Research and Development of K-12 Learning Games Via the Undergraduate Student

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1. Abstract

There is an increasing amount of specific research on children's interactive learning games and the fascination of video games. "The fact that children spend considerable amounts of time playing computer games is a phenomenon that has not gone unnoticed by educators"[Robertson and Good 2005]. This paper explores how an undergraduate Computer Graphics program can take advantage of current research while considering the k-12 curricula. The current traditional-undergraduate population consists of a vast reservoir of potential insights and curricula should be developed to take advantage of these insights. These students are one of the first groups of students where most have had technology available to them throughout there educational careers. This area is just newly explored and will take time to understand how it can actually enhance classroom activity and whether these technologies can be successfully integrated into the classroom.

2. Research on Collaboration

Research indicates that various ages of children face physical, emotional, developmental, and social challenges when considering the use of software and hardware technology. Many studies point to the benefits of collaborative learning. Studies conducted by Inkpen et al. on individual, cooperative and competitive groupings compared solo play, parallel play and integrated play. This study showed that girls and boys solve more puzzles playing together on one machine in the integrated play condition than play with themselves in the solo play. The research also made the point that even though they enjoyed playing with friends, it was difficult to share an input device. This study pointed out that changes in current hardware and software might improve children's physical and social needs. Grouping children around one computer does not negatively affect performance and in the case of female/female groupings, it can have a positive effect. [1995]

The above research along with current research demonstrates that creating interactive learning games modules where the student's work together can be extremely rewarding and beneficial to the learning experience. Ideally, these learning game modules would provide the same type of fascination, challenges and entertainment that mass-market video games have achieved in captivating the students. Similar to the structure of these mass market games, the learning game modules should be developed not only to provide cooperative play but to allow students to work independently to progress further in the learning game modules. The design should allow for this learning to occur both at school and at home. Many studies have demonstrated the need for not only collaborative learning but that the same type of challenges demonstrated in computer and video games. The "Read-It Five-to-seven-year-old children learn to read in a tabletop environment", studies found that "children exhibit a significantly higher level of engagement and activity when working alongside each other. Such findings are especially relevant for one particular activity that most children share: education. A collaborative environment is more likely to elicit increased intrinsic motivation, which is an important factor in productive learning of new skills". [Sulis et al. 2004] The study further states that video games are based on challenge, fantasy and curiosity, which combine intrinsic motivations for learning with interpersonal motivations. Cooperation and competition are a result of this type of play. [Sulis et al. 2004]

3. Hardware Issues

Along with collaborative learning, the method of deployment of educational learning games must be considered. The learning game modules should have the same look and feel of existing computer and video games. There has been a tremendous amount of research centered on the optimum methods for interactive techniques. Numerous options should be considered when choosing the devices to provide for the interaction. Each of these options has their advantages and disadvantages for learning game module development. In a study done comparing Drag and Drop vs. Point and click mouse interaction for children, by Inkpen et al, included 36 girls and 32 boys ages 9-16. It was revealed that point-and-click had better accuracy rates and preference for boys and girls than the drag-and-drop. Girls were able to complete more games with the point-and-click rather than the drag-and-drop method. The problems with the drag-and-drop method were:

1. It made their fingers and hand tired.
2. It was hard to keep the mouse button down
3. More errors were committed
4. If target was missed the user had to start over.

[1996] Inkpen additionally states, "Today's children will be the adult computer users of tomorrow and interactions with computer today will shape their future relationship with technology." In order to design effective interaction techniques, "we need to use a deeper understanding of task, device and the interrelationship between task and device from the perspective of the user". [1996]

Other studies have focused on hardware and interaction of interfaces dictated by the configuration of hardware. The research conducted in Mouse and Touchscreen selection in Upper and Lower Visual Fields by Po et al. focused on how to interpret functional specialization of the Upper Visual Fields and Lower Visual Fields when using a mouse or touchscreen display. This study evaluated eight subjects, 5 male and 3 female, ages 19-40. Although this research was not targeted specifically to children the implications are worth considering when creating educational games for children. In the performance speed, error rate and user preference,

touchscreens yielded certain advantages in selecting targets as small as four pixels. [2004]

Along with this research, studies have demonstrated that the Upper Visual Field is more attuned to object recognition by exhibiting longer persistence in those fields. [Heidner and Groner 1997] Further studies correlate the relationship of the Lower Visual Fields and LVF and brain areas responsible for visually-guided motor processing. The two visual systems provide options when determining the methods to be used in learning game modules. The use of the touchscreen methodology could provide faster and more accurate response to the interactivity within the learning module, adding to the success of the game. Unfortunately, touchscreens might not be economically available to many educational institutions. [Bridgeman et al 1997; Milner and Goodale 1995; Po et al. 2003; Danckert and Godale 2001]

