Collaborative immersive environments for the classroom

Abstract
One-to-one computing in the classroom is becoming a reality and the impressive capabilities of the devices being deployed provide an opportunity to create immersive learning environments in the classroom at low cost. We developed a platform that allows the creation of virtual worlds in the classroom using augmented reality technology and to test it, a game to teach electrostatic concepts.

Our initial tests of the platform show that it is possible to create a virtual environment inside the classroom using class oriented mobile devices and affordable technology. Future work will be done to understand what learning problems are best suited for this platform.

Keywords
Augmented reality, games and learning, education, one-to-one computing, collaborative learning

ACM Classification Keywords
H.5.2 User Interfaces, K3.1. Computer Uses in Education

General Terms
Augmented reality, collaborative learning
**Introduction**

One-to-one computing is becoming a widespread reality in many classrooms around the world. However, the deployment of devices in the classroom doesn’t improve the learning of the students by itself: technology must be supported by well designed activities based on pedagogical models to achieve the desired learning outcomes. Collaborative learning is one pedagogical model that has been successfully integrated with classroom activities [12]. In a collaborative learning activity, students work in group through a coordinated effort to achieve a specific educational goal [4].

Although the implementations of collaborative learning activities supported by technology have achieved good results, the impressive capabilities of the devices that are being deployed in the classroom allow us to aim higher. There is an enormous opportunity to take advantage of these capabilities, including wireless networking, video recording and powerful processing, to create engaging and immersive collaborative game environments in the classroom. Videogames operate under a series of good learning principles that allows the learner to master a specific domain [5]. Immersive videogames, in particular, foster an intrinsic learning potential, allowing the players to create new identities and explore virtual worlds [3].

Augmented reality (AR) is a particular technology that is well suited to create these environments in the classroom is [9]. This technology has had an explosive growth in the last years, made possible by the improvement in the capabilities of mobile devices; it is well suited for face to face collaborative activities [7].

In recent years, there has been extensive research in the creation of virtual learning environments. However, most of them are focused on creating realistic experiences outside the classroom [11], which make them difficult to deploy, or lack the technological support to create rich visual elements [2], losing the benefits that immersion provides. In this work we present a platform that allows the development of immersive collaborative games using affordable one-to-one computing devices inside the classroom.

**Augmented reality platform**

The platform we developed creates a virtual world inside the classroom, which can be visualized and explored by each student using his or her device. This device can be any mobile computing platform that has a display, a camera, wireless network capabilities and enough processing power to render 3D graphics. In our case, we used Convertible Classmate PCs [1] which are educational oriented low cost netbooks and are especially well suited because of the included rotatable camera and their touch-screen. The devices are connected using the wireless network to a server that synchronizes the virtual elements in the augmented world.

The interaction with the virtual world is achieved by creating a map that encompasses the entire classroom: Each desk is covered with a set of fiducial papers, markers that allow the augmented reality system to place virtual objects over the desks. To interact with a virtual object, each player must first identify the object by looking through his/her augmented display, and then, using a series of interface buttons, perform a specific action.
In the game the portals are used to collect the minerals. They are electrically charged to help the astronaut’s work.

To make the task more difficult, there are a series of asteroids in the space that have to be avoided.

The minerals that have to be collected have unknown electrical charge that must be discovered through exploration.

**figure 1.** Each student sees through their augmented reality devices the virtual objects that surround them in the classroom.

To allow player-to-player interaction, each student must wear a small fiducial marker in his/her forehead. This allows the rest of the players to identify him/her using the camera in their devices. A series of action buttons are provided in the interface, allowing different interactions between players when one identifies another. This kind of student-to-student interaction increases the immersion in the system, allowing the visual augmentation of the players (e.g., adding a helmet or mask) and the display of relevant information for the activity when a player is found (e.g., health points, player statistics, etc.).

During the activity, the teacher is also a part of the immersive environment. Using the same device with augmented reality properties the teacher can visualize the existing objects in the virtual world and see how each group is interacting. The teacher’s interface also provides summary views of the state of the students, showing if they have correctly achieved their goals in a given activity.

**An electrostatic game**

Using the platform described in the previous section we developed a game, First Colony, to teach the basic electrostatic concepts of charge interaction and the law of forces between charges (Coulomb’s Law) which have been proven to be a difficult subject matter for students [10]. In the game, the students take the role of astronauts of the first human colony in an extra-solar planet that are on a mission to recover a precious mineral found in space. The mineral has the unique quality of storing electrical energy and, due to the limited resources of the colony, it is essential that the astronauts capture these. Because of the fragility of the mineral, the astronauts can only interact with it at a distance, using a special device that creates an electric field surrounding them. Due to the minerals’ size, the astronauts must work in small teams of three to capture these using their electric charges to move them to special portals that can teleport them to the processing plant (Figure 1).

The game is structured in puzzle-like levels: in each level the teams must collect a mineral which is placed in a different scenario. The levels progressively increase in difficulty by introducing different aspects of electrostatics: the effect of the charge and mass of the objects, the effect of the distance between charges and the concept of additive forces. Additional in-game elements are added to make the puzzles more challenging, including asteroids that can break the minerals (Figure 1).
Discussion and Future Work
Preliminary testing of the platform shows that it is possible to create immersive games with current and affordable one-to-one computing devices. The use of augmented reality provides a simple way of creating virtual worlds inside the classroom, and the presented platform provides a huge potential for creating diverse activities and games. More extensive tests will be developed to analyze both the usability of the system and the learning achieved with the game.

The proposed platform focuses on one of the possible applications of augmented reality in a learning environment. In this platform, augmented reality is used to aggregate virtual objects in the real world, with which each student interacts and observes from a different point of view. We identify two other ways of using AR in a learning context: to augment tangible objects in a shared view [8] and to integrate virtual and real objects, recognizing characteristics of the world [6]. Therefore, the main research question that rises from this work is what kinds of learning problems are best suited for the proposed platform’s affordances?

Acknowledgements
Research supported by the Center for Research on Educational Policy and Practice, Grant CIE01-CONICYT, Games for Learning Institute, Microsoft Research and INTEL.

Bibliography