Educational Games in the PK-12 Environment

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Abstract

The purpose of this research was to determine the effect of learning games on preschool children in terms of learning outcomes, level of engagement and satisfaction. The presenters will discuss the preliminary findings of this research as well as the practical implications of using learning games with young children. Additionally, the presenters will discuss the teacher satisfaction with this intervention as well as future research opportunities and recommendations.

Introduction

In recent years, the computer game and simulation industry has grown fast and become a part of American culture. Computer learning games are not only welcomed as a way to motivate learners, but also can serve as a mechanism for learning. Prensky (2001, 2006), Aldrich (2005), Gee (2003, 2005), and Shaffer (2006) have written extensively about the potential benefits of using computer games for learning. According to Mitchell & Savill-Smith (2004), games assist all different learning styles by supporting confidence and encouraging multimodal literacy through the use of video, audio, and text. Game players, especially children, are more interested in games with good audio and video (Vernadakis et al., 2005). Kirriemuir & McFarlane (2004) identified that the experience of game play seems to be affecting learners’ expectations of learning activities. Therefore, the idea of integrating computer learning games into the curriculum is becoming an important research topic in education.

The use of computers has been prevalent in education even at the preschool level. Much of the research conducted in preschools has looked at the impact on the social skills of preschool children (Chen & Chang, 2006). Using computers in a preschool setting has been found to increase the motivation of young children (Mioduser, Tur-Kaspa, & Leitner, 2000). However, there is a lack of understanding whether game-integrated technology tools indeed can enhance student-learning outcomes in the area of literacy as compared to technology tools without games and simulations. There is a growing need to understand, empirically, how well the learning with educational computer games occur particularly in the preschool setting. Limited research has been completed on the impact of computer learning games in preschools (Chen & Chang, 2006; Clements & Sarama, 2003). As a result, a key goal of this study was to investigate how computer games may affect student learning outcomes in the preschool setting.

Literature Review

Computer Literacy Games and Preschoolers

In early childhood education, the use of computer software as both a successful learning tool and teaching method has increased rapidly over the last thirty years (Blok et al., 2002). Preschool children should not be kept away from computer learning games based on their age or developmental levels. Instead computer learning games combined with traditional teaching methods have the potential to enhance children’s learning and help them meet educational goals (Vernadakis et al., 2005).

Children’s learning through the use of computer software is becoming viewed as a positive learning tool that can be used as a major contributor to a child’s education (Plowman & Stephen, 2007). Computers are becoming more accepted by teachers and children in early childhood classrooms (Hinitz, 1989). While there were previous concerns about the ability of very young children to use computers, research has shown that young children can become confident and enthusiastic computer users (Plowman & Stephen, 2007).

Lonigan et al. (2003) examined the effects of Computer Assisted Instruction (CAI) on the phonological skills of pre-school age children who were considered at-risk in their reading skills. Children who participated in the CAI group were found to have stronger vocabulary skills, rhyming skills, and increased overall reading skills after...
playing with the computer game as compared to the comparison group. Additionally, the children who participated in the CAI rated the intervention program more favorably than students who were in the comparison group. Macarcuso et al. (2006) studied the effect of *Lexia Phonics Based Reading Program* (2001) and *Strategies for Older Students* (2001) in a public school. While Macarcuso et al. did not find a significant difference between the experimental and control group, there was a trend favoring the experimental group. Macarcuso et al. stated they did not find a significant difference due to the large standard deviation within the groups. Macarcuso et al. conducted a secondary analysis on students who were Title I eligible. Title I students in the experimental group showed literacy growth that Title I students in the control group did not make.

Computer learning games have been effective at increasing the literacy skills of young children (Lonigan et al., 2003; Macarcuso et al., 2006). This research was designed to determine if computer learning games that are available for free through the internet can increase the literacy skills of very young children. Additionally, this study looked at the impact of computer learning games on the letter naming fluency and initial sound fluency skills. These literacy skills are vital to students’ success in the area of reading (Kaminski & Good, 1996, 1998; Laimon, 1994, Martson & Magnusson, 1988).

### Computer Game Features For Preschool Children

Most educational games are designed to engage children in a virtual environment and through practice with interactive elements children gain knowledge in the subject matter presented in the game. The interactive exercises in computer games should be designed in such a way as to be significantly different than through traditional instruction (Gredler, 1996). These differences are often achieved with the features of computer software to engage children and enhance their learning through the use of color, sound, animation, audio and visual feedback, and age appropriateness (Chute & Miksad, 1997; Kirchner, 2002).

