GEAR: A Game Based on E-learning and Augmented Reality Concepts

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Abstract—This paper describes the design and evaluation of a prototype GEAR, an educational game that uses augmented reality for enhancing the learning process. GEAR is a tool specifically designed to develop students' learning model. It is based on the fact that students can visualize principles and test their learning in virtual scenarios while they are enjoying it. GEAR's unique focus on alternative modes of doing laboratories exercises yields particularly interesting results. The presentation of GEAR is taken as an opportunity for proposing a uniform platform of practicing any course material using augmented reality and taking into considerations the pedagogical issues.

Experiments were performed with one class of students. Results suggest that enjoyment and excitement are important factors in motivating students, and also that GEAR produces interesting new opportunities for social interaction and exchanging knowledge.

Index Terms—E-learning, augmented reality, games, learning motivation, teaching improvement

I. INTRODUCTION

Augmented reality is designed to blur the line between the reality the user is experiencing and the content provided by technology [17]. In some cases, augmented reality has the possibility of enhancing education across the curriculum by being integrated into educational games [7]. Moreover, by exposing students to an experiential, explorative, and authentic model of learning, augmented reality has the potential to help shift modes of learning from students' simply being recipients of content to being knowledge creator. Likewise, AR encourages informal learning that is easily accessible may prove particularly effective in engaging students, extending learning to spaces that might help them form connections with content, the locations that provide the context for it, and the peers that they share it with [24].

There is a need for a training system that transcends the classroom, speeds up the learning processes, eliminates the old teacher-classroom-student model and evolves toward a methodology in which the young apprentice is the one who develops his or her own competencies guided by a tutor within a collaboration framework [21]. One of the most important purposes of an educational environment is to promote social interaction among users located in the same physical space [15]. Multiple users may access a shared space populated by virtual objects, while remaining grounded in the real world. This technique is particularly powerful for educational purposes when users are collocated and can use natural means of communication (speech, gestures etc.), but can also be mixed successfully with immersive AR collaboration.

AR has been used in many fields such as medical imaging, aviation and training [1]. AR’s main characteristic is that it enhances information, from the real world using computer-generated objects, onto the user’s world-view. The ideal AR system will be able to compose computer-generated images or videos with the real world in real time in such a way that the user cannot tell the difference. GEAR is a game based on E-learning and augmented reality concepts. It is simple and provides user with clear and concise information. An e-learning environment where learners enjoy interacting with technology and with their own peers while constructing their own knowledge does not exist. Augmented reality in this sense could bridge the gap that exists when looking at this particular problem. GEAR, as a visual tool serves as an aid deployed on site during the class, provides an active learning environment, and roots knowledge on social interactions among people while preserving the teaching objectives. GEAR is taken as an opportunity for proposing a more general practice platform about the usage of AR interactions in computer-mediated learning environments inspired by a constructivist teaching model [2].

This paper is organized in the following way: section two describes related work, organized in games and augmented reality in education. Section three describes the GEAR system and the method used to investigate the efficiency of using AR games to improve students’ outcomes and motivation. The results obtained based on one class experiments are presented in section four. Finally, section five discusses the results.

II. RELATED WORK

A. Games in Education

Games are used in conjunction with real-world simulations [6]. The ability to overlay computer graphics onto the real world is commonly called Augmented Reality (AR). AR interfaces enhance the real world experience, unlike other computer interfaces that draw users away from the real world and onto the screen. Augmented Reality can also be used to enhance collaborative tasks.

An AR game is needed as a platform to develop an application for real use in classrooms. For the development of any educational application technological, domain specific, pedagogical and psychological aspects have to be considered. Now researchers consider how
games might be used in pursuit of engaging effective learning experiences [20]. Squire and Jenkins describe five detailed scenarios designed to illustrate the pedagogical potential of computer and video games [23]. Games become the central focus of the students’ lives: they play games in classes, in their off-hours, even as part of their private contemplation. Much of the learning occurs through participation in gaming communities, as the most gifted players pass along what they have learned to the other players. Games teach by encouraging competition, experimentation, exploration, innovation, and transgression [27]. The teachers monitor the game play to increase their grasp of each student’s potential. The objective of GEAR from a pedagogical point of view is to increase emphasis on knowledge issues and the management of the practical resources. The students will come to understand the global picture of digital logic. These materials are covered in a computer organization course (COSC 2410).

