). These researchers have noted several affordances games offer that align with constructivist learning:

- Games are learner (gamer) centered,
- Games require the active participation of the learner/gamer,
- Games require the learner/gamer to solve problems and make their own meanings, and
- Games can create relevant, contextually based situations.

Also, because of the flexibility inherent to the technologies supporting game design, game designers are able to create environments where higher order thinking is required to solve ill-defined problems, engage in high-level discussions, and utilize scientific reasoning skills (Steinkuehler & King, 2009; Boyle, Connolly, & Hainey, 2011).

Beyond all these learning benefits, games are also a valuable social learning experience. Many players actually prefer collaborative games. Trespalacios, Chamberlin, and Gallagher (2011) studied students' video game preferences and found that students prefer multi-player games over single-player games; specifically, the players preferred working in groups because it fostered companionship, collaboration, competition, and challenge. Research on collaborative educational games has shown that gameplay positively impacts the development of collaboration skills (Sánchez & Olivares, 2011) and player's perceptions of their social interactions (Mansour & El-Said, 2009). Specifically, students enjoy playing collaboratively because it encourages discussion among players (Sharritt, 2008).

Research has also shown that players in multiplayer games have the capacity to work together in such a way that new knowledge is constructed. For example, using an online protein folding game called *Foldit*, gamers collaboratively generated models that solved a problem that expert biochemists had failed to solve themselves (Khatib et al., 2011). When collaborative games are designed well, the games can act as a facilitator to peer activities, improving social interactions and communication patterns. Through that facilitation, players become better equipped to solve problems within the game by gaining resources from fellow players (Kirriemuir & McFarlane, 2004).

Researchers have found that peer collaboration enhances learning while students play educational computer games (Chatterjee, Mohanty, & Bhattacharya, 2011). Specifically, J.C. Hertz, author of *Joystick Nation: How Computer Games Ate Our Quarters, Won Our Hearts, and Rewired Our Minds,* posited that "the discourse is where the learning happens" (Foreman, 2004, p. 58). Essentially, games promote social constructivism by promoting collaboration, specifically collaborative discourse. Now game researchers are starting to have the data to prove that learners are truly constructing knowledge socially as they engage in discourse during gameplay. Steinkueler (2006) confirmed that players in a virtual game environment participated in a discourse; it was created, maintained, and transformed during gameplay.

The sociocultural learning that takes place within the game works best when there is shared power and authority through scripted collaboration (Demetriadis, Tsiatsos, & Karakostas, 2012). Often, scripted collaboration can be achieved through positive interdependence and jigsaw pedagogy. According to Johnson, Johnson, and Holubec (1993), "positive interdependence is successfully structured when group members perceive that they are linked with each other in a way that one cannot succeed unless everyone succeeds" (p. 9). The notion of jigsaw pedagogy is that each student in a group becomes an expert on one aspect of the activity, and teaches it to the other group members (Aronson, 1978; Aronson & Patnoe, 2011).

Collaborative Mobile Games

Well-designed collaborative mobile games are excellent examples of constructivist learning; in fact, they offer a unique way for students to socially construct knowledge. According to Klopfer (2008), students playing collaborative mobile learning games "help each other, observe each other, and act together to create communities as they learn to solve problems" (p. 223). Such mobile games promote social constructivism by scaffolding effective collaboration, in particular collaborative discourse.

One of the foundational collaborative mobile games that pioneered this field of study was *Mad City Mystery* developed and studying by Squire and Jan (2007). The game was designed with intersubjectivity; as mentioned earlier, intersubjectivity is Vygotsky's requirement for how a social interaction must be structured in order to promote effective learning. After studying the discourse between players, Squire and Jan (2007) felt that such intersubjectivity contributed to successful discourse. Specifically, they concluded that players engaged in scientific argumentation because of the task, roles, embedded resources, context, and encompassing activity system of the game. Squire and Jan (2007) found that the interdependent game roles of *Mad City Mystery* "encouraged students to share information, synthesize what they read, communicate orally with their group, ask questions, and debate meanings" (p. 24). They argued that the success of *Mad City Mystery* was achieved through game mechanics—roles and collaboration were two facets of gameplay that scaffolded student thinking.

Several researchers in the field of mobile learning games incorporated this concept of intersubjectivity into their game designs by creating interdependent roles (Bressler & Bodzin, 2013; Dunleavy, Dede, & Mitchell, 2009; Rosenbaum, Klopfer, & Perry, 2007). Research by Bressler and Bodzin (2013) revealed that the game built better relationships among the players; it was designed to promote collaborative problem solving using interdependent roles. Dunleavy, Dede, and Mitchell (2009) published results on a large-scale implementation of an AR game called *Alien Contact* that was funded by the U.S. Department of Education; *Alien Contact* was also designed with interdependent roles and their results showed high student engagement and students found the role-playing very motivating. Rosenbaum, Klopfer, and Perry (2007) included interdependent roles in their mobile AR game called *Outbreak @ The Institute* and found that students were not only motivated by the authenticity of their roles but also by the communication and collaboration that the game required. Overall, research indicates that collaborative mobile games hold promise for promoting effective collaborative practice by scaffolding collaboration during gameplay through interdependent roles.