Lonigan et al. (2003) studied the effects of Computer Assisted Instruction (CAI) on phonological skills of pre-school age children who were considered at-risk in their reading skills. The study found, among the software’s features were highly digitized speech and colorful graphic images that kept the children’s attention while they completed a series of interactive tasks within the context of the game’s adventure setting. Throughout the game children heard auditory content using headphones. The game provided clear instructions and tutorials for the children to follow. This required an active response from the child. The children were able to review the instructions at any time during game play. The game allowed the children to practice seven phonological tasks, which included recognizing when words rhymed and matching words by their first, middle, or last sounds. These features performed an important aspect in the children’s learning.

Additionally, computers can assist learning by using the computer’s speed to help children recognize words when they are quickly flashed on the screen. This helps the children to see the shapes of the letters and how they are grouped together to form words. A study was conducted to measure the accuracy rate of word recognition by children who saw a word flashed on the screen for a limited period of time (Blok et al., 2002). A sixty-seven percent accuracy rate was achieved consistently with all the participants who used the computer program. While similar to the traditional educational method of using flash cards, the use of a computer for this method of instruction allowed for a consistent interval of time for each word (Blok et al., 2002).

Audio feedback for early childhood educational software is important to provide encouragement, reinforcement and modeling when needed (Chute & Miksd, 1997). Nikolopoulou (2007) noted that feedback to right and wrong responses should be provided in a pedagogically appropriate way so children are encouraged to continue on their work. Many times, audio feedback as a feature of the computer program can provide feedback at a rate that a teacher may not be able.

Children who have been raised in the culture of video games and computers compared to past generations require more stimuli to keep them involved in the learning process (Gredler, 1996). Keeping this in mind, making early childhood software can be a difficult task, but knowing what features to implement and what features to look for in software is a significant step. When all the features of color, sound, animation, gender preference, audio and visual feedback, and age appropriate are used properly, well-designed software is made. This type of software allows children to learn through active exploration and interaction (Lonigan et al., 2003). A secondary purpose of this study was to determine the features of the learning games (i.e., Starfall and AOL Learn Your Letters) that had an impact on the engagement of the young children. Engagement in an instructional task is vital for the task to have the desire impact on learning.
Teacher Perceptions Of Computer Software Features

Medvin et al. (2002) examined thirty-eight teachers and day care providers’ characteristics influencing the frequency of computer use in their preschool classrooms. The findings showed that the teachers who had more training were more likely to have higher levels of motivation for computer use in the classroom. The results also found that teachers who had both quality and quantity prior experience with computers were influenced by their self-efficacy and anxiety. Teachers viewed computers as an important material in the classroom, but still had anxious feeling about using them. After the workshops in the study, the teacher’s computer anxiety reduced while self-efficacy and values enhanced. Chen and Chang (2006) conducted a study that gathered information about 297 state pre-kindergarten and their attitudes, skills, and instructional methods towards the use of computers. The results of the study found that early childhood teachers are not ready to integrate computers into their classrooms yet because more than half of the teachers felt unconfident in using computers in their classrooms. In addition, less than a third of teachers demonstrated the skills to select appropriate children’s educational software for their classrooms and only half of the teachers felt comfortable teaching their students how to use computers.

The last purpose of this study was to determine if any of the features of the learning games had an impact on the perceptions of the teachers in the classroom. Positive teacher perception of a computer learning game is important for the teacher to decide to use classroom time for the game. However, positive teacher perception does not necessarily equate to an effective program.

Research Questions

This study had three purposes and from these, the research questions were developed. The research questions were:

1. Is there any significant increase in literacy skills of the two groups?
2. What features of the learning games may enhance student engagement?
3. What features of the learning games enhanced teacher perceptions of student satisfaction?

Methods

Participants

The study started with 21 children and ended up with 15 children who participated throughout the entire study. Six students were lost due to attrition. This was because the children no longer received services at the preschool. The age ranges of the 15 participants were 34 to 60 months old and they attended a Child Development Center preschool. The school had a full time staff and taught pre-school level education to children. The children were selected based on their age and enrollment in the pre-school. All of the parents of the children consented to having their children participate in the study.

Researchers

A five-person research team included two faculty advisors, one from the computer science/information technology department and one from the teacher education department, conducted this study. The three student researchers participating included one from the liberal studies department, one from the computer science department, and one student from the communication design department.