The next section answers the following question: What is the educational value of the then-emerging medium of augmented reality games?

B. Augmented Reality in Education

In education, the E-learning framework as described by many researchers is very efficient in accessing information and using interactive learning. However, students raised in a high environment technology advances need more than e-learning to succeed in education. They need motivation [26]. It is like, one has the latest vehicle model, he knows how to drive but he is not motivated to go anywhere. The key to nowadays students is motivation.

Thus, the use of AR in formal education could prove a key component in the learning environment method in the classrooms and the laboratories of the future by providing fun and motivation [3, 18]. At the same time AR in education uses three theoretical learning perspectives: associative view (learning as activity), cognitive or constructive view (learning as achieving understanding), and situative view (learning as a social practice). Each theoretical perspective implies a different set of teaching approaches or practice models.

As we move forward, the big challenges won’t be technological. We are a long way from having tapped the full pedagogical potentials of existing game hardware and design practices [9]. As Orson Scott Card claimed, games have tremendous educational potential [5]. A good educational game can enable players to explore ideas in virtual worlds and to force players to form theories and test their thinking against simulated outcomes [19]. Thus, augmented reality could lead to new teaching tool. The next section suggests a motivation-centered augmented reality model for education which implements augmented reality applications using the E-learning framework and the motivation aspects: excitement, competition, experimentation, exploration and collaboration.

III. THE MODEL

Engagement theory, with its roots in situated learning and social constructivism, offers a useful framework for designing many E-learning models [22]. A learner-centred approach is shifting the focus on university campuses from teaching to learning [13]. In effect, knowledge is no longer transmitted, but is constructed by students through inquiry, synthesis, critical thinking, problem solving, and communication [14]. The technology tools available to the instructor to enhance and create interactivity are varied [12]. Boettcher and Conrad have determined that there are two types of courseware packages available: those designed only for web-based instruction and those that are considered course-management tools [4]. The packages designed for instruction offer the ability to design, develop, and deliver a web-based course. Course management packages make it possible to link to the university’s administrative functions. However, there is a need for a more professional tool which provides more excitement and motivation. Thus, the motivation-centered augmented reality model for education is developed based on the students’ motivation, teachers’ competencies, and on the suitability and appropriateness of the AR game for achieving a good quality of the learning experience through collaborative activities. A motivation-centred approach is shifting the focus on university campuses from learning to excitement.

![Figure 1. A motivation-centered augmented reality model for education](image)

The model is based on motivating student to be more engaged in E-learning through the use of augmented reality game. The student’s role change from active learner to an augmented learner involved within virtual environment. In such environment, an augmented learner enjoys exploration, experimentation while collaborating with some students and competing with others. The flexibility of collaborative environments provides scaffolding for learners in times of rapid change where standard instructional approaches can be less adequate [8, 25].

Moreover, the motivation-centered model is based on teachers’ designing and managing skills. Teachers are challenged to design technology-rich experiences and environments based upon interactive and collaborative learning (Herrington et al., 2005). Teachers are motivated to learn new ways which actively engage students in the construction of knowledge (Davidson, 1998). The teacher’s role changes from authority figure to a facilitator of knowledge then to a game manager and/or designer. Thus the teacher’s approach will be: (1) demonstrating the material (rule of the game), (2) allowing students to discover knowledge and (3) discussing the result of student’s exploration. In brief, the student’s role is becoming larger while the teacher’s role is shrinking.
The next section describes GEAR, a tool that helps academics move from E-learning to an enjoyable E-learning environment that help them overcome many of the problems they may encounter, such as managing the quality of teaching and learning in an environment, where a society moving, from the Information Age to the Virtual reality Age, mandates change.

