School Scene Investigators: Evaluating Engagement during a Forensic Science Mystery Game

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Abstract: Sixty-eight middle school students played *School Scene Investigators: The Case of the Stolen Score Sheets*. Developed explicitly for this study, the game was built using ARIS and utilized quick-response codes set around the school environment. Working in groups, students played unique roles, collected and synthesized virtual forensic evidence, and solved the mystery. Evidence was collected in several forms: pre-surveys, post-surveys, field observations, and focus groups. Quantitative data was analyzed using a hierarchical multiple regression model. Qualitative data was thematically analyzed using qualitative analysis software. A merged analysis revealed that gender does not statistically predict engagement, yet different game elements engage genders differently. Interest in science does not predict engagement, although playing the game seemed to increase interest in science. Gaming attitudes predicted 23% of the unique variance in engagement level. Lastly, the engagement instrument showed all players were experiencing flow.

Introduction

Pure engagement in an activity can be characterized by the theory of flow as developed by Csikszentmihalyi (1990). Over the past 15 years, researchers have been studying flow in technology mediated learning environments. Cooper (2010) conducted a review of such published studies and concluded that, "studies indicate a positive relationship between flow and learning in technology environments" (p. 4). Given this positive relationship and the documented findings of high engagement during handheld augmented reality games (Dunleavy, Dede, & Mitchell, 2009), this research study sought to gain a deeper understanding of learner engagement, or flow, during a mobile augmented reality (AR) science game. Engagement was measured quantitatively using a self-report survey that empirically assessed flow. Examples of Likert-style survey items included: "I was challenged and I felt I could meet the challenge" and "I was totally focused on what I was doing." Based on the literature, several variables were included in the regression model: interest in science (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003; Singh, Mido, & Dika, 2005), gaming attitudes (Bonanno & Kommers, 2008), and gender (Gardner, 1998; Hoffman & Nadelson, 2010). Students were also observed during gameplay and interviewed in focus groups.

Using a mixed methods approach, this study researched the following questions:

1. How much variability in engagement level in a mobile AR science game is explained by gender?
2. Controlling for gender, do interest in science and gaming attitudes account for significant variability in level of engagement in a mobile AR science game?
3. What are the components of the engagement experience for middle school students while playing a mobile AR science game?

Game Overview

School Scene Investigators is a mobile learning game where students investigate 'crimes' that occur at their school. The first fully operational game was *The Case of the Stolen Score Sheets*. Players used forensic science to analyze the evidence and solve the mystery. This narrative-driven, inquiry-based game was played on iPhones supplied by the University. As students moved throughout their school building, they encountered quick-response codes (QR codes) that they scanned to access relevant game information. Triggered events included meetings with virtual characters and the retrieval of evidence.

The game was played in groups of three or four students. Each student had a unique role: techie, photographer, social networker, or science whiz. When groups had only three individuals, no one played the photographer; game design allowed for this role to be non-critical. Based on their roles, players were provided with different pieces of information as they progressed through the game. Players had to share information to navigate through the game and solve the mystery.

Throughout the game, players were exposed to basic elements of forensic science, like analyzing fingerprint, hair and other trace evidence. In order to complete the game, students utilized basic skills in observation, data collection, and data analysis. Players were challenged to synthesize several pieces of data in order to reach a conclusion. This enrichment activity concluded with a win-state; teams figured out which suspect committed the crime.

This game broke new ground in terms of its design. It took advantage of the medium's affordances, yet minimized some documented limitations (Dunleavy, Dede, & Mitchell, 2009). First, the game was played inside to minimize the influence of outdoor environmental factors. Second, the game relied solely on wireless Internet and QR codes to reduce technical difficulties and frustrations caused by GPS error. Finally, the game was situated in a location yet scalable. It utilized generic school locales such as a library, gym, principal's office, etc. This structure allows any middle or high school teacher to implement the game simply by printing out the QR codes and posting them in relevant locations.

Methodology

Data collection took place during March 2012. A convenience sample of 68 middle school students was obtained from a diverse, urban area in Pennsylvania with mostly low-income households. Data was collected in quantitative (pre-surveys and post-surveys) and qualitative forms (focus group discussions and field observations). During analysis, data sets became interactive to allow for a merged analysis. A hierarchical multiple regression analyzed how well gender, interest in science, and gaming attitudes predicted engagement level during the game. Focus group transcripts were coded to look for repeating themes and concepts in order to evaluate the components of students' engagement and confirm the reliability of the quantitative study.