Intervention

The computer learning games used in the study were Starfall and AOL Learn Your Letters. Both games are early literacy games designed for preschool children and can be accessed free over the Internet. These games were chosen because the content was appropriate for the age of the children in the study and they were easily accessible from online sources at no cost.

Starfall. The authors of Starfall report that it teaches early letter recognition skills and literacy through the use of sound, color, animation, and simple games. Children are able to choose from different letters in the alphabet and a series of activities focuses on the letter chosen. Starfall was created in 2002 by a team of educators and designers. This program addresses the assessed skills of letter naming fluency and initial sound fluency.
America Online (AOL) Learn Your Letters. The authors of AOL Learn Your Letters report that the game teaches letter recognition skills by asking children to choose the words that start with a letter shown to them at the bottom of the screen. This program addresses the assessed skills of letter naming fluency and initial sound fluency.

After a review of the literature and an analysis of each game, the researchers identified features in each of the games to be evaluated. These were evaluated on a scale of 1 to 5, with 1 representing an almost non-existent feature and 5 representing a very prominent feature in the game (See Table 1). Features that were shown to not be significantly different in either game were removed from the table. This significance was determined by comparing the average ranking of the AOL game features from the average ranking of the Starfall features. As seen in the table, all identified features were found to be more predominant in the Starfall game.

Table 1. Differences in Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Starfall</th>
<th>AOL</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomness of game play (different scenarios depending on student choices)</td>
<td>3.4</td>
<td>.4</td>
<td>2</td>
</tr>
<tr>
<td>Engagement 4.</td>
<td>8</td>
<td>2.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Student can explore game on their own at their own pace (non-linear game play)</td>
<td>4.0</td>
<td>.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Real world activities and situations drawn from life</td>
<td>4.2</td>
<td>8</td>
<td>3.4</td>
</tr>
<tr>
<td>Surprise elements</td>
<td>4.4</td>
<td>2.4</td>
<td>2</td>
</tr>
<tr>
<td>Challenging 4</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Procedure

The parents of the children at the Child Development Center signed consent forms for their children to participate in the research study. All children were pretested prior to the study beginning. The tests used for the pretest were the two subtests from the Dynamic Indicators of Basic Early Literacy Skills (DIBELS). The pretest consisted of an initial sound fluency component and a letter naming fluency component. Each child was tested by one of the five researchers. The guidelines and procedures of the tests were followed.

Two computers were set up at the center and the children were randomly assigned into two groups. The first group completed the intervention using Starfall. The second group completed the intervention using AOL Learn Your Letters. All children were exposed to the early literacy instruction of the preschool. The games were installed on the computers in a way so that the children only had access to the games and not to the Internet. The names of the children were posted on the desk next to each computer so they and staff members would have a visual reference of which children were on each computer. A sign up sheet was created for each child’s name to be checked off as they played each day. Children were assigned to play their game for ten minutes. After ten minutes, the next child played the game until all of the children had played each day. The study ran for six weeks, five days a week. Children who refused to engage in the computer game were not forced to play.

The researchers ran the first two weeks of the intervention. This served as a model to the CDC staff as to how the intervention should be implemented. The staff of the CDC center conducted the rest of the observation with a student researcher making fidelity checks twice a week. The CDC staff recorded on the sign-in sheet whether the children played the game or did not play due to absence or other reasons.

At the conclusion of the study, the children were given post-tests. An alternative form of the DIBELS assessment was used for the post-test. Each child was tested on initial sound fluency and letter naming fluency. Additionally, the preschool staff and researchers filled out surveys for each game.

Results

Q1. Is there any significant increase in literacy skills of the two groups?

Through the data analysis and T-test results, a significant difference in literacy skills between the computer games Starfall and AOL’s Learn Your Letters was found. A total of six T-tests were run with the data. For each
computer game, the pre-test and post-test scores were compared separately, for both initial sound fluency and letter
naming fluency.

In the comparison of the Letter Naming Fluency pre-test and post-test scores, a significant difference was
found. When compared all 15 kids’ pre-test scores to their post-test scores, the one-tailed paired sample t-test
returned a $p$-value of 0.016, which is statistically significant at the conventional significance level of $p<0.05$. This
result indicated that both learning games increased the children’s letter naming fluency skills in general. To further
understand the learning outcomes at each game level, the researchers compared the pre-test scores with the post-test
scores for each game group. Of the t-test of the preschoolers who played the AOL’s Learn Your Letters game
showed a $p$-value of 0.023 ($p<0.05$) while the Starfall group returned a $p$-value of 0.078. These results indicated that
the AOL game was more effective in increasing children’s letter naming fluency than the Starfall game.

