Students design, develop, and deploy their own location-based augmented reality games to understand science issues in their communities.

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Augmenting your own reality: Student authoring of science-based augmented reality games

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MUCH OF THE WORK in the Scheller Teacher Education Program (STEP) lab at MIT has centered on researching and developing new technologies that teach powerful new ideas and motivate students to delve deeper into science, technology, engineering, and mathematics. Many of these technologies are based on principles of simulation. While simulation has dramatically transformed the world of science and engineering research and development, its pedagogical potential has not yet reached far enough into K-12 schools. For years STEP has done research and development based not only on desktop computer-based simulations but also on mobile participatory simulations.[1] Participatory simulations also use a distributed computer-based model, but differ from traditional computer simulations in that they allow learners to take on the role of a part of a system (a fish in a pond, for example, or a fruit fly on an island), make changes and choices as if they were that element, and then observe the effects on the model. More recently, the STEP lab's research has developed a significant component that explores the educational use of augmented reality

(AR)—technology that blends real- and virtual-world experiences. These AR experiences engage students by merging a real-world context with digital simulation.

Augmenting reality

While some AR work focuses on heavily augmenting the real world with a lot of digital information, our work explores learning in real-world contexts that are lightly augmented using digital information from mobile devices like cell phones. The affordances of mobility enable activities that leverage the authenticity of real-world environments and live social interactions with other participants.[2] Within these mobile AR simulations, students primarily interact with each other and with the real environment around them. This experience is augmented with information that is accessed periodically from location-based simulations that run on personal digital assistants (PDAs) or cell phones.

The software that enables this technology combines a simulation engine with features that afford elements of game play—participant roles, goals, feedback, and challenging puzzles—to create games that are truly immersive. These games offer a new take on technology-enabled learning: the technology supports explorations and learning situated in the students' natural context: their own community and surroundings. The power in AR, which sets it apart from traditional curricula and even from purely virtual learning environments, lies in truly augmenting the physical landscape, using digital technologies to enable students to see the world around them in new ways and engage with realistic issues in a context with which the students are already connected.

TimeLab 2100

In one of the more recent games, TimeLab 2100, players role-play as affiliates at the MIT TimeLab in Cambridge, Massachusetts, in the early twenty-second century. Global climate change is out of control, and players have been assigned the task of changing the past (pre-2010 A.D.) to improve the game's present (2100 A.D.). In the game scenario, players use future technologies to travel back to the present day, where they are allowed to make small "paper-based" changes to our world. Players of TimeLab 2100 have been asked to use this technology to place new items on local election ballots in the form of measures to decrease global warming (for example, providing incentives for improving home energy efficiency) or to decrease the inevitable impacts of global warming (for example, raising roads out of a floodplain so that they will remain usable). As players are sent to explore parts of the MIT campus and research the changes that have taken place between today and the game time (2100), they are split into teams that cover different territories. Players conduct their research in pairs, with each member of the pair carrying a handheld device that allows them to be accompanied by a virtual guide (Matt or Anne) who provides them with expertise in either the scientific (Matt) or social-political (Anne) implications of each option for inclusion on ballots. In order to promote collaboration, players receive half only of the dialogue between Matt and Anne (Figure 8.1), which they must then share with their partners. This collaborative mechanism enforces a simple jigsawing of information between the two players.

Figure 8.1. A sequence in the TimeLab 2100 game

For example, one of the locations players might visit is a ZipCar station, a network of cars that can be rented by the hour through Web reservations, where they learn about a possible ballot measure to expand shared transportation options. In Figure 8.1, Matt and Anne discuss the social-political and scientific impacts of shared transportation practices. At another location, near the river, players learn that the road and sidewalk that they see is usually underwater (in the year 2100) and need to consider what to do to avoid losing use of that road. Each pair of players investigates six or seven different possible ballot measures related to climate change. At the end of the game, the players meet together and debate which three measures they will ultimately put on the Cambridge city ballot. They weigh the estimates of impact and likelihood that they have obtained along the way and incorporate their own personal feelings and expertise.

After playing TimeLab 2100, one student commented, “It really scares me to think that the place I call home might someday be underwater.” This shows that they connected the place in the game with their own community. Another player most enjoyed “running around and seeing new things, the way ordinary stuff was imagined as futuristic.” Feedback like this shows that players were able to connect the digitally represented future world with the real world of their own experience.

