UTILIZING INTERACTIVE TABLETOPS FOR EDUCATIONAL GAMES

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Abstract: There exists a multitude of different platforms for educational games. As technology continues to mature, various new devices will arise, some of which may yield substantial benefits for such educational applications. In this paper, we discuss the potential effectiveness of one particular device for educational games, interactive tabletops. We introduce what we believe are the key reasons why interactive tabletops are appropriate for this domain. In addition, we present two of the games we have developed for evaluating our claims. Although we have not yet conducted a complete user evaluation, we will provide some of our impressions from preliminary trials.

1 INTRODUCTION

In recent years, the advances in interactive tabletop technology has proliferated the use of digital tabletops. Although tabletop computing is not a new technology, it has not experience true acceptance and application due to limited functionality and expensive and complicated construction. However, recent advances such as the DiamondTouch surface (Dietz and Leigh, 2001) and FTIR (Han, 2005), in addition to our own new multi-touch technology, mitigates the aforementioned limitations by allowing for the low-cost construction of robust multi-touch surfaces. Consequently, these technologies have precipitated tremendous growth in applications for interactive tabletops. In particular, we are interested in pedagogical applications in the form of educational games and whether or not interactive tabletops would be an effective platform in this regard.

The educational benefits of games have been well documented and extensively investigated in research (Schwartzman, 1997; Garris et al., 2002). Empirical evidence has shown that games can promote motivation, thereby causing students to become more intensely involved in a particular learning activity and ultimately allowing them to retain more knowledge (Cordova and Lepper, 1996). Additionally, games encourage active learning where students are actively involved in the learning process, as opposed to passive learning where students follow the instruction of a teacher. Literature suggests that active learning strategies can have a much more significant effect on knowledge acquisition than those of the passive ilk (Bonwell and Eison, 1991).

The effectiveness of games on the learning experience, however, cannot be measured simply in terms of the game itself. The particular device which presents the game to the user should be a significant consideration as it also contributes to the overall learning experience. There exist a number of platforms for educational games; however, in this work we are not interested in providing a comparative study between the various types. Instead, we want to focus our attention on one particular platform, interactive tabletops. More specifically, we want to explore the potential benefits of applying educational games to this technology. In addition to discussing how interactive tabletops can enhance the effectiveness of educational games, we will describe the two games (Block Earth and Wave Touch) that we have designed and implemented on our newly developed multi-touch tabletop surface. Since we have not yet conducted a complete

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user evaluation in regard to these games we will, instead, provide some preliminary observations.

2 BACKGROUND

The intuitiveness and the engaging effect touch-based interfaces afford are indicative of its allure among users. Touch interaction allows users to feel more directly connected to the interface and its this tangible quality that helps the interaction feel more ”natural” and ”compelling” (Forlines et al., 2007). Although these types of interfaces may seem new, they have been researched and developed dating back as far as 1972 (Smith and Sherwood, 1976). However, not until recently, research regarding touch-based technology has been stagnated. With new developments such as the DiamondTouch surface (Dietz and Leigh, 2001) and FTIR (Han, 2005), as well as the release of the iPhone and Microsoft Surface, research in touch-based interfaces has finally started gaining momentum. Notably, there has been a marked increase in research pertaining to tabletop computing. One of the main draws of tabletop interfaces is the social nature of them. Tabletop interfaces allow multiple users to come together in an intimate fashion and work collaboratively on a shared medium. Intrinsically, this type of environment promotes social interaction and enhances collaborative work among a group of users (Stewart et al., 1999; Rogers and Lindley, 2006).