When comparing the growth of initial sound fluency there was no significant growth difference between
the two groups. Also, when comparing the growth of letter naming fluency for the computer games there was no
significant growth difference.

Overall, the results showed a significant difference in literacy skills of the letter naming fluency test for the
computer game AOL Learn Your Letters. The other computer game, Starfall, showed no statistically significant
results in either of the letter naming fluency test nor the initial sound fluency test.

Q2. What features of the learning games may enhance student engagement?

The Child Development Center staff and the researchers who observed the study responded to a satisfaction
survey. Questions were asked regarding student engagement for each game. The responses were ranked on a 1 to 5
scale, with 1 representing low student engagement observed and 5 representing high student engagement observed.
Table 2 shows the average score for each engagement question asked for each game.

Table 2. Teacher Rating of Student Engagement and Satisfaction

<table>
<thead>
<tr>
<th>Engagement and Satisfaction Questions</th>
<th>Starfall</th>
<th>AOL</th>
</tr>
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<tbody>
<tr>
<td>The learning game is visually appealing</td>
<td>5</td>
<td>2.8</td>
</tr>
<tr>
<td>The audio is appropriate</td>
<td>4.8</td>
<td>3.2</td>
</tr>
<tr>
<td>The animation is appealing for my students</td>
<td>5</td>
<td>2.8</td>
</tr>
<tr>
<td>It plays smoothly during use</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td>The interactive features are appropriate for my students</td>
<td>4.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Overall, it is easy to use</td>
<td>4.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Overall, my students are engaged when playing the game</td>
<td>4.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Overall, my students are happy to play the game</td>
<td>4.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

The above results show a significant difference in the perceived engagement of the children between the
two games. Starfall was observed to engage the children and keep their attention more than AOL Learn Your
Letters. Starfall was seen to be significantly more visually appealing, had better audio, better interactive features,
and was easier to use. All of these features contributed to the children being more engaged with the Starfall game.
The survey respondents also observed that the children’s enjoyment of the Starfall game was much higher than the
AOL game.

Q3. What features of the learning games enhanced teacher perceptions of student satisfaction?

Six different educators and assistants at the pre-school were asked to fill out a questionnaire regarding the
two computer learning games. Of the two programs, Starfall was the unanimous choice in terms of student
engagement and ease of use, earning an average score of 4.5 out of 5. AOL’s Learn Your Letters received a much
lower approval rating, averaging a 2.5 out of 5. AOL’s hardest shortcomings were in the student engagement
category (See Table 2). AOL Learn Your Letters was rated 1.2 out of 5 on “Student Happiness” and 1.3 out of 5 on
“Student Engagement”. Respondents indicated they did not believe that the students learned the content by playing
the game, averaging a 1.7 out of 5. Clearly, the educators favored the Starfall game because of its high level of
student engagement.
Eight T-tests were performed on each of the eight teacher ratings, comparing AOL Learn Your Letters to Starfall. In t-test results, AOL Learn Your Letters scored significantly lower than Starfall in the categories of visual appeal (p-value 0.015), animation appeal (p-value 0.003), ease of use (p-value .04), student engagement (p-value 0.00002) and student happiness (p-value 0.00001). Starfall was rated to have superior visual appeal due to its rich and colorful visual style. Starfall’s color palette is bright and features primary colors. The AOL game features a dull purple-grey color scheme that may not have appealed to the children. Starfall scored higher on audio as well, because the game featured several dozen audio clips of sound effects and human voices. Each animation was accompanied by an appropriate sound effect. AOL used repetitive sound clips and a short music loop, which may have caused the children to become bored. Starfall also used superior animations. There were two to five animated sequences for each letter in the alphabet, and the children would often repeat the same letter to see the animations again. AOL had two main animations: a transition animation, and one looped animation of a flying cow. After have the children watch these same two animations over and over, they appeared to grow bored and wanted to stop playing.

Starfall was rated slightly higher than AOL on its interactive features because Starfall offered a wide variety of mini games for the students to play. This interactivity appeared to engage the students more than AOL’s limited interactivity, which required the students to click matching letters and then play a repetitive item-collection game. The pre-school teachers rated Starfall higher on ease of use, although neither group of children appeared to have any confusion or difficulty in playing. AOL may have received a low score in this category due to the fact that it scored low in all the other categories. AOL’s other poor scores may have influenced this score as well. AOL’s two lowest marks were in student satisfaction and happiness. This is clear, as several students refused to play the game because it was not engaging enough. Students playing the Starfall game appeared to be happy and deeply engaged. Many of the students expressed complaints when their Starfall turn was over, but the AOL children seemed to be relieved or indifferent when asked to end their turn.

