Augmented Reality in the Pre-Kindergarten Classroom— An Exploratory Study of the Effects of an Augmented Reality Book Set

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Abstract

Augmented reality (AR) as an emerging technology has gradually been introduced into educational contexts, and previous research presented promising results of AR involved curriculum and class activities. This study incorporated an AR book set to six pre-kindergarten classrooms. Students in the three experimental classes engaged with an AR picture book while the students from three control classes only accessed a 2D picture book of the same content. The results revealed that students in experimental classrooms had significant growth in letter recognition and motivation compared to their peers in controlled classes, which implicates the effects of AR in areas of letter recognition and motivation within the preschool literacy learning process.

Introduction

Reports have shown augmented reality (AR) has been described as a newly emerged technology that combines computer-generated virtual information into the real environment (Azuma, 1997; Di Serio, Ibáñez, & Kloos, 2013). However, most of the AR related research has been focused on grades beyond those in which children learn to read and STEM related fields (Yuliono, 2018; Sirakaya & Alsancak, 2018), AR's effect on young children especially on their literacy learning is not known. To merge the gap, this study integrated an AR picture book into the centers/stations of kindergarten classroom and examined AR's impact on pre-kindergartener's literacy development as well as motivation in literacy learning.

Literature Review

In the field of learning technologies, augmented reality (AR) has begun to draw attention from many educators and researchers (Akçayır & Akçayır, 2017; Huang, Chen, & Chou, 2016); numbers of previous studies have indicated that AR can enhance students' learning performance (Chang, Hou, Pan, Sung, & Chang, 2015;

Ferrer-Torregrosa, Torralba, Jimenez, García, & Barcia, 2015). For instance, by incorporating AR into lessons, students have been known to exhibit a higher degree of curiosity and surprise (Bujak et al., 2013) a better understanding of the content they are learning (Yoon, Elinich, Wang, Steinmeier, & Tucker, 2012); and more interest in reading storybooks (Wang, Lee, & Ju, 2019) . Moreover, studies have also shown that AR can make learning more attractive and effective (Dünser and Hornecker, 2007) and can enhance students' attention span as well as learning motivation (O'Brien & Toms, 2005; Sumadio & Rambli, 2010).

Despite the development of a range of AR integrated learning materials (McKenzie and Darnell, 2004; Woods et al., 2004; Saso et al., 2003; Zou et al., 2004) and a growing number of related research initiatives that have been conducted (Brown & Harmon, 2013), studies that involve young children (3-6 years old) are scant (Akçayır & Akçayır, 2017; Sirakaya & Alsancak Sirakaya, 2018). Moreover, an interesting distinction in the body of literature on Augmented Reality is that most studies use marker-based as opposed to location-based AR meaning the interactivity is triggered by scanning an image rather than moving about the environment (Sirakaya & Alsancak Sirakaya, 2018).

In this research, an AR integrated picture book was introduced to young children (3 to 6 years of age). By scanning each page of the picture book using an application on tablet screens, students engaged and interacted with a 3D animation that delivered vivid multi-sensory content about letters and vocabulary (sound and visual stimuli). Based on previous literature, reading picture books has been proven to be a promising learning activity for language and literacy skill development (Bus, van IJzendoorn & Pellegrini, 1995; Lever & Sénéchal, 2011) as well as cognitive engagement and artistic thinking (Cheng & Tsai, 2014; Elia, van Den Heuvel-Panhuizen, & Georgiou, 2010; Hsiao, 2010) in an early childhood educational context. Interestingly enough, a research initiative led by Masataka (2014) showed that given two sets of picture books with the same content, the e-picture book paired with touch screens lead to better learning performance than the print version. Furthermore, Dünser, Walker, Horner, and Bentall (2012) found that AR enhanced books are more effective than traditional books with text and illustrations in secondary physics learning. Building upon previous research findings and to expand the scope of prior investigations, this research will study the effects of an AR incorporated picture book on young children's language art skills, and it will address two research questions:
(1). Will access to augmented reality (AR) activities impact young children's (3-6) letter recognition ability?
(2). Will access to augmented reality (AR) activities impact young children's (3-6) motivation to acquire literacy skills?