4. Collaborative Hardware Issues

Other considerations when developing the interaction of learning game module's is the possible use of other selection devices such as laser pointers. Research conducted by Vogt et. al. on 24 participants between the ages of 20-29, might be a significant alternate consideration for children's learning games. This research centered on the comparison of mouse pointer to laser pointer interaction in a problem-solving task involving groups of one, two and three people. "We show that collaborative performance is largely orthogonal to motor performance and that the interaction patterns are dependent on the task and on the group size". [2004]

Their observation results revealed that most participants found it easier to use the mouse due to their familiarity with it. Others preferred the laser pointer because it was less restrictive than the mouse. Additionally the laser was better for collaborating and strategizing, but the mouse was easier when fine motor skills were required. "This suggests that laser pointers are better suited for collaborative activities involving information sharing and active discussion while multiple mice are better suited for collaborative activities requiring continuous, precise display manipulation or distributed problem solving". [Vogt et. al. 2004]

5. Behavioral Considerations

Beyond the collaborative and hardware issues that must be addressed when developing interactive learning games in the classroom curricula; off-task behavior must be acknowledged and anticipated. Research has indicated that this type of "gaming the system" can have a detrimental affect on the learning objectives. Gaming-the-system as portrayed in this research is not really cheating a tutorial or other learning module, but basically finding the loopholes or ways to circumvent the objectives. It was discovered that some of the students would use the built in support features of the tutorial software, for example, to obtain the correct answers without having knowledge of the answers. This type of behavior would also employ techniques such as clicking every checkbox within a set of multiple-choice answers until the tutor identifies a correct answer and allows the student to advance. [Baker et. al. 2004] It is important to understand this type of behavior when developing learning game modules and using this knowledge to work to the advantage of the module's learning goals. This could involve developing the help and support functions as part of the overall learning process. The main goal is to keep the student occupied with the module in a learning methodology. It should be noted that one of the key components of classroom activities and learning is well defined in Carroll's Time-on-Task hypothesis [Baker et. al. 2004; Fitts 1954; Intriligator and Cavanagh 2004]. Under this hypothesis, the longer a student spends engaging with the learning materials, the more opportunities the student has to learn". "This hypothesis suggests that off-task behavior will reduce learning. If it is the main reason why off-task behavior reduces learning, then other types of off-task behavior, such as talking to a neighbor or surfing the web, would have a similar effect on learning as gaming the system does." [Baker et. al. 2004; Fitts 1954; Intriligator and Cavanagh 2004] This could be an indication that computers may not be able to completely replace the human instructor, but might enhance some types of learning.

6. Children as the game designer

Instead of studying the child as a game consumer, research by Good and Robertson put children in the "line of construction", allowing the children to design and implement their own games. They investigated the relationship between game creation and the development of children's narrative skills. The main list of characteristics which children felt were important when they have a good sense of purpose, goal to complete and the players' choice and ability contribute to the action or plot. Collaboration and interaction through dialogue, varied pace such as adventurous, exciting and scary. Good quality graphics were cited a being important along with narration rather than lots of on-screen text. The appearance of the characters and their motives were also an important contribution. [2005]

Good and Robertson also stated that good games go beyond a simple quest, events and consequences; they should have an effect on the plot. From the onset the player needs a clear indication of purpose and goals within the theme. The objects and the visual aspects should be representative of the game. The character appearance should give an indication of their personality. The environment should flag the player as to what their choice of actions may bring. If they have to move aimlessly through the game the motivation could diminish. [2005]

7. Implications

The development of learning game modules is an extremely daunting task with countless options and paths to follow. The learning game modules should incorporate all the technology available with the understanding that many educational programs do not have these technologies. In these instances, the learning game modules should be designed to accommodate less sophisticated technologies. The need for this form of educational tools can be best illustrated by examining the statistical information on who plays these games. Over 50% of all Americans play video games. Of these gamers, 30% of the most frequent Computer players and 38% of Console gamers are under 18 years of age. The encouraging aspect of video gaming is that 96% of the parents questioned are concerned about what their under 18 year olds are playing and that 60% of this same group play video games with their children at least once a month. [IDSA 2002] This indicates that including the parent in the activity could have positive effects on learning and learning game modules.

8. Undergraduate Student Survey Results

The current undergraduate population consists of a vast reservoir of potential insights. These students are one of the first groups of students where most have had technology available to them throughout there educational careers. In an effort to gain insights into how they would view learning game curricula, we preformed a survey of our current Computer Graphics students. We, at this point, surveyed a sampling of 39 students predominantly sophomores and juniors on some of the important aspects of learning game development. Listed below is a summation of the responses followed by the questions used in the survey.