Discussion

The data collected showed a growth in the preschooler’s letter naming skills that played the AOL Learn Your Letter computer game only. These results were unexpected due to the engagement observations and the efficacy questionnaire that compared the two computer games. Starfall was rated higher than AOL’s Learn Your Letters in both engagement and efficacy. The computer game (i.e., AOL Learn Your Letters) that showed significant enhancement of letter naming skills was the computer game ranked low in engagement and efficacy. This is an valuable finding as it is important to realize that learning games that have high levels of engagement and features (e.g., colors, sounds, animation) may not be the best choice educationally. Starfall was rated as more engaging for the children to play than the AOL Learn Your Letters game. This is significant due to the fact that the children who played the less engaging game did show significant improvement in their letter naming fluency. Engagement has been seen as an important factor in the ability of a computer game to educate; however, in this study, the Starfall game was observed to be significantly more engaging, yet it did not produce a significant educational benefit. This is likely due to the fact that, while AOL Learn Your Letters was observed to be less engaging, it did provide repeated exposure to multiple letters during the time allotted for each child to play the game. Starfall while possibly more entertaining took much longer per letter for the child to progress through the game. In a ten-minute session, a child might be exposed to one or two letters on Starfall while the child on the AOL Learn Your Letters game may have been exposed to four letters or more. AOL Learn Your Letters also randomly generated the letters, while the children could choose a letter while playing Starfall. This could lead to the possibility that the children playing Starfall chose to view the same letter or letters each session, while the children playing AOL Learn Your Letters were exposed to random letter the program generated. This may have increased the number of letters to which the children in the AOL Learn Your Letters group were exposed to.

The staff of the Child Development Center reported to the researchers and documented on the sign-in sheets as well as observed during fidelity checks, that the students in the second group more often refused to play AOL Learn Your Letters because they did not like or want to play it. This phenomenon was not seen in the other group which played Starfall. The researchers also observed that the children who did play the game seemed to be easily distracted while playing. The children who played the AOL game had post-test scores in letter naming fluency that were higher than their pre-test. Despite a perceived lack of engagement with AOL Learn Your Letters, an educational benefit was still found.

The high level of engagement in the Starfall game was detected. The pre-school children openly showed their feelings about the games. The children had no problem with telling their teacher that they did not want to play AOL Learning Letters. In comparison, the Starfall group of children had very high attendance and almost always
eagerly sat down to play the game. AOL Learn Your Letters earned very low marks for “Learned Content” most likely due to the low engagement level of the students. This assumption ignores the quality of the material learned during the very short periods of engagement on the AOL game. Although the students were far less engaged, they appear to have absorbed higher educational content. 

The findings of this study seemed to confirm the meta-analysis results of Means et al. (2009) in one aspect, “… the expansion of time on task for online learners were the only statistically significant influences on effectiveness.” The Starfall game was certainly engaged the preschool children, but the games such as the matching, drop and drag, watching the animations often took a very long time to complete and the time consuming parts were often off task activities. For example, when you click on the letter “C” in the Starfall game, there is a cat that will climb up and down the edges of the rectangle display area, which takes up precious educational time. It is clearly an off task engagement since it shows a cat running with an irrelevant background music. On the other hand, the AOL Learn Your Letters game forced the children to be on task by minimizing off task activities. Based on this observation, we conclude that on task engagement is critical for student learning outcomes. Off task engagement does not seem to have a direct impact on the learning outcomes, although it may help increase student satisfaction and overall interest toward the subject matter. Of course, it is important to point out that enhancing study interest and increasing their positive attitude toward learning are important aspects of education. Some may even say that increasing satisfaction and nurturing interest are more important than the actual subject matter learning for young kids. Hopefully, our findings can help increase educational game designers’ awareness on the importance of integrating more on task engagement activities for effective learning outcomes.

Limitations and Suggestions for Further Research

Based on the results of this study the following areas are suggested for further research. Further research should focus on variations of this study including longer intervention and maintenance periods, a larger sample size, and participants of different ages. In this manner, research can ascertain the impact of a technology-based intervention overtime, on a larger population, and at varying age levels.

Acknowledgement

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