Methods

Participants and Context

Three early childhood schools located in the southwestern region of the United States participated in this research. This study followed a cluster randomized research design that involved three experimental classes and three control classes from the three schools. In each school, two pre-kindergarten classes were chosen, one class served as an experimental group that used an AR-enhanced picture book, while the other class participated as a control group utilizing the very same electronic book minus the AR features. Daily schedules across all campuses included: self-directed activity time, whole group instruction, play time (mostly outdoor recess), and mealtimes. While all schools had the same types of activities each day, the order of the activities varied. This selection approach is meant to control the potential variance associated with different educational environments at each of the three sites.

Teachers often had at least one assistant in the classroom at all times and there was a general emphasis on letting children learn through play. Many of the centers at all sites involved activities that allowed children to build, create, read, and engage in pretend games. The observer notes showed that these classrooms were student-centered and often activities were led by student initiative except for whole group reading time or mandatory scheduled meals and outdoor activities.

Augmented Reality Book Sets

This augmented reality set comes with a picture book and an application on the iPad (disruptED, 2019). The contents of the book were based on the 26 letters used in the English alphabet with 2 letters on each page. The letters were displayed in color and had accompanying with cartoon figures that became animated in the AR version. As students scanned each page, animations were triggered on the screen of the iPad with music and narration to provide students a multi-media learning experience. The animation could be activated from different angles and as many times as students desired. Students were able to go to or jump to different letters simply by flipping the pages

of the picture book. At the end of the book, there is a final page which demonstrated all of the 26 letters, when this page was triggered, the letter songs will be triggered as a final review of all letters.

There are tracing, letter matching (card reveal), and spelling games found throughout both versions of the book sets, and navigation through the AR book sets depended upon the version students were using. For example, with the AR version, turning the page could be done by swiping or scanning a particular page whereas the 2D version didn't allow children to use the technology to interact with the book in the same manner, but presented the same games and content.

Research Design

In each of the three experimental classes, an AR picture book station was setup for six weeks (see Figure 1); these stations consisted of an iPad, a timer, a picture book, and a roster. Each station was placed in an area of the classroom that students were already used to completing centers/activities in (for example, a round table).

Figure 1. AR Station in One of Classroom

Researchers are fully aware of the concerns and potential disadvantages of incorporating AR related activities into classrooms, especially in pre-kindergarten settings, since AR needs to be manipulated via technology, particularly touchscreens. A major issue found within current research is the fear of subjecting students to excessive amounts of screen time (Yilmaz, Kucuk, & Goktas, 2017), which may correlate with poor academic performance or health-related risks due to reduced time sleeping and exercising (OECD, 2015; Park, Kang, & Kim, 2014). To mitigate the impact of these risks, this study intentionally designed our approach of integrating an AR picture book into early childhood classrooms through systemic time limitations. In each class, students were able to interact with an AR picture book station during self-directed learning blocks, but they were only be able to use the materials a maximum of 10 minutes each turn or session. A timer was provided to avoid excessive screen usage, and children were only allowed to visit the station once or twice per day. Under this strategy, this study attempted to protect child participants from potential harm brought by overusing the technology, and therefore create a safe space for students to explore and participate in AR integrated picture book activities. Therefore, students came to the station anytime when their teacher allowed self-directed activities and interacted with the materials for up to 10 minutes, up to three times per day. A timer was left on the table to limit the time spent to avoid the excessive electronical devices usage. Researchers assisted teachers keeping track of the time by allowing students to mark their names on a roster. Students then left the table when their time was up and moved to other stations. During the process when students were interacting with the AR picture book, researchers took field notes, which documented students' interaction process and behaviors of students interacting with the technology.

Beyond the concern for screen time and student safety, attention must be paid to whether or not students (and teachers) are able to take advantage of the AR materials in their entirety. Uygur, Yelken, & Akay found that only half of the teachers participating in their study had ever heard of AR and "78.2% (172) of the teacher candidates stated that they never used the augmented reality applications before" (2018). Their recommendations for the future use of AR by teachers is they receive appropriate training and exposure to AR technologies in order to grant users more affordances via deeper knowledge. In order to ameliorate this issue, each teacher received training prior to their students' use of the materials and was visited at least once during early implementation to ensure students were able to take turns using the device.