MAIN FOCUS OF THE CHAPTER

Well-designed mobile games represent a flexible, constructivist approach that can promote meaningful learning across subjects, ages, and even environments. In this section, we will detail three mobile AR games that were designed to afford constructivist learning through collaborative interactions: one is set inside a school, one is situated on and around school grounds, while the last one is located at a working farm. All games were built using the augmented reality platform called ARIS (www.arisgames.org).

ARIS, a free open-source platform, was selected due to its inclusion of game-elements, functionality both with and without GPS and with and without geospatial features, and its strong user-community support groups.

Inside, by Denise Bressler

The school bell rings and it's time for homeroom. The rebellious boy in the back questions, "Mr. Johnson, can we get out the iPads and keep playing the game?" It's Day 2 of a 5-day classroom experience called *School Scene Investigators: The Case of the Mystery Powder*. Even though the first period bell has yet to ring, the kids are eager to get back into the game and keep playing. This is the power of game-based learning.

School Scene Investigators: The Case of the Mystery Powder was designed to engage groups of eighth grade students by using iPads as tools to solve a forensic science mystery based inside their school. Someone has stolen money from the cash register in the cafeteria and left behind this unknown white powder. Was it the janitor who uses cornstarch as a cleaning agent? Was it the front office secretary who baked sugar cookies for the staff? Or was it the student who is making a rocket using baking soda? All had valid reasons to get supplies from the kitchen, but who stole the cash? The gameplay took students through a process of scientific exploration in order to analyze evidence and make a case for the identity of the real criminal.

I designed and developed *School Scene Investigators: The Case of the Mystery Powder* for several reasons. First, there is an increasing number of mobile devices such as iPads being used in schools, yet I find that they are not being effectively used for mobile learning. Second, with the curricular shift to Next Generation Science Standards, I wanted to create an experience that would enable students to experience content in context and not just memorize facts; I wanted the students to think like scientists. Third, I believe that games embody some of the best learning theories—and when well-designed—make for engaging and meaningful learning.

So, I partnered with a local middle school, and presented my idea to the principal and the eighth-grade science teachers. They were enthusiastic and supportive! Since I intended to test the effectiveness of my game over a traditional classroom experience, the teachers felt that their mystery powder lab would make for a good control test. They demonstrated the lab experiments for me and gave me all the documentation about the lab. The teachers also gave me all the necessary equipment to take home and conduct the experiments on my own so that I could record videos and use them in the game. Throughout the process, the teachers seemed ready and willing to try this mobile game in the classroom.

To develop the game concept, I used the mystery powder lab as the foundation for the narrative. In the lab experiment, students use iodine, vinegar, heat, and pH paper to test known powders including cornstarch, baking soda, and sugar. Then, at the end of the lab, they are given a mystery powder which is a combination of two known powders. They run all their tests again and try to determine the makeup of the mystery powder. So, I based the game narrative around a mystery powder which was left at the scene of the crime. I associated each known powder with a suspect.

In order to make the game feel like an authentic mystery within a school, numerous locations throughout the school were chosen for inclusion in the game. Students left the classroom and visited locations such as the cafeteria, the front office, the gym, and the auditorium: quick-response (QR) codes were posted in these areas. Quests would pop up on-screen indicating where the group should look to find their next QR code. Not all players had quests at all times nor did they always have the same quest. This design decision encouraged a diversity of players to take a leadership role. Also, in order to provide students some control over their decision-making within the game, the game offered branching paths; in other words, the game was not perfectly linear.

It was also important to me to make the game collaborative, but I did not just want students to work in groups. I wanted to design the game to actually scaffold collaboration and communication. So, I looked into jigsaw pedagogy and cooperative learning principles. In jigsaw pedagogy, each student in a group becomes an expert on one aspect of the activity in order to teach it to the other group members (Aronson, 1978; Aronson & Patnoe, 2011). I felt that incorporating this concept would get the students to have ownership over some of the content from the game and then it would encourage them to communicate in order to share that information. As far as cooperation, one of the most important elements of cooperative learning as defined by Johnson and Johnson (1999) is interdependency. This means that group members feel like they cannot succeed on their own, but rather success will only happen if everyone succeeds. For cooperative learning to work, it's also important that students do real work together and share resources, while being supportive of each other. In order to win the game, students were going to have to work together and share information so their success would depend on effective cooperation.

To structure jigsaw pedagogy and cooperation into the game, I had each player select a role to play. To begin the game, each group member selected either the techie, photographer, social networker, or pyro-technician. The roles were designed to be interdependent; each role would provide a different game experience for the player through role-specific information. Therefore, each group member needed to have a unique role. A group could not have two techies, for example. Due to the interdependent nature of the roles, each student was highly accountable to the group for his or her informational knowledge which gave them the sense of being an expert on a topic. For example, the social networker was an expert on the vinegar test; he or she had the knowledge of how each powder reacted to the vinegar and what the reactions meant. This information was delivered in the forms of video evidence and stored in the social networker's inventory. In a similar regard, the techie was an expert on the iodine test, the pyro-technician knew about the heat test, and the photographer had all the information about the pH test.

