Location, Location, Location: An Exploration of Location-Aware Learning Games for Mobile Devices

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Abstract: This paper explores some of the location-aware augmented reality games in existence today and how these types of games might help students develop the skills needed for the 21st century worker. Research on mobile games suggests that games are able to support the learning of 21st century skills such as critical thinking, resource management, strategic thinking, collaboration, teamwork, communication and reflection. Augmented reality games can give students experiences such as conducting an investigation that involve these skills. When you deliver an augmented reality game via a handheld device equipped with a global positioning system (GPS) you can use the portability of the device and the surrounding environment to enhance learning.

Introduction

Educational theorists and researchers are beginning to identify both mobile technologies and games as potential resources in the support of learning. "These tools [are] potentially powerful resources in supporting the development of learning communities of offering experiential learning and in encouraging the development of meta-level thinking skills" (Facer, et al., 2004, p. 399). The research around emerging handheld technologies builds on "traditional" games research, but uses "ubiquitous digital technologies such as GPS devices and handheld computers to reintroduce learners to *place"* (Squire, et al., 2007, p.266). While there are different types of games currently available through handheld devices, this paper will limit exploration to location-based augmented reality games. Augmented reality games are "played in the real world with the support of digital devices that create a fictional layer on top of the real world" (Squire & Jan, 2007, p. 6). When you add devices, such as PDAs, equipped with GPS, these are transformed into location-based augmented reality games. (Squire & Jan, 2007)

Why Handhelds?

Handheld devices have unique features that lend themselves to being ideal for gaming. According to Squire, et al. (2007, p. 266) these characteristics are:

> (a) *portability* – ability to take off site (b) *socioability* – ease at exchanging data and collaborating face to face, (c) *context sensitivity* – ability for devices to "know where they are" in the world providing real and simulated data in real time, (d) *connectivity* – ability to be connected to other handhelds, devices, and networks via integrated 8.02 11 and digital broadband (over cellphone spectrums), and (e) *individuality* – ability to provide unique scaffolding that is customized to the individual's path of investigation. Furthermore, students come to school with handheld devices already in their pockets, creating new opportunities for integrating technology into the classroom.

MUVE over AR, There's a New Game in Town

While multi-user and augmented reality games are hardly new, using these tools on mobile devices provides for an enhanced experience that neither of these alone can provide. Multi-user virtual environment (MUVE) interfaces offer students an experience in which they use avatars to interact with other players in a digital environment. MUVEs provide "rich environments in which participants interact with digital objects and tools, such as historical photographs or virtual microscopes" (Dunleavy, Dede & Mitchell, 2009, p.8). The interface facilitates communication among avatars using media such as text chat and virtual gestures. Instructional designers can construct shared simulated experiences otherwise impossible in school settings.

Augmented realty (AR) interfaces enable ubiquitous computing models in which students carrying mobile wireless devices through real world contexts engage with virtual information that is superimposed on physical landscapes. This infuses digital resources throughout the real world, augmenting the students' experiences and interactions. (Dunleavy, Dede & Mitchell, 2009) Dede (2005) describes learning enhanced by mediated immersion in distributed learning communities based on MUVE and AR interfaces as fluency in multiple media; learning based on collectively seeking and synthesizing experiences; active learning based on experience that includes frequent opportunities for reflection; expression through non-linear, associational webs of representations rather than linear stories; and co-design of learning experiences personalized to individual needs and preferences.

The MUVE and AR interfaces also pose a contrast. In a MUVE, students are virtually embodied in a digital world; everything they encounter is in virtual form – including other students. In an AR, students interact with a mixture of virtual and real-world objects, people and environments. They can communicate with classmates face-to-face instead of the mediated interaction among avatars in MUVEs. While MUVEs may offer them the chance to do things impossible outside of that environment such as magic and teleporting to another location, AR includes the greater fidelity of real world environments, the ability of teammates to talk face-to-face and capacity to promote kinesthetic learning through physical movement through richly sensory spatial contexts. (Dunleavy, Dede & Mitchell, 2009)

When we use handheld computers equipped with GPS to develop outdoors AR simulations we develop a place-independent AR simulation, which can be superimposed onto any physical area. A teacher could implement a game outside the school building in an area such as a playground, sports field or parking lot. (Dunleavy, Dede & Mitchell, 2009)

Games in Play

Augmented reality games give students experiences such as conducting an investigation and are organized around problem solving activities (Squire, et al., 2007). In *Environmental Detectives*, students work in teams of 2-3 playing the roles of environmental engineers who are called in to investigate a simulated chemical spill on a college campus (there is also a version for high school students). Some of the information needed was incorporated into the digital content of the game while other information was in the form of supporting documents, interviews with on-location experts and witnesses. Virtual samples could be taken and reported using the GPS function of the handhelds; results would be returned based on the player's location. GPS was also used to help players navigate the campus and indicate their position. The game is designed as an open-ended game with no one correct solution. There are consequences, both positive and negative, to each decision and players must work within those constraints. As students work to locate the spill they have to consider the political, financial and practical trade-offs. (Squire & Klopfer, 2007; Rosenbaum, Klopfer & Perry, 2007)

In *Mad City Mystery* middle school students investigate an untimely death caused by murder, suicide or the combination of several interacting toxic chemicals that are commonly found in the region. Virtual media (text, documentation, multimedia) are triggered by location, determined by GPS. (Squire & Jan, 2007) The goal of this game is to help students think like scientists, to see "interactions in their environment as interconnecting geochemical processes and to use scientific understanding and scientific argumentation to understand key contemporary issues facing their local environment" (p. 6).