IV. METHOD

GEAR is a game based on the motivation-centered augmented reality model for education. It has combined knowledge with the new technologies of AR to produce interesting new opportunities for social interaction. Moreover, it is designed by combining the excitement of the game with the pedagogical objectives, so that it can produce deep conceptual understandings of the material.

GEAR has been developed to provide an instrumental support to the implementation of a constructivist academic learning environment using AR and to overcome deficiencies of traditional classrooms. In the following we present the main features of the tool, we outline its implementation and we discuss its effectiveness.

GEAR is carefully designed to ensure that activities have educational merit and that students do not become taken with the technology alone. The tool draws inspiration from the basic principles of constructivism and overcomes the main limitations of traditional classrooms (monotony, dullness, and tediousness) [19]. In addition to constructivism, associability is needed to implement learning activities, and situated learning highly improves the social interaction among learners. The effectiveness of the tool has been demonstrated by the satisfaction of students revealed by questionnaires administered at the end of the semester.

The main features of GEAR are focusing on a common workspace, experimentation, exploration and collaboration. Researchers have found that when students are assigned to individual computers, they will spontaneously cluster around machines in pairs and trios [27]. In a classroom setting, students work together better if they are focused on a common workspace. When users are collaborating in front of a desktop screen, they are often sitting side-by-side and their attention is focused on the screen space. In this case, the task space is part of the screen space and is separate from the interpersonal communication space.

GEAR has been tested at the University of Houston to review the comprehensive level of students regarding digital logic.

A. Participants

Because each student has a different play experience, we team students by group of two, so that the emphasis on cooperative and competitive gaming is preserved by students’ cooperation within a team and students competitions among teams. Dividing participants into groups force them not only to learn just to play the game but to become members of game playing communities where gaming knowledge is shared among and across players. Students’ age varies between 20 and 25, and overall there were 5 females and 20 males.

The game actively involves students and allows them to investigate digital logic from a different perspective. In order for a student to be successful in GEAR, it takes a good deal of knowledge, timing and teamwork. The game will provide audio feedback sounds for correct and incorrect answers. Sounds proved to be successful for motivating students as it sounds like a TV show game. Besides, earnings points are appealing to users.

B. The system and the materials

The system is composed of many “glyphs” –3D augmented reality markers-, a camera, a PC and a very bright environment.

C. The procedure

The game prototype is tested under good lighting conditions, as augmented reality won’t work in dark environments because it is based on the camera’s recognition of the black and white printed markers. Each experiment is composed of two rounds for different teams of two. First, the teacher as mediator of the game introduces the game rules to students, second she divides the students into small groups (maximum two), and third she distributes the markers for each group. Students compete to earn as many points as possible in a limited time frame (one minute). Computation of average success is the total number of scores divided by the number of games played (for a fixed time of two minutes per group). Thus, the one way to measure the degree of learning obtained through a particular mode of education is quantified by the average success score.

The winner group is chosen by computing the average of the two players in a group relatively to their time. The winner group will have an extra of 6 points on the exam, the second group wins 4 points and the third only gets 2 points.

V. RESULT

A survey of 25 students of COSC 2410 class found that 95 percent of them had played games before they were 10 years old, and more than 48 percent of them were still playing games weekly. Sixty percent of cosc 2410 students spend more than two hours a week playing computer games. By comparison, only 40 percent spend more than two hours a week watching television, and only 31 percent spend more than two hours per week reading anything other than assigned textbook. On the one hand, one would expect these technologically advanced students to be early adapters and enthusiastic users of new media. On the other hand, given the bad reputation that gaming has in some circles, it may be news that so many students can play games and keep up the good performance in classes.