Once roles were selected then gameplay began. Each day of class aligned to one chapter in the game. In the first chapter, students were introduced to the problem and the main characters. The very first quest sent students out of the classroom and down to the principal's office. After scanning the code labeled PRINCIPAL, players read through a conversation with the principal. The virtual character secretly asks for your help in determining who stole money from the cash register in the cafeteria. Your next quest sends you to the cafeteria to explore the crime scene. There, you meet a detective who gives you an incident report to fill out as you work your way through solving the crime. The incident report also doubles as an assessment measure. To end the chapter, a series of quests direct your group to locations around the school where you meet each of the three main suspects: the janitor, the secretary, and the student. The game automatically saves your progress, so students were able to login the next day and pick up right where they left off. In Chapter 2, players visit locations where they believe the suspects may have left some powder evidence behind. As they scan each QR code and encounter each powder, the player character conducts some simple tests using vinegar (conducted by the Social Networker), iodine (conducted by the Techie), heat (conducted by the Pyro-technician), and pH paper (conducted by the Photographer). All content knowledge and test results are conveyed during gameplay, generally in the form of videos and pictures. All evidence is automatically saved in the player's inventory. During Chapter 2, the game prompts players to make observations of each test and write down their observations on the incident report. This is how the game helps players think like scientists. Additionally, since each player gets unique information, players have to share their observations with group mates so that everyone has the same information on their incident report. In Chapter 3, the detective in the game offers the players a chance to test the mystery powder from the crime scene. This part of the game was an actual hands-on science experiment where teams conducted several tests on a real mystery powder; their observations and scientific findings moved the plot forward in the game narrative by narrowing down the suspects from three to two. In Chapter 4, students were prompted to revisit the crime scene and look for more evidence. Upon taking a closer look at the cash register, they notice a tool mark indicating that the suspect used a specific type of tool to force open the drawer. Then, they secretly look for what types of tools the suspects had access to and make a final determination about who committed the crime. In Chapter 5, the group presents their final analysis to the school principal and, if they select the right suspect, then they win the game.

Research showed that game players experienced deeper engagement, higher levels of scientific practices, and better collaboration than students participating in a traditional curriculum activity. Engagement was measured through a self-report survey. Scientific practices were measured using the open-ended assessment instrument known as the incident report. Teams in the game performed better on the open-ended assessment instrument than teams in the control group. Collaboration was qualitatively analyzed by recording and transcribing the conversational discourse of several groups of students in both the control and the game. Overall, *The Case of the Mystery Powder* provided the scaffolding and support necessary so that students could work together effectively using mobile devices and socially construct knowledge.

While research results were extremely positive, there were also some roadblocks along the way. First, the school's wireless internet signal was not strong enough in certain areas of the school and the iPads would drop their signal or the game would freeze. This was frustrating for players and they would have to reboot the application or reconnect to the school Wi-Fi system. Second, groups were supposed to stay together and every group member was supposed to scan every QR code. Some groups did not abide by this instruction and then they would get stuck because they were missing a key piece of information. Third, human error was a slight problem. There were several versions of the game running simultaneously in order to make sure that groups did not cheat off one another. So, if you were playing version A, the janitor was the real culprit; however, if you were playing version D, the student was the real culprit. Mostly this was an effective design decision, except for the day the mystery powders were mislabeled. Depending on the game version being played, students were told to test Mystery Powder A or Mystery Powder B. Well, *correctly* analyzing the *wrong* powder meant that the detective in the game told students that they were wrong and asked them to re-analyze their results. Mislabeling the powders forced students into this situation. Game teams in the classroom were so convinced that their lab reports were correct that they argued with the teacher using evidence from their experiment to support their claim that the game had to wrong. It was the conviction of the students that led us to test the powders which confirmed that indeed the powders were improperly labeled, and the students had indeed analyzed their data accurately.

I think this anecdote is the perfect story to demonstrate the powder of this type of learning experience. The students were so invested in playing the game—and winning the game—that they were angry when the game told them they were wrong…since they were so certain they were right. It's that investment in their learning experience that led to higher levels of engagement and deeper levels of learning. It's equally important to note that collaboration was effectively scaffolded through interdependent roles and students thrived because of it. Students were put in the uncommon situation of having to work together rather than compete against each other. Throughout the course of gameplay, groups of individuals formed into a cohesive social unit, where ideas were questioned, refined, and elaborated upon through social discourse. As Richardson (2012) explained, the new paradigm of education should be about doing real work, where students are asking good questions and working with each other to determine the answers. This is exactly what students were doing while playing *School Scene Investigators: The Case of the Mystery Powder*.