Results and Discussion

First, as measured by the engagement instrument, all players experienced flow. Field observations supported this finding and students referenced different aspects of flow during focus group interviews. High engagement seemed attributable to certain game design elements; frustration and cognitive overload were lowered due to reliance on wireless Internet and QR codes. Second, gender did not predict engagement level; boy and girls were equally engaged albeit by different game elements. Boys seemed more apt to enjoy using the phones and scanning the codes; girls referenced the storyline. Third, kids were engaged regardless of interest in science. Better yet, the way players experienced science within the game seemed to change their perception of science, which increased their interest. Finally, gaming attitudes statistically predicted 23% of the unique variance in engagement. Enthusiastic gamers experienced higher levels of flow while playing, probably due to their comfort with the game format and previous gaming experience. Overall, these research findings support a closer look at using mobile AR science games as way to engage a critical population in STEM areas by providing opportunities to have fun with science and to feel capable of success.

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The Battle for Dondervoort: Using the powers of pervasive games and play communities in education

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"What are you? A fortification master? Cool. I'm the counsel." (student, 14 years, 2010)

Which character suits you best?

The interface of the game

The Battle for Dondervoort

The Battle for Dondervoort is a pervasive, social school game developed with students and teachers, that teaches youngsters (ages 12-15) about an important and unique part of Dutch history in a rather unconventional and innovative way.

Do the loyal civilians win at the end of the week?

Or the traitors?

The game

The game transforms the classroom for a week into the fictional fortified city named Dondervoort during the Dutch Eighty Years' War (1558-1648). Every student has a custom-made house and plays a different character in this city, for example a fortification master, a host, a carpenter, a thief, a metal worker, the counsel, a noblewoman and so on. The goal of the class is to defend their city from the Spanish invaders, which attack every night. In order to do so, they have to work together and share information with the rest of the class that *only* their character has received by mail. But they need to be aware; there are also traitors among them who secretly work for the Spaniards. Who to trust? And who wins the game at the end of the week: the loyal civilians or the traitors? During the week teachers from different classes can also use *Dondervoort lessons* to support the game experience. In these lessons students can earn game assets. At the moment, teaching packages are available for *History, Mathematics, Arts,* and *Gymnastics*.

At the end, students will make a field trip to a fortified city nearby their school to play *Urban game*. Similar to the school game, the students have to prevent secret saboteurs from causing misfortune.

Therefore, they have to discover important buildings in the city and expose the saboteurs. This way the students also visit a real fortified city and are able to associate Dutch history with the present.

For More information (in Dutch):
www.slagomdondervoort.posterous.com/
http://www.slagomdondervoort.nl

View of the fictional fortified city of Dondervoort

Every student owns a house in Dondervoort

Powers of pervasive games and play communities

The game uses the powers of pervasive and social gaming principles to motivate and educate. These principles are:

- Using the strengths of the play community, as defined by DeKoven (2002), to let students educate each other. In the beginning students take a test that appoints them with a suitable character in Dondervoort. The game encourages them to share the unique pieces of information given to the character. This way, the students teach each other. This is an important strength confirmed by the teachers involved.
- The game is pervasive: you can play it anywhere and at any time during the week. It blurs the boundaries between game and not-game, spatial, temporal, and social (Montola, 2009). By doing so, it also blurs the boundaries between lessons and not-lessons, school and not-school, learning and not-learning. The game uses and creates an active play community outside the classes (in breaks and at home) to share information. Testing revealed that students do this a lot.
- The game combines the strengths of digital technologies and real life. You cannot win the game by just clicking your mouse. You need to work together (talk, fight, stalk, negotiate, etc.) in real life too. This perfectly fits the post-digital world these students live in (Copier, 2007).

Students testing the game

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Visual Literacies: From Print to Screen

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Picturing the UP – The Game

Picturing the UP is a quest-based iPhone/iPad educational game created in the ARIS learning environment platform. The game situates contemporary digital photography in relation to historic archival research, as well as mobile technologies. In this game, players visit historical locations in the Upper Keweenaw Peninsula in order to learn more about their histories and to compare the past and present. More specifically, players first encounter a historical photograph of the location, and then meet a location guide that provides historical background. Next, they access a contemporary photograph of the location and receive a secret prize.

The game was created in a Fundamentals of Digital Imaging class as a pedagogical tool for understanding digital photography and digital imaging in a larger historical as well as technological contexts. The students in the class conducted three photo-shoots, created mobile images in Photoshop, conducted historical research and prepared the historical narratives for the game. I organized their visual and textual data into narrative quests using the ARIS Platform.