Games were clearly their preferred medium of entertainment (more than 61 percent), but they remained suspicious of their educational use as some students gave good comments without any explanation such as “great potential”, “good potential”, and “very high”. However, other students wrote detailed comments about what they thought as the educational potential of this game. One student commented that “GEAR has much potential of helping students making learning easy”, others positive comments are observed such as: “To help reinforce things those were taught in class”, “fun way to involve students”, “I would be more motivated to study with this software”, “good way to review the material”, and “Students learn things while they playing”.

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Interestingly, people raised in an era of instantaneous global communication, advanced technology and gaming-environment like to learn by their own ways “playing computer games”. Exactly what students learn from the game-playing experience depends heavily on the goals teachers and game designers set for them. The course 2410 students express their enjoyment of learning by commenting such as “It is very interesting due to the fact that it increases knowledge when playing it”, “Makes learning more fun and drills the stuff into your head”, “Easy to learn, reinforces things I already knew.”, “It was fun and educating”. Besides, ninety percent of students consider that GEAR produces interesting new opportunities for social interaction and exchanging knowledge.

The students assign different levels of importance to factors which are more powerful in boosting their motivation to learn. Excitement, experimentation and exploration obtain the highest percentage around eighty two percent, while collaboration gets eighty percent, and finally the competition factor gets a hold of sixty six percent.

Several minority students were totally uninterested in playing the game until they realized that it was possible to win.

VI. DISCUSSION

The results obtained so far indicate that using GEAR is a positive step forward towards achieving the goal of effective learning. One of the interesting observations we made was the impact GEAR had on the whole class collaboration. Besides, students trust that their learning will be highly enhanced by adding to the E-learning framework environment the following features: excitement, experimentation and exploration, collaboration and competition. In fact, GEAR managed to provide a unique, compelling educational experience.

The potential benefits of using gear as an AR system in teaching and learning environment are: (1) Provision of tool that enable the fast and efficient generation and dissemination of learning material, and a set of virtual scenarios and support materials that student can control and interact with. Many students wrote comments such as “interactive participation to abstract ideas”, “It was interactive”, (2) Simplifying the teacher’s task in providing much more stimulating practicing exercises and exam reviews. Some students mentioned that they “think it's a good way to review the material”, and (3) enabling team working, which is essential when working in industry. Developing team skills is an essential part of the learning process; one student said that he enjoyed being a member of a team to study with this software (GEAR).

This application of Augmented Reality (AR) may be used in many ways to provide significant value in education and for learning such as different learning styles, authentic learning, realistic models, and engagement and interactivity. In fact, the ability to provide visual and time lapse examples engages many styles of learners. The ability to annotate real elements and the ability to add to reality by superimposing virtual aids, will aid in instruction, learning and remembering elements of materials. The ability to provide a means of "seeing" phenomena in 3D, thereby bringing the contextual three dimensional nature of the real world to the learning.

VII. CONCLUSION

The model discussed earlier (Figure. 1), has three benefits: (1) it accommodates different learning styles, (2) it provides a collaborative forum, and (3) it allows for the organic genesis of a technological and information literacy infrastructure on campus.

GEAR’s immediate task is to build a tool set so that educators around the world can localize augmented reality games to their own facilities. This GEAR design model emphasis the fact that there is a natural crossing over between teaching strategy and game design [10, 11, 16].

Teacher strategy by demonstrating the material, allowing students to discover the answers and consenting to use discussion as a mean to enforce the collaboration and social interactions, associate with the AR interface of visualizing the materials, giving students enough time to find the correct answer and teaming students in groups.

Moreover, Gear is a tool that leads to fostering an education-prone environment. Although augmented reality technology is not new, its potential in education is just beginning to be explored. Unlike other computing technologies, AR interfaces offer seamless interaction between the real and virtual worlds, a tangible interface metaphor and a means for transitioning between real and virtual worlds. Educators should work with researchers in the field to explore how these characteristics can best be applied in a school environment.

In order to better understand the educational efficacy of GEAR in learning, extensive evaluations are necessary. Evaluations should be done on different levels such as on usability issues of the application and/ or efficacy for supporting learning.

REFERENCES


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