Outside, by Julie Oltman

Several years ago, a second-grade teacher in a small Northeast American city designed a unit to teach her students about the founders of their school, the colonial Moravians. The teacher wanted to introduce students to the colonial way of life and encourage an understanding and appreciation for the local history and the history of their own school which just so happens to be the 9th oldest independent school in America. The curriculum centered around a teacher-designed workbook where each chapter described a facet of colonial Moravian society or history such as "The Moravians Sail to America" and "How Were Decisions Made?". Led by the teacher, students would read and discuss the chapters together and then complete the accompanying activities such as word searches, crossword puzzles, or picture coloring. This workbook was supplemented with field trips to a local museum and a working colonial Moravian farm, as well as various craft and writing activities. Compared to the limited time many second-grade classrooms have to spend on history, it was a very robust traditional curriculum that typically ran from mid-October through mid-March. Since its development, the unit had changed little over the years. Then, in 2014, the teachers (in their questionable wisdom) graciously allowed this doctoral student to introduce them to game-based learning and we've been learning together ever since.

During the first summer, I worked with the three teachers to build a game that aligned with the content of their Moravian history unit. We play-tested prototypes of the game with our own children and other educators trying to find the ideal pace of play and level of difficulty. I wanted the game to feel like a *real* game and not something akin to "chocolate covered broccoli" (Bruckman, 1999). Feeling like a real game was important because I wanted the students to, hopefully, experience flow[1] and truly enter the "magic circle"[2] offered by successful games. If students are "in the zone", having fun, and fully engaged, then previous research (see Admiraal, Huizenga, Akkerman, & Ten Dam, 2011; Bressler & Bodzin, 2013) suggests that we could possibly generate a highly productive learning experience for these young elementary students. I say research "suggests" it would work because to date, I have been unable to find any previous literature describing children as young as second grade playing what we define as "serious games"; games that required player agency, higher order thinking, and problem solving. This wasn't going to be a simple skill rehearsal or quiz-type game. This game was going to require students to do things like navigate a satellite map, use clues to complete quests, and work with a partner to level up and progress.

A complex game such as this requires time to develop before it is ready for deployment within an enacted curriculum. It is truly an iterative process. So that summer, we edited the game, tested the game, edited the game again, tested again, and so on. All in all, we went through about four beta versions before we settled on our true 1.0 production version of the *Moravian History Mystery*. All during the initial game development, the three teachers were very helpful in providing feedback that enabled me to tailor the game for second graders and together, we discovered some game-design principles that may be helpful specifically for young students. First, we learned that geospatial skills require significant scaffolding. Second-graders may know what a compass rose is but navigating a satellite map is a whole other ballgame! Secondly, the game's reading requirements needed to be both grade level and not distracting to gameplay. If the reading is too hard, the screen has too much text on it, or the text isn't critical to advancing in the game, the kids just skip it. Third, we found that video content was not received well in initial testing because videos simply took too long. These kids wanted to play! Videos slowed them down and the kids got annoyed and didn't pay attention to the videos anyway. Lastly, we discovered that certain types of gaming activities were popular and well received such as collecting items, typing codes, and figuring out the right order. Since that first deployment, we have continued to "tweak" the game as we've learned more about what works and what doesn't work and as we think of ways to expand the game's content and quality.

To build the game, I considered several different gaming platforms but ultimately decided to use ARIS (www.arisgames.org). It was free, could be played on any iOS device, required no coding skills, and (most critically) allowed for GPS-enabled AR. Why was AR so critical? Well, the subject of history is hard for elementary students (Bransford, Brown, & Cocking, 2000). As one of my teachers wrote in a post-game survey, "History at this age is difficult, I believe, because they are so into the here and now." Research backs up this observation and tells us that students find social studies, including history, boring and not relevant to their lives (Zhao & Hoge, 2005). The teachers were excited about adding a game to the curriculum because the content was difficult and, well, kids love games, right? The teachers were also excited to "use technology" and do something to "jazz up" the unit. Personally, I was excited because this particular school was located in a historical district and was thus literally situated *right in the middle of history*! It was the perfect opportunity to get the kids *outside* to explore the historical content *in situ.* It would be easy to place our students at historical sites and AR would allow us to bring those sites and associated historical characters to life. How cool would it be to actually interact with a historical figure while standing on the very spot that figure once stood over 200 hundred years ago? Or, how neat would it be to stand in front of a building in 2014 and see what that same building looked like in 1742? I believed that experiencing history in such an active, engaging, and location-based way would have a significant impact on the students' learning experience.

Everyone was excited with the project's potential, however, building a good game that is aligned to learning objectives while still being engaging is only one facet of creating a successful game-based learning experience. Implementation logistics are critical. Not only were we going to be bringing 6-9 pairs of students outside to traverse a couple of small-city blocks, but each of these pairs was going to be potentially scattered, heading towards different locations at different times. Thankfully, teachers are often masters with student logistics and our team of teachers didn't let us down. To maximize safety, and (as we like to say) limit vehicular interactions, we ultimately decided to 1) have each pair of students chaperoned by an adult and 2) limit the gameplay area so that the only street the students had to cross was a seldom-used side street. Corralling enough adults for each gameplay session was challenging but we didn't feel it would be wise to allow pairs of seven-year-olds to wander a large area unaccompanied, especially when they would probably be paying more attention to their iPad than to where they were going! Fortunately, we drafted several "specials" teachers, a few administrators, as well as some fellow doctoral students to help us on game days.