TimeLab 2100 is a game that balances some portability (the ability to move the game from place to place) with some location specificity (having the game connected with specific features of the real landscape). As part of this AR research agenda, STEP and several other research partners (notably Harvard University and the University of Wisconsin) have explored the costs and benefits of AR games that can easily be moved from one place to another with those that are deeply rooted in a particular location. Games that are location agnostic can be relatively easily brought to different places; players can play them literally in their own backyard. This means that they can play a particular game in one or more sessions without the need to leave their neighborhood or schoolyard. Harvard’s Alien Contact is an example of such a game.[3]

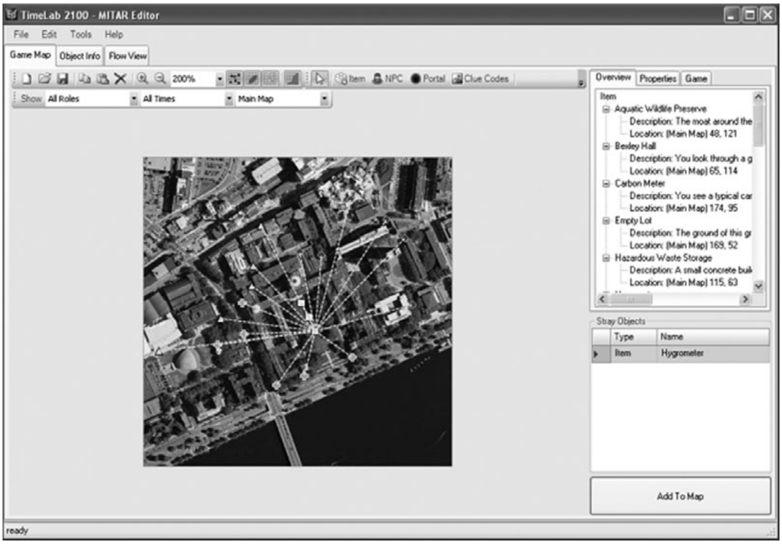
What these games gain in their portability, they lose in their connection to a particular place. A game that is deeply rooted in a location incorporates many aspects of the real world as key elements in the game. These location-specific games not only bring the real world into the game, but they also bring new meaning to familiar real-world locations. This location specificity, however, comes at the cost of laboriously building games for particular locations, including the requisite research or transporting students to special locations at great cost. The University of Wisconsin's Saving Lake Wingra was an example of such a game.[4] TimeLab 2100 was somewhere in the middle of these two extremes. It was designed to be connected to important real-world locations, but ones that were generic enough—for example, a bus stop—that reasonable substitutes could be found in other locations.

Authoring augmented reality

In order to make authoring or reauthoring games accessible to designers and educators, STEP has developed an AR authoring tool that allows designers or teachers to create AR games with a drag-and-drop interface (Figure 8.2). This tool allows the game designer to choose a map for the location where a game will be played, create characters and items, design interactions, define roles, and create a fairly dynamic experience. In other words, it includes the ability to bring in new maps, position characters and items, make logical connections between these items, incorporate data, and insert media.

After designing several games, it became apparent that the best way to connect player to location (be it a park or the community around a school) was to have the players themselves create the games. This not only solves the problem of the balance between location specificity and portability, as the players themselves put in the work to customize the game to their community. It also provides an opportunity for players to engage in important cognitive tasks and learn technical skills. The transition from player to

Figure 8.2. Interface for the AR editor



author provides a valuable learning opportunity since it brings with it a deeper experience in all of these dimensions, along with, and perhaps most important, the chance to be imaginative and creative.

In a first attempt to meet this need for students, the AR GameBuilder has been created to support student authoring of AR games. AR GameBuilder provides these basic features:

- Predefined maps and GPS coordinates provided by a teacher or instructor that students can choose from.
- Virtual characters and items that can be placed in any location on the map and identified with different symbols. Characters contain text, images, and audio/video.
- File management support that makes collecting, organizing, and deploying files easier.

The first iteration of the AR GameBuilder provided only these capabilities and was used as part of the National Science

Foundation–funded initiative, Local Investigations of Natural Science, at the Missouri Botanical Gardens. Students aged eleven to thirteen participated in a two-week summer workshop on AR game creation centered on two locations in their community. They wrestled with the appropriate kind of game to develop on this platform. But they were then focused, by instructors, on narrative and characters and were able to create games that fit the medium. Students were clearly proud of their work and took a lot of ownership of their games. One student commented: "I learned how to make a computer game I will never forget." In an interview with one of the project staff, another student commented on the pride and ownership after building their own game:

Interviewer: Describe what you've been working on for the last two weeks.