As previously indicated, the recent advances in touch-based technologies have significantly reduced the construction costs of interactive tabletops, allowing for more widespread accessibility. As a result, a myriad of different applications have been explored, ranging from business to gaming, along with research regarding usability (Abednego et al., 2009). However, we’re particularly interested in the pedagogical applications of interactive tabletops. Over the past few years, there have been numerous works regarding these types of applications. DigiTile (Rick and Rogers, 2008) helps students learn about concepts of math and art by leveraging collaboration. Likewise, the suite of learning applications, ClassificationTable (Morris et al., 2005), MatchingTable (Morris et al., 2005), and PoetryTable (Morris et al., 2005), rely on the collaborative and social affordances of interactive tabletops to teach students foreign language. Teaching Table (Khandelwal and Mazalek, 2007) utilizes an augmented tabletop environment to teach math fundamentals to children, ages three to five. In this application, children engage in several different activities, which involve moving around numbered blocks on top of a tabletop to accomplish certain mathematical tasks. Similarly, Read-It (Sluis et al., 2004) teaches young children how to read through the use of tangible objects on top of an interactive tabletop. There have also been educational tabletop games to help autistic children. SIDES (Piper et al., 2006) is a four-player cooperative tabletop game aimed at helping children with Aspergers Syndrome improve group working skills.

3 INTERACTIVE TABLETOPS FOR ENHANCING EDUCATIONAL GAMES

Interactive tabletops have the potential to greatly enhance the overall effectiveness of educational games. An obvious digital affordance of tabletop technology is the support of computing power. A tabletop interface is typically built on top of a computer so it can exploit the processing capabilities of the CPU and GPU and, thusly, provide rich graphical information to the user. Aside from this obvious advantage, there are other more salient reasons why interactive tabletops can serve as an effective platform for educational games. These reasons are related to tabletop interaction modalities, collaborative properties of tabletop environments, and motivational stimulation.

3.1 Tabletop Interaction

Interactive tabletops afford immersive interaction environments in which users can participate. Users actively engage with these interfaces through a plethora of interaction modalities, most of which involve some form of physicality. One of the more distinct and recognizable modalities is touch interaction, or in other words, direct manipulation. Instead of using indirect methods such as keyboards and mice, which are standard on conventional computers, users manipulate interface objects by directly touching them on the tabletop surface. This modality is much more intuitive and engaging than pushing buttons on a keyboard or clicking on a mouse. In a sense, the indirectness of a mouse and keyboard cultivates a state of detachment between the user and their actions, whereas touch interaction promotes a greater sense of control and awareness. Interactive tabletops can also allow for users to interact with applications via tangible objects on top of the tabletop surface (Khandelwal and Mazalek, 2007; Sluis et al., 2004). These unorthodox interaction techniques blur the line between the physical world and the digital world, which contribute to the immersive and engaging effect of interactive

tabletops.

The relevance that these interaction modalities have on education pertains to the concept of active learning. Active learning entails active participation of a student in the learning process. So instead of passively listening to a teacher, learning is better served by engaging in activities that force the student to actively think about the material (Bonwell and Eison, 1991). Therefore, it is reasonable to presume that interactive tabletops improve learning by utilizing interaction modalities that encourage active learning. In fact, past research affirms this notion (Price and Rogers, 2004). When students use interactive tabletops they are physically engaged with the interface. They become more engrossed in the environment, which in turn intensifies their involvement with the educational activity. Presumably, students will exhibit higher levels of attention and critical thinking allowing them to learn more from the experience than they would have from conventional methods.

3.2 Collaborative Experience

One of the key pedagogical benefits that interactive tabletops afford is the ability to incite collaborative environments. Empirical evidence has shown that large interactive displays, positioned horizontally, encourage groups of people to work together in a "socially cohesive and conducive way" (Rogers and Lindley, 2006). The physical orientation of the tabletop forces users to arrange themselves in a face-to-face fashion around the interface, allowing them to easily converse and refer to pertinent information. This arrangement is akin to organization around meeting room tables and is conducive to natural and fluid group work.