A second implementation consideration was that, while we believed the game would be fun for students, we also anticipated that it would be challenging. The game required problem solving, reading (which for some 2nd graders is still pretty hard), and map navigation. Given the anticipated level of difficulty, understanding that gaming is often a social experience for children, and believing in the idea of social constructivism where learning occurs in a social context (Bandura, 1971; Inal & Cagiltay, 2007; Vygotsky, 1978), we felt that it would be important to have the students play with partners as teams.

We hoped there would be plenty of opportunity for peer scaffolding and that adults would not have to intervene too often. To increase the chances of good teamwork, the teachers considered student personalities and reading levels, typically pairing a stronger student with someone who typically needed more help. This seemed to work as one of our teachers later commented during a postgame interview, "the one who's a little bit higher, he probably would have been a little pushier in the classroom…as opposed to the game…he was just enjoying the game so much…I really think that helped him be a helper…to succeed with the game."

Gameplay would always start in the classroom. The first day, I would connect my iPad to the Smart Board and show the students the game interface and we would talk about how to navigate the satellite map. We quickly discovered that second-graders require significant scaffolding when it comes to geospatial skills. The first group of students were "lost" once they went outside, not knowing which direction to walk to reach their intended destination. We quickly revised our introduction to include more information on how to know which way you were facing and which way to walk and encouraged the students to be thoughtful of what direction they were heading. The campus has a cemetery, called "God's Acre", that was located north of the gameplay area. We instructed the students to turn and face God's Acre if they were disoriented to ensure they would be facing north, matching the orientation of the iPad's satellite map. Adjustments such as this can only be made once you've gone "live" with your game. You don't really know what is going to work or not work until the first time out. Fortunately, because we were using a design-based research approach[3], we had the flexibility to make on-the-fly adaptations as needed and this resulted in smoother, more enjoyable gameplay experiences each time we ventured outside with a new group.

Once the students had been oriented to the game, assigned their partners and chaperones, and given their iPads, we headed outside and each team of students decided where they wanted to go next. The team members would take turns holding the iPad and navigating to the next location as well as take turns reading out loud. The children were told that the adults "had caught some kind of temporary history virus and didn't remember anything about the Colonial Moravians" so they could not help with any of the quests. While their primary role was to ensure the safety of the students as they traversed the campus, the adults could also help with technology issues and mediate if there were any significant sharing issues between students. At a predesignated time, the chaperones would inform the students game time was over and we would all meet back in the classroom. (The first two years, we had the students complete a flow survey at the end of gameplay to measure their flow experiences).

After all the iPads had been returned and the students were seated at their desks again, the teacher would lead the class in a discussion about the game. This debrief session proved to be very helpful and enjoyable for the students as well as the teacher. The students were excited to share what they had done in the game and the comments often led into a broader discussion about relevant Moravian history topics that went beyond the intended curriculum. For example, one student recalled that Moravian girls and women were required to wear different colored ribbons to indicate their marital status and followed that observation with the comment that it was "sexist!" The teacher took that opportunity to lead the class in a discussion about how sexism is perhaps an example of how modern society (usually) differs from colonial society. This was certainly not a topic in the workbook! It was a discussion, however, that centered around an important societal norm that the teachers wanted the students to understand and the students were excited to talk about it and share their opinions. One teacher felt that the game really helped generate this type of engagement in discussion and commented, "they would make references to things they learned in the game or things they did in the game. I think that's a little bit empowering for them because they're like hey, we already know about this. Whereas before, they didn't know anything until we told them."

Over the past three years, we've played this game twice with seven different second-grade classrooms for a total of 14 separate play sessions. While we're still analyzing the data from years 2 and 3, our first-year results were very encouraging. Data indicate that nearly all students experienced high levels of flow. One student described her experience as, "Sometimes, I felt like it was so real that I almost wanted to touch it, like shake the person's hand," while another stated that, "It felt like it was only ten minutes long". These students were truly immersed in the gameplay experience and had entered the magic circle of gaming. Results also indicate that learning occurred. Almost two-thirds, 61%, of students performed better on unit content that was included in both the game and regular instruction than unit content that was not in the game at all. The data also show that students who were less successful on the test overall (scoring below the test average) actually performed better on game-related test items than the non-game related test items. This suggests that perhaps the gameplay experience enhanced the learning experience particularly well for students who don't typically respond well to traditional instruction.

It is very important, however, to note that we do not suggest that GBL can stand on its own as an alternative to traditional instruction. This GBL experience was deliberately *integrated into* an existing curriculum. Post-game classroom discussions, led by the teachers, were critical so teachers could help students process their gameplay experience, make meaning, and put into context what they had just experienced. Students were excited to share and contribute to the class discussions and continue the type of social constructivist learning that we believe GBL can enable. Beyond the initial gameplay day, these game experiences were also used later as sort of an anchor-point during the unit by both teachers and students with in-class dialog often starting with a phrase similar to "remember when we played the game and we/you had to….". GBL shouldn't happen in a vacuum if it's to be fully utilized as a powerful learning tool.