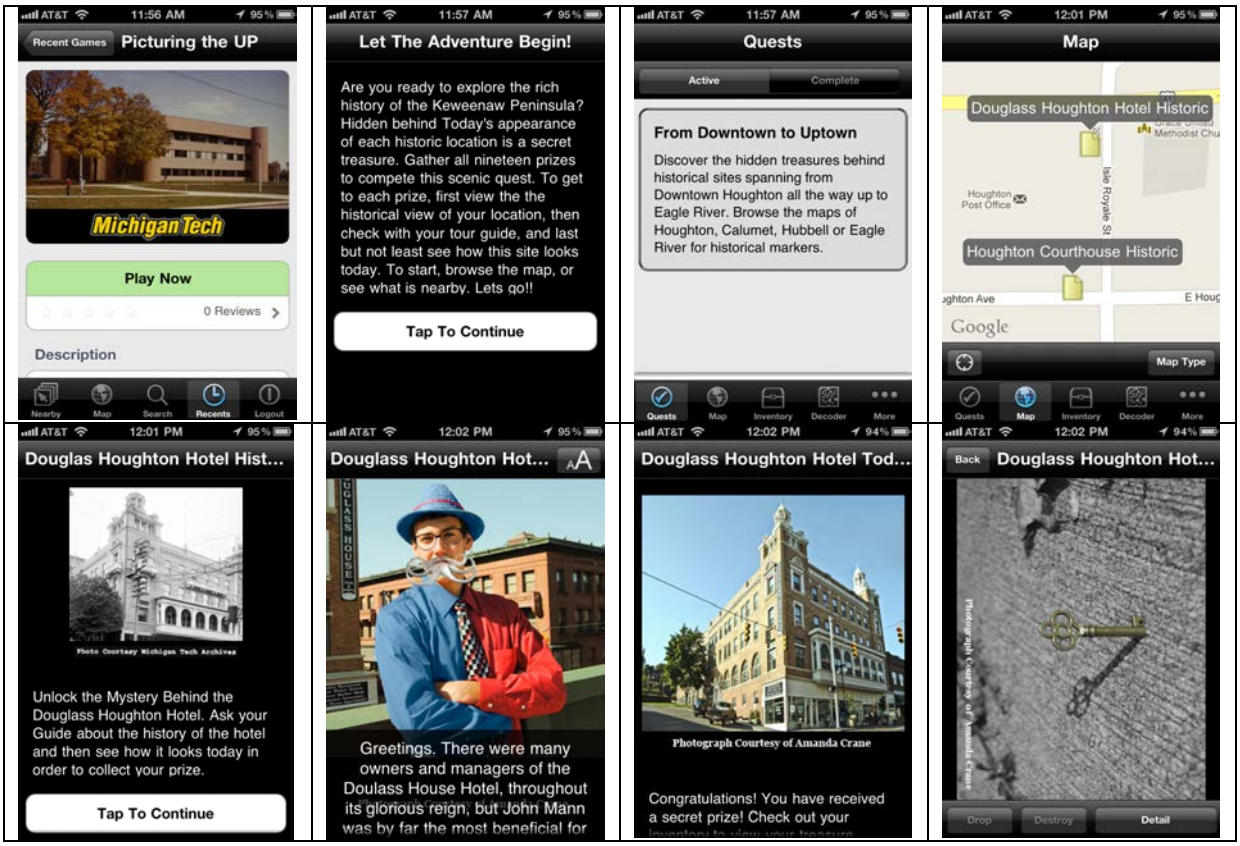

Figure 1: **Screenshots from the game.**

Engaging New and Old Technologies

As every year new visual technologies enter our society, it is important to provide media students with analytical frameworks that allow for comparative media analysis, connecting "new", "current" and "obsolete" media. Digital camera photography thus should be situated in the larger historical trajectory of analog photography as well as in the emergent field of cell-phone photography. The emphasis on the importance of history in understanding contemporary technology is further underscored when the subject photographed is also situated within a larger historical archive. Thus engaging with archival prints offers insight both into the development of the photographic technology itself but also of the cultural and socio-historical contexts. Adapting digital photographs for mobile games on the other

hand, opens up questions about the storytelling powers of visual technologies, as games provide "means for producing new forms of narrative" (Gordon, 2011: 6).

The *Picturing the UP* game engages with two major strands of digital media, namely locative arts and historical games. As a locative media game, *Picturing the UP* engages the notions of mobility and mobilization as synchronous as well as anachronous experience as it builds upon "the exploratory movements of locative art [that] are located between the art of communications and networking and the arts of landscape, walking and the environment" (Hemmet, 2006, p.348). As a history-driven game, it provides an opportunity for both the authors and the players of the game to engage with an augmented view of reality, where history acts as a supplement to the contemporary physical presence. As a history-based game, it also allows both parties to enter the historical research process and become visitors, photographers, gamers, and most importantly, historians. (Kee, Graham, et. al., 2009)

To sum up, the game attempts to provide a critical pedagogical model (Crocco, 2011) for teaching digital photography through engagement with older and newer forms of technology, historical archives, storytelling, and locative media in a mobile learning environment.

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