So then how exactly do collaborative environments contribute to the learning experience? One can say that part of the reason is due to the assistive nature of the environment. When students work individually they must rely on themselves and on the tools that are presented to them to develop an understanding of a concept. When students work collaboratively, however, they can benefit from the assistance of others to arrive at an understanding. Studies have found that collaborative interaction increases the amount of common knowledge that is shared by the participants as well as the amount of overall knowledge that is acquired by each individual (Jeong and Chi, 2007). Moreover, collaboration can potentially bolster motivation and ultimately provide a more enriching learning experience (Inkpen et al., 1999; Jung et al., 2002). Passive learning environments and individualized learning tend to instill a sense of boredom within students. As a result, their attention may waver during the course of the experience causing them to attain less knowledge. In contrast, collaborative environments introduce a social element that induces more active involvement (e.g. working together to achieve a goal). Although it is conceivable that certain participants may be left out of the activity by more socially active members, this is less of a concern with games since teamwork can be coerced. Several practical applications attest to validity of the aforementioned claims by demonstrating the effectiveness of collaboration on education (Rick and Rogers, 2008; Morris et al., 2005; Piper et al., 2006).

3.3 Motivational Enhancement

Motivation is a critical psychological factor in the learning process. Students who exhibit higher levels of motivation in a particular learning activity learn and retain more from the experience (Cordova and Lepper, 1996). This notion is sensible because motivational stimulation correlates with a deeper desire to learn, whereby increasing engagement and the poignancy of the knowledge acquired. Ostensibly, students that have more motivation typically put forth more effort in the learning process. Therefore, another way interactive tabletops can improve learning is through enhancing motivation. As previously stated, the collaborative environments of interactive tabletops increase the motivation of students. Moreover, these interfaces can potentially bolster motivation through the novelty of its touch technology. Although somewhat of a speculative assertion, touch-based interfaces appear to conjure astonishment from its users, especially young children, which may be part of the reason why Apple's iPhone has been so wildly popular. Due to their futuristic appeal, interactive tabletops may elicit more interest and curiosity from users than conventional devices. In turn, users may feel more inclined to interact with these types of interfaces.

4 INTERACTIVE TABLETOP GAMES

In order to eventually gauge the legitimacy of our assertions, we developed two example applications called, Block Earth and Wave Touch. We implemented these games on our newly developed multi-touch surface, which allows for the simultaneous interaction of multiple users. These particular games were developed specifically for children; however, participants of any age may benefit from them.

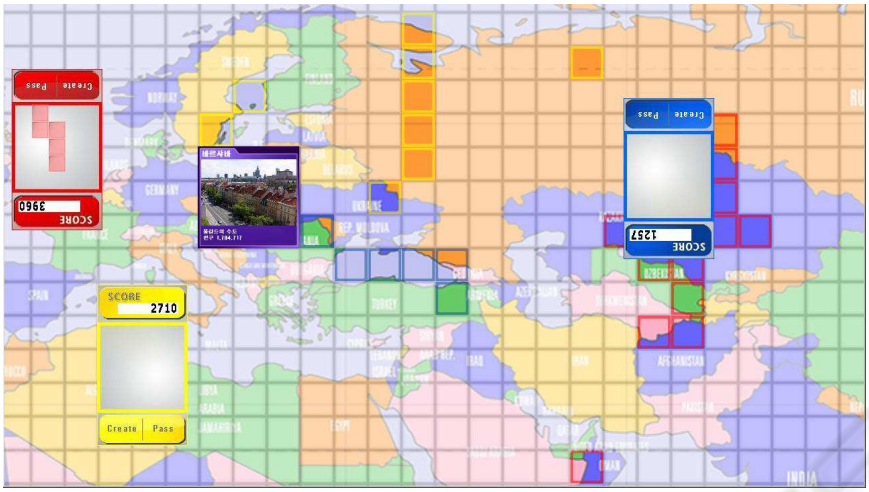

Figure 1: Block Earth.

4.1 Block Earth

Block Earth is a simple game which teaches users general geographical information. More specifically, users develop a familiarity of the world by exploring a world map and learning about the location and shape of various different countries and continents. The mechanics of the game are simple, each user maintains control of a particular color and, alternatively, places blocks on the map to uncover hidden locations. At the beginning of a game there exists an assortment of colored blocks placed randomly on the map, with each color corresponding to a particular user. Alternatively, each user receives a randomly shaped block and must place it diagonally abutted to a block of their assigned color, or they may choose to pass their turn. If the block that was placed overlays one of the hidden cities on the map, the user will receive a score equivalent to the citys population. In addition, an information panel will appear containing relevant information about the specific city (Figure 1). A player wins by attaining a certain amount of points. There is no risk of user alienation since each player will alternate turns, therefore, everyone will be able to actively participate in the game.