Simply bringing students outside often increases the excitement level and engagement of students and that, I believe, certainly elevated the gameplay experience for this group of young, energetic scholars. Given that it's typically a challenge to keep seven-year-olds in their seats, why fight it? Use it. Make learning not only mentally active but also physically active and if it makes sense for that particular content area, consider utilizing game-based learning. After all, you never know where the follow-up conversation will lead both you and your students.

Off-Site, by Farah Vallera

An enthusiastic, husky third grader could barely contain his fervor as he trotted down the grassy path toward the cow pasture on his "first-ever" tour of the agricultural education center. He and his class-mates from a predominantly white, middle class, suburban elementary school were there to learn about agriculture. I listened happily as his guide while he rambled on to his teacher about how much he loved seeing the goats, chickens, horses, and now the cows, before he confidently (and audibly) declared, "I don't drink any milk that comes from an animal, though!" While my brain caught up to what my ears imagined they had just heard (and sadly it was not the first time they had heard such a statement, even from folks much older than this fellow), I curiously asked, "Where does your milk come from then?" His reply was simple, "Wegman's[4]".

It was apparent to me then that students needed agricultural education, or at the very least, basic literacy of agricultural concepts. Following that encounter, I read a great deal on how U.S. students' agricultural literacy had been progressively diminishing (Doerfert, 2011; Kovar & Ball, 2013; National Research Council [NRC], 1988), and I was compelled to do something about it. I decided to design and build a fully STEM-integrated, agricultural-based curriculum module for upper-elementary students that could supplement existing science and math education in the classroom. The 10-day module was created using innovative educational and mobile technology, where content was presented in an interactive iBook and project-based performance tasks using AR, geographic information systems (GIS), Google Earth, and virtual presentation software were administered using iPads. Design-based research methods were also utilized throughout all stages of the development and implementation processes and the participating teachers offered valuable feedback for the module's iterations.

The *Agricultural Literacy through Innovative Technology* (AgLIT) curriculum module was tested in fourth-grade classrooms in an urban elementary school with outstanding results. Participating students demonstrated knowledge growth in STEM and agricultural literacy, positive attitude changes regarding such topics as conservation and environmental conscientiousness, and developed 21st century skills that included communication, collaboration, critical thinking, and creativity. Following the implementation of the curriculum, students that participated in the module's classroom testing and a control group of students from the same school that received regular classroom instruction (and took the pre- and post-tests) took a trip to the previously mentioned agricultural education center to experience agriculture and farming firsthand. Aside from spending a day at the farm, students participated in an AR *Farmhand Training Program,* an interactive game and guided tour of the farm, on their iPads. This value-added, on-the-farm activity was designed to tie knowledge acquired in the classroom to authentic, real-world activities. For the students that did not participate in the in-class module, they were introduced to farming practices and integrated STEM activities in an authentic environment.

My focus in this chapter is on getting kids off-site to help fortify classroom knowledge and experiences in authentic environments. Bringing students to the farm they studied in the module allowed them to make connections and transfer their knowledge between situations. The AR game was designed using constructivist and game-based learning theories and built in the ARIS platform. Since our society is overcome with information available instantaneously at our fingertips, encouraging today's learners to construct their own knowledge using the tools and methods with which they are most comfortable and familiar seems like a logical step in curricular and game design (Newmann, Marks, & Gamoran, 1996). According to Jonassen (1992), constructivism "is concerned with how we construct knowledge from our experiences, mental structures, and beliefs that are used to interpret objects and events" (p. 137). Activities should contain authentic experiences that encourage discovery through students' construction of knowledge of the world (Jonassen, 1999). Games designed with this in mind allow students to solve real problems in their own ways. The intent was to design an authentic experience where students could explore their natural environment, ask questions, solve problems, and learn through engaging gameplay.

ARIS provided the platform to make this happen. Programmed quests could drive students' movements between stations on the farm, virtual conversations could engage students in the content, badges of completion could generate a desire to "level up" and continue on, and embedded questions could test their understandings of the information they were encountering. The 28-acre farm—that was home to goats, cows, horses, pigs, chickens, ducks, a community garden, and a trail through the woods—could be transformed into a narrative, mobile AR game led by the virtual version of one of the farm's actual student volunteers.

However, since the game development was a substantial undertaking, extensive trials and testing took place. Prior to implementation of the final version, a simple AR farm tour was tested with farm visitors during an open house, where participants moved from station to station in a linear fashion. I realized quickly that I could not have a static, linear pattern of station visits with four classrooms full of fourth graders. Students would have to visit different stations at different times in order to keep things moving forward and prevent pile-ups. Additionally, the farm's wireless signal did not cover the full 28 acres, so mobile hotspots were necessary for uninterrupted gameplay. With these things in mind, the game passed through several additional iterations before the final version was administered.