In *Reliving the Revolution* players try to find out who fired the first shot at the Battle of Lexington. The educational goal is to teach "historical thinking and inquiry skills . . . it is a case study for thinking about how games can support historical empathy, citizenship and ethical thinking skills" (Schrier, 2009, p. 1). Students use GPS-enabled PDAs to receive information at certain hot spots as they walk around Lexington Square, which still has buildings and spots that were involved in the Battle of Lexington. The participants play one of four roles and the evidence they receive depends on their role. After the students work together in pairs to gather information, they all come together and deliberate about who they think fired the first shot based on the evidence they gathered. Students are able to get into the historical framework and begin to see what happened through the eyes of historic figures. They were learning to be empathetic and to judge the evidence based on the biases and motivations that the speaker might have. They looked at other opinions, compared and corroborated evidence with others. (Schrier, 2009)

The game, *Savannah*, consists of two components. At first, children (ages 11-12) play outdoors at being a pride of lions. They interact with the virtual Savannah and explore the opportunities and risks to lions. This is accomplished through PDAs with GPS. (Facer, et al., 2004)

> In order to 'sense' the Savannah, children use their handheld PDAs (with headphones), moving around the playing field outdoors acting as lions. They hear the sounds of the Savannah . . . see still images of the environment and animals to be found in the zones . . . children can also 'mark' specific information and send it back to the Den for later analysis . . . they have an energy bar that lets them know their specific energy levels at any time . . . [they] receive messages sent by facilitators in the Den – such as 'you are too hot', 'you are hungry' or on occasion 'you are dead – return to the Den.'(Facer, et al., 2004, p.400)

In the Den there is an interactive white board and flip chart. On the whiteboard is a map of the Savannah and a series of energy bars that relate to each player. When the children return to the Den, they can pull up the trails they made in the Savannah and recall the sounds and images they encountered at specific points. Each game lasts approximately 15 minutes. During the game, the children have to negotiate with each other in order to decide whether or how to collaborate in achieving the game's objectives. They also have to balance the costs and benefits of different types of activity. (Facer, et al., 2004)

MIT and the University of Wisconsin developed *Alien Contact!* to teach math, language arts, and scientific literacy skills to middle and high school students. The premise of this game is that aliens have landed on Earth and seem to preparing for a number of alternative actions, which could either be peaceful or threatening. The game is designed with multiple potential layers of complexity and is also designed to allow multiple entry points on which teacher may build on future iterations. Students, who assume different roles within their teams, work to explore the AR world, interview virtual characters, solve math problems, scientific literacy and language arts puzzles in order to determine why the aliens have landed. Students must collaborate and "jigsaw" their individual pieces of information together to be able solve the problem at hand and advance to the next stage of the game. (Dunleavy, Dede & Mitchell, 2009)

The mobile city game called Frequency 1550, developed by The Waag Society helps students playfully acquire historical knowledge of medieval Amsterdam. In a comparison of students who played the game and those who received instruction in a regular, project-based lesson series, those playing the game gained significantly more knowledge. (Huizenga, Admiraaal, Akkerman & ten Dam, 2009)

Conclusion

Research on mobile games suggests that games are able to support the learning of 21st century skills. These include critical thinking, resource management, strategic thinking, collaboration, teamwork, communication and reflection. The learning of skills in these environments is also supported by educational theories such as Situated Cognition and Social Constructivism as well as Vygotsky's theories about how play enhances development. (Schrier, 2009) Mobile games provide a means for "conducting novel learning activities that involve different tasks including physical motion, problem solving, inquiry and collaboration; all those are activities that support different cognitive and social aspects of learning" (Spikol & Milrad, 2008, p. 31). According to Klopfer's (2008) findings "Mobile games excel at connecting to existing classroom ecologies, and extending them in powerful new directions. These games fit naturally into the current landscape of teaching and learning in current schools, and also can connect school, game play, and the real world" (p. 221). Studies have shown it is beneficial to be able to "marry information and location to better learn and remember the information" (Schrier, 2009, p. 2). The portability of the handheld device and the surrounding environment enhance learning. "Placing information in a physical context organizes the new information and enables further elaboration on the material, by allowing the person to process it more meaningfully" (Schrier, 2009, p. 2).

Educational gaming through mobile devices is still not widely adopted but "many researchers see the potential of wireless mobile learning devices to achieve large-scale impact on learning because of portability, low cost, and communications features" (Roschelle, 2003, p. 260). The ever increasing use of mobile phones and PDAs, and the price drops that have been occurring, affords the opportunity for these devices to be important tools when used to support education. While there is much research to be done in this area to determine the impact of learning through mobile games, the future could hold exciting developments.

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