The majority of students responded that a good learning module would deal with Science, Math and Physics. There were also responses referencing History and English. The main themes were a race against the clock or each other. Fantasy such as time travel or actually playing the part of a historical figure dealing with the issues of that time period was an aspiration by many of the student's games. The goals were closely related to the type of game being proposed. In most cases there was a mechanism for advancing through layers of the game, along with good graphics, good sound and most of all "good game play". In our sampling there did not seem to be an overwhelming preference of whether they preferred Player vs. Environment (PVE) or Player vs. Player (PVP) type of play. The need to advance by beating a score, the computer or a competitor and move to the next level based on their newly acquired knowledge was an overwhelming response.

The most interesting aspect of the survey was that no one really addressed the winning of the game. There seemed to be more emphasis on how one progressed through the game, mainly through layers, rather than how to win. This observation along with the other responses strongly supports current research cited in this paper, especially the studies of Good and Robertson. It appears obvious by the sampling of these students that intrinsic goals of improving their scores through game advancement, group play, good graphics and sound are key elements in creating learning games. Students also overwhelming responded that they felt that the use of video game technology would have enhanced their k-12 leaning, especially in subjects that were difficult for them to comprehend.

9. K-12 Teacher Survey Results

Along with the survey of students, we also questioned a number of k-12 educators to gain some insights into the educators' response to learning game modules. The only overwhelming response from k-12 educators was that they desired more opportunities for learning computer technology themselves. Many responded that they were not prepared for computer technology and did not have the financial support to become current or "chase the technology". In our questionnaire we asked about "interactive learning modules" and in a separate question asked about "video games" in the class room. Very few responded that they would ever even consider using a video game in their classroom. Most responded that they would be in support of an "interactive learning module" for learning and support. This indicates that the words "video game" is not synonymous with learning. We are not endorsing pandering with different terminologies, but the negative aspects of some video games could retard the good that can come out of these learning modules. We need to understand why students will spend hours learning, reading and working to progress to the next level in a video game.

Another interesting insight of the teacher survey was that most of the educators viewed the use of a computer as an individual activity and not a collaborative one. They also pointed out that collaborative activities were extremely important for enhancement of learning and explorative skills in the classroom. A few teachers pointed out that the computer should not replace the connection between teacher and student, especially with the younger students. The socialization of the classroom was considered as important as what they learned. Physical fitness was also cited as an area where the computer should be excluded as a form of computer learning activity.

For the most part the educators we surveyed did not use computers or computer learning modules in the classroom. This was mostly due to the lack of funds and available technology, as well as training.

10. Conclusion

The success of any game depends on the clearly defined goals of the game. The goals of learning game modules must be more than just "learning math". It should also include an intrinsic aspect that creates excitement within the game. The real question than becomes: How do you capture the enthusiasm and thrill of fantasy within video games and incorporate that into the design of the learning game module?

To integrate learning game modules into the k-12 classroom technology asset limitations must be recognized. Thus, the learning game modules must be effective with affordable dual input device devices until the more expensive and sophisticated techniques such as touch screens, laser pointers and table top environments become cost effective within the k-12 school system. Some educators in the survey stated that they did not even have working computers in their classrooms at this time. They also brought out the point that the schools systems did not have adequate tech support to house any type of technology.

11. Future Work

Our research is ongoing and will continue to accumulate survey results from both the k-12 educators and undergraduate students. In addition, we are developing a set of survey questions to be distributed to k-12 students as well as their parents. The exploration of the research in this field will be an ongoing activity providing additional insights into the implementation of learning game modules into the classroom. A current outcome of this research and exploration is that we have nine students creating learning game modules, which will be tested in summer and fall of 2005 on k-12 students. We have also planned a specific course to offer to interested undergraduate students in Fall 2005 which will provide undergraduate students the opportunity to research, develop and test learning games. By assessing the research and participants we hope to gain additional insights for this new area of study as well as additional funding.

1. Student Survey

If you were designing a children's learning game, how would you answer the following question based on your experience with playing games.

1. In your k-12 educational experience, what course do you feel could have been enhanced by computer technology or game technology?
2. What would the game be?
3. What is the goal of the game?
4. What is the key element, theme, or topic?
5. Would it be Individual player, Player vs. Environment (PVE) or Player vs Player (PVP)?

1. K-12 Teacher Survey

1. What types of technology would you like to integrate into the classroom?
2. How do you feel it would benefit students learning?
3. What is your vision of technology?
4. What subject matter would a computer or some kind of interactive learning module better enhance their learning experience?
5. Give a child a computer and what do they do?
6. What do you feel is your biggest roadblock in education and technology?
7. Do you bring the video game entertainment into the classroom?

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