Eighty-seven students from the urban elementary school that was part of the AgLIT pilot test were bussed to the agricultural education center on a Monday in April in two separate groups. Forty-three students visited in the morning, and forty-four in the afternoon. During each two-and-a-half-hour tour, students were split into four groups of roughly 11 students. Each group was assigned a tour guide (who carried with them a mobile wireless hotspot for internet service) to lead students around the farm. The four groups of 11 were then further divided into "pods" of three or four. Each pod received an iPad and students chose their roles as either agricultural scientist, biotechnologist, bioengineer, or mathematician (representing each STEM subject) in order to help Farmer Kathy prepare for the farmers' market. Assigning these roles required that students pass the iPads between group members and that all members participate in the activities. The groups were reminded to be careful, given their first quest, and then headed to different odd numbered stations around the farm, spending between 12-15 minutes at each.

Throughout the game, students visited eight locations where they were able to interact with animals, see agricultural production firsthand (such as cows being milked, milk being cooled and pasteurized, and cheese being made), learn from tour guides or content matter experts (for example, how to maintain soil health, compost organically, and control pests in the garden without chemicals), and participate in hands-on science and engineering tasks (fence design and fecal floats). The iPads directed the students from station to station, instructed which students were responsible for leading each quest (based on their initial STEM designation), and provided formative questions for knowledge assessment. Upon completion of each station, students collaborated to answer the exit questions (such as calculating how many gallons of milk the farm's cows could produce in one day) or solve STEM challenges (such as determining the health of goat manure based on the presence or absence of parasites) that were aligned to Common Core Math and Next Generation Science Standards. Students would not only need to pay attention to the information they were receiving (like how many cows were on the farm and how many gallons a cow could produce in a day), but apply STEM skills to answer the questions appropriately. Correct answers earned students a badge and new quest to continue on to the next location. Incorrect answers required the group to rethink their answers and try again.

Fun game mechanics were also used to continue moving gameplay forward and introduce more difficult challenges. After students visited the baby goats in the goat barn, they received a message on their iPads saying one of the babies had gotten loose. Students had to search the area around the barn to locate the lost goat (a QR code hidden behind a tree) and scan it with their iPads. They were then tasked with an engineering challenge that required them to build a new fence to keep the goats from escaping. Using craft sticks, cardstock, glue, markers, and twine (to represent an electric fencing option), students designed their fences using a small plastic goat for scale. Taking into account material cost, design, and safety, students discussed their choices upon completion.

During another part of the tour, students entered the indoor arena to see the farm equipment and supplies and complete a hands-on science task. Students learned how the veterinarian regularly visited the animals to make sure they were all healthy. Since students were involved in the "training program," they would also have to learn how to assist in making sure the goats' manure was healthy enough to spread in the soil to grow crops. Students prepared fecal samples for a fecal float to determine the level of parasites and the health of the manure. For the fecal float, students were provided with the actual equipment and supplies scientists would use when conducting such a test: gloves, test tubes, racks, non-toxic float solution, and enlarged images of the parasites that may be present. Students ground the fecal matter, applied the solution, let the mixture settle, and analyzed a digital slide of results to determine the health of the fecal matter. They discussed the types of parasites they saw in the slide and how "healthy" they believed the sample was before entering their assessment into the iPads. There was concern that students may not want to participate because it was "gross" to smash fecal matter; however, only two students did not want to "suit up" and complete the challenge.

The tour was a huge success! Students, teachers, tour guides, and Farmer Kathy were all excited about the game and how mobile technology encouraged meaningful learning in an authentic environment. Students were surveyed immediately following the tours regarding how they enjoyed playing the AR game on the iPads compared to traditional tours that only offered a guide. Overwhelmingly, all students (100%) agreed "playing the game" on the iPads added value to their visit to the agricultural education center. Additionally, the students' teachers described the visit as the "best" and "most informative" field trip they had experienced and commented on how engaged, behaved, and attentive their students were. Tour guides and content matter experts described the students' interactions positively and noted how curious and excited they were to participate and use iPads on their quests.

Still, there are limitations when trying to get kids off-site. Aside from the costs involved in bussing, entry fees, and technology considerations, time, support, permissions, safety, and even allergies can impact the success of a trip. Partnering with an agricultural education center allowed for students to visit at a drastically reduced cost (with no actual cost to them directly). Developing such partnerships is necessary for sustaining such programs but their cultivation can lead to increased opportunities for both students and off-site organizations.

Providing authentic situations in which students can learn meaningfully is an essential part of thoughtful design. Using mobile technology that engages and motivates, or in this case, moves students through an off-site experience while still encouraging their interaction with the environment, turned out to be a truly value-added innovation outside the classroom. Gameplay, while fun and appealing on its own, motivated urban students to confidently explore a farm and learn collaboratively.

FUTURE RESEARCH DIRECTIONS

Game-based learning research has begun to rightfully move past the simple question of whether games can be used for learning. When well designed and well implemented, game-based learning works (Hoffman & Nadelson, 2010; Gee, 2003; Prensky, 2001). There are many deeper questions that future research can pursue. What happens to a teacher's thoughts about pedagogy after experiencing game-based learning for the first time? Does game-based learning effectiveness vary across various populations (elderly, special needs students, etc…) or content subject areas (STEM vs humanities)? How does game-based learning impact retention? Is the game-based learning experience more powerful when students build their own games?