4.2 Wave Touch

Wave Touch is another simple game but in this case users learn about historical artifacts pertaining to their culture. In essence, players are immersed in an underwater-esque environment and must uncover hidden treasures scattered throughout the background. When a player discovers and selects on a piece of treasure, information about that treasure will be presented. In the current implementation, the types of treasures presented concern Korean heritage; however, the game can be tailored to any culture. Players can move around in the environment using various touch gestures. Dragging a single finger around the interface causes the scene to be translated in the direction of the finger motion. Using two fingers, players can zoom in or out by applying pinch or reverse pinch gestures. In addition, each point of contact on the interface will generate a realistic water ripple effect (Figure 2).

Wave touch supports competitive and collaborative game environments. Players can choose modes which allow them to compete individually or work together to find treasure artifacts. In the competitive mode, each player will alternate turns and receive scores based on the type of treasure they find. Occasionally, a player may select a ”fake treasure,” in which case they will be awarded no points. In the collaborative mode, all players can interact simultaneously to uncover treasure items.

5 PRELIMINARY IMPRESSIONS AND FUTURE WORK

Although the actual design of educational games is a significant issue (i.e. game elements should be carefully engineered to conform to specific educational purposes), that was not our underlying concern with this particular research, which is why the design of our games may appear rather shallow. Instead, our sole purpose was to ascertain the potential effectiveness of interactive tabletops as a platform for educational games (i.e. whether or not this research line warrants further investigation).

Figure 2: Wave Touch.

We have just recently finished developing the two aforementioned games, so we have not had an opportunity to conduct a full-fledged user evaluation. We have, however, had several participants experiment with the games and provide us with some initial feedback. Almost all participants commented on how pleasing the multi-touch interface was, with several remarks alluding to its attractiveness and ease of use. Everyone appeared quite engrossed in the applications, largely in part due to the touch interaction. There was almost unanimous agreement preferring this type of interface to conventional computers for group activities. Several participants enjoyed the social atmosphere afforded by the tabletop environment. With the Wave Touch game, we overheard a lot of enthusiasm and cooperation between the participants with remarks such as ”Oh there it is!!” and ”I just saw it! Go up, go up!” There were also minor discussions sparked by game content (e.g. in Block Earth, when surprised about the population size of a particular city, users would comment on that subject). Essentially, these preliminary reactions demonstrate the dynamic atmosphere that interactive tabletops can provide and reinforce some of our claims about why they can enhance the effectiveness of educational games.

In the near future, we plan to conduct an extensive user evaluation to properly assess the value of interactive tabletops for educational games. It may also be worthwhile to explore other issues such as potential limitations and challenges. In addition, we are thinking of ways to refine Block Earth and Wave Touch to provide deeper educational worth instead of merely superficial content.

6 CONCLUSIONS

In our work, instead of concentrating on a specific educational game intended for a distinct pedagogical purpose, we were more concerned about interactive tabletops as a platform for these types of games. We wanted to elucidate a rationalization of why interactive tabletops would be an effective platform for educational games. In this work, we hypothesized that interactive tabletops enhance educational games through touch interaction, collaboration, and motivational stimulation. The touch-based interaction modality of tabletops provides users with a more intuitive and engaging interaction technique, which helps promote a more immersive and exciting environment. The physical layout of interactive tabletops naturally allows groups of people to work collaboratively on a task. Studies have proven that this type of intimate interaction on a large, horizontal display fosters effective collaboration, which in turn improves the learning process. All of these factors combine to cultivate an environment that can stimulate motivation among users.

To examine the validity of these claims we developed two educational games called, Block Earth and Wave Touch. Block Earth teaches young children about general geographical information, such as country and continent locations. Wave Touch teaches children about information pertaining to their heritage, such as famous historical artifacts. In the near future, we plan to conduct an extensive user evaluation with these games. That said, preliminary impressions have indicated that our assertions regarding the benefits of interactive tabletops for educational games hold some merit.

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