Student: I have been working on a game for Miller Park, and I have been working on finishing it and writing all my clues and everything. . . .

Interviewer: Which parts of it did you like, and why?

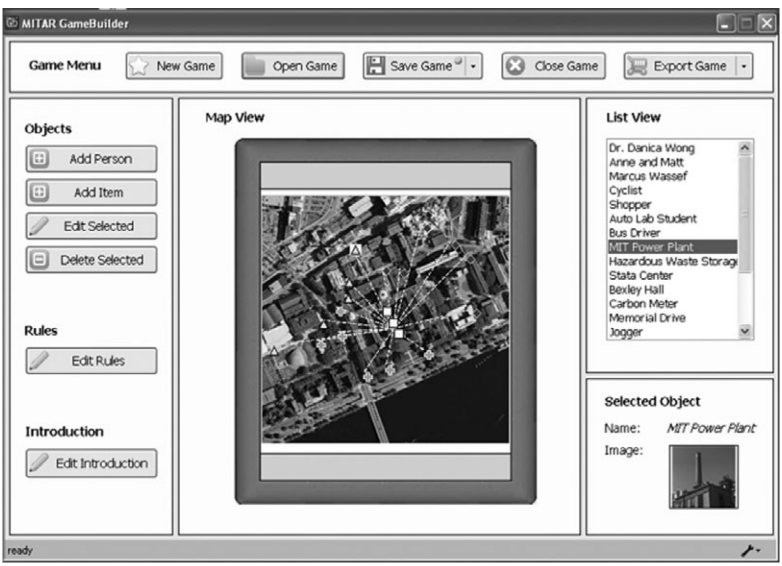
Student: I liked building off of my game, I liked making the characters because it was fun to just make up somebody and make up my own game. Usually I'm used to someone designing it for me and then buying it, for like forty dollars.

While the students successfully authored AR experiences, most of these experiences were linear narratives that simply told a story as players moved from point to point in order. Although building such an experience builds some technical and writing skills, it does not force the authors to consider the causes and consequences of actions in the game. The result is also less gamelike than one might hope. Linear nonbranching causality does not allow students to understand more of the sophisticated ideas in either the sociopolitical or scientific realms. What if you talk to the leader of the local watershed advocacy group before going to see the mayor? What if you collect scientific data only upstream and not downstream? These much more complex ideas offer a richer opportunity for students to understand issues in their communities and express their understanding of the relationships that surround them.

In order to support this more complex thinking, a newer version of AR GameBuilder supports rules. Rules allow students to create simple connections between actions at one location and consequences at another. Interviewing one witness might reveal an important new item in the game that was not previously available; speaking to one person may alienate another. Retrieving a data sample at one location may open up opportunities for comparison with other locations. Figure 8.3 shows the logical connection through rules between the two figures on the map (marked by the triangle and plus, and between the triangle diamond). Taking action in one of those locations affects the others.

This new version of the AR GameBuilder is a central tool used by another National Science Foundation–funded program, Community Science Investigators (CSI), a partnership between MIT and the Missouri Botanical Gardens. CSI combines geographic information systems (GIS), AR game authoring, and service-learning. Through these tools, students study important issues in

Figure 8.3. AR GameBuilder logical connection



their community using GIS, create AR games that express their understanding, and communicate to the community about those issues. For example, students in one community could study a watershed using GIS to understand where the water comes from and where it goes. In doing so, they might notice that runoff in certain industrial areas is a problem. They could then build AR games to allow people in the community to explore those locations and understand different options for dealing with this problem. These students then could work with the community to change those locations. Similar initiatives could be imagined around other environmental issues, as well as social issues in the community like crime and traffic. CSI is just starting in schools, and data will be available in future studies. Early feedback from teachers has shown that AR game authoring is a favorite of both students and teachers and is often the motivating factor in getting the students to engage with the issues in their communities.

Final thoughts

There are many opportunities in developing AR games and engaging learners in creating games. As more fully featured mobile devices become ubiquitous, AR games can be more than a standalone experience and instead integrate into the daily lives of students, challenging them to think differently about their communities and themselves. AR has the potential to engage students by seeing information in context and providing a platform through which they can creatively explore content by designing and exploring scenarios through the lens of games.

Notes

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