In the future, it will be particularly important to understand how well these games work for all achievement levels and, if they work well for low performing students, why that is the case. Research shows that game-based curriculums are "successful, if not more so, at supporting science learning among students classified in lower academic levels than their peers participating in higher academic level courses" (Sadler, Romine, Stuart, & Merle-Johnson, 2013, p. 493). Given this finding, mobile games might be of interest to the educational psychologists who study attention-deficit disorder (ADD), attention-deficit/hyperactivity disorder (ADHD), and other attention disorders. There is reason to believe that collaborative mobile games could have a positive impact on students with ADD and ADHD. Students with ADHD have showed improved performance in gaming because gaming helps overcome the deficits caused by the executive functions of the ADHD brain (Dovis, Oord, Wiers, & Prins, 2012).

CONCLUSION

Throughout this chapter, we hope we have demonstrated that well-designed collaborative mobile games can foster effective collaborative learning and social construction of knowledge. Due to today's culture of high-stakes testing, most schools still place emphasis on content mastery; students are acquiring isolated skills and specific facts rather than spending time on more meaningful, learner-driven processes such as social constructivism and conceptual thinking (Kohn, 2000; Ravitch, 2011; Richardson, 2012). In order to combat the emphasis on content mastery, we encourage instructors to integrate collaborative mobile games into their instruction as a way to truly support meaningful learning.

This chapter detailed three mobile AR games that were designed to afford constructivist learning through collaborative interactions: one set inside a school, one situated on and around school grounds, with the last one located at a working farm. Gaming is very often a social experience for children (Inal & Cagiltay, 2007), so to replicate a true gaming experience and to optimize opportunities for peer-scaffolding, students were put into teams of 2, 3, or 4 students depending on the game. Designing a mobile AR game that affords the social arrangement where students work collaboratively, while still contributing actively is essential to engaging and motivating them to take ownership of their own learning. In some cases, students shared an iPad; while in other cases, all team players worked on their own iPads.

In conclusion, the well-designed mobile games detailed in this chapter are excellent examples of constructivist learning. These games are learner centered, require agency, and remove the fear of failure. As Squire (2008) observed, "games are fundamentally about doing. Perhaps the biggest difference between game-based and more traditional approaches to learning is that game designers most often start with the user experience, specifically with what the user does" (p. 22). This is different from traditional instruction, which often starts with a transmissive, "sage on the stage" approach. Successful mobile games continue to go further in that they are immersive, require the learner to solve problems, encourage the learner to make meaning, and are intrinsically motivating. All in all, mobile games represent a flexible approach that can promote meaningful learning across subjects, ages, and even environments.

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KEY TERMS AND DEFINITIONS

ARIS: A development platform for creating and playing mobile augmented reality games. The acronym stands for Augmented Reality and Interactive Storytelling. Designed to be user-friendly for non-programmers, it is open-source, web-based, and free to use. For more information, visit arisgames.org.

Augmented Reality (AR): Augmented reality is a virtual media platform that provides overlays of digital information on top of real-world objects, images, or quick response (QR) codes.

GPS: An acronym that stands for Global Positioning System. It is a radio navigation system that enables the determination of exact position anywhere in the world.

Moravians: A Protestant religious group that emigrated to America in the 18th century to escape persecution. Their church is still active today.

Quick-Response (QR) Codes: Visual markers that look like two-dimensional barcodes. They contain digital information such as a website address. Special software is required to scan them and access the embedded information.

Social Constructivism: A theory of learning mainly associated with Vygotsky that emphasizes intrinsic learning through social interactions.

STEM: The acronym stands for science, technology, engineering, and mathematics. It's an interdisciplinary educational approach where learners engage in real-world problem solving.

ENDNOTES

1. Flow, as described by Csikszentmihalyi (1990), is a psychological state of enjoyment where the subject is engaged in an activity that is sometimes characterized as being "in the zone". In a game-play environment, players often lose their sense of time and their sense of their surroundings outside of the game indicating that the player is fully engaged in the activity. Flow is possible when there is both an ideal level of challenge matched with an ideal level of skill. Flow has also been shown to be connected to positive learning outcomes in game-based learning (Brom et al., 2014; Hamari et al., 2016; Hou, 2015).
2. A magic circle, as defined by Klabber (2007) and Huizenga (1949), is an agreement between the game and the gamer where the gamer accepts the game's premise of an alternate reality and adopts a new role with all of the inherent powers and limitations. It is a space away from the "real world".

By stepping into this magic circle, the player is open to new ideas and possibilities. Some have compared the magic circle to the "fourth wall" in the theatrical arts.

3 A design-based research (DBR) approach (Barab, 2006) is a methodological approach that allows for in-the-field adjustments to be made to the project's intervention (in this case, the gameplay experience). It is often used as an effort to discover learning strategies that will work in an authentic environment. Instead of adapting the classroom environment to the intervention, the intervention adapts to the classroom environment. In some ways, DBR is akin to a teacher's process of being flexible and making adjustments while enacting a curriculum to ensure its success.

4 Wegman's is a local grocery chain in the eastern portion of the United States.