Assessment

All of the six participating classrooms participated in both pre- and post-assessments delivered by researchers before and after the intervention, the same assessment was used for both pre- and post-tests. Students were asked to identify as many letters as possible from a PowerPoint to determine if there were any gains in rapid letter naming throughout the study. On each slide of the PowerPoint, students were shown a letter for up to five seconds, and researchers then recorded correctness of letter recognition within the timeframe. In order to attain a higher level of alignment between the pre-test, post-test, and the book sets, the assessments were created in the same font as the materials students were using.

Teachers from the participating classes were asked to fill out a student motivation survey that included a smaller set of questions from the larger CLI Circle Engage assessment (UTHealth, 2018) (see Table 1), and were asked to participate in an interview before and after the study that sought for their opinion on the AR picture book in terms of its affordance upon students' literacy achievement and growth in motivation. Teachers both made predictions and reflections about the use of AR in early childhood literacy during these interviews indicating that their views on AR might have evolved or changed.

Table 1. Assessment of Motivation to Read

Motivation to Read			
Please rate the following statements	1 - Rarely	2 - Sometimes	3 - Consistently
Child shows interest in reading by self-selecting books during centers or free choice periods.			
Child shows enthusiasm and engagement during shared or interactive reading activities.			
Child asks to be read to (including books and/or print in the environment).			
Child asks the meaning of text (including books and/or print in the environment).			

The data source was first organized based on the scores of pretests and posttests by the control groups and experimental groups. Independent t-tests were conducted to compare any differences between the two groups. Teachers' interviews were transcribed and coded by the researchers along with field notes following a bottom-up scheme (Miles & Huberman, 1994).

Results

Letter Recognition

For experimental classes that involved AR picture books, the number of letters students in these classes could recognize in the posttest was not significantly different from their pretest ($t = 1.02$, $p > 0.05$). There were no significant differences in students' posttest between experimental classes and control classes ($t = 0.9$, $p > 0.05$). A possible reason could be attributed to students' high prior knowledge about letters, because teachers mentioned in interviews that based on their teaching experience, the average number of letters students in this age group can

recognize should be around 13, while the pretests showed that students in these three schools were able to recognize are 20 out of 26 letters. However, the classroom observations showed that even though students from both experimental and control classes seemed to have learning growth, students in experimental classes appeared to have a larger jump in number of letters recognized. Thus, an independent t-test was used to test the differences of growth between these two groups' pretest and posttest. The results showed that students from experimental classes had significantly more growth than the students from control classes ($t = 2.36$, $p < 0.05$). The results indicated that an AR picture book helped students in experimental group to recognize more letters.

Motivation

Data related to motivation was obtained via a Student Motivation instrument filled out by teachers. Students from all classes appeared to have high prior motivation in literacy learning. On average, their literacy motivation score was 2.39 out of 3 in the pre-test. The results from the t-test indicated that students' motivation in experimental classes increased significantly ($t = 2.32$, $p < 0.05$), while the score of control group was not. However, there was no significant difference between the two groups' posttest scores. These results suggest that AR can increase students' motivation during literacy learning, as the score in the experimental group increased significantly. It is possible that the 2D video can also improve students' motivation, which may explain why the posttest scores of the two groups were not significant.

Discussion

The goal of this study was to examine the effects of augmented reality on young children's letter recognition ability and motivation to practice and learn literacy. Students in the control group and experimental group used the same application with the same content and activities embedded except the control group used a 2D format while the experimental group used AR. A main feature brought by AR is its movability; by scanning each page of the picture book, a 3D animation corresponding to a specific English letter would pop up. Students were then able to interact with it by touching the screen, and/or by involving kinetic movements such as to look at the letters from different angles and distances. This spatial interaction could not be obtained via 2D animations in which students can only manipulate the learning contents via the screen itself completely disconnected from the physical book. As a teacher stated in the post-interview, this application provided kids:

"with an opportunity to interact with letters in a different way than they have right now. So, I think it will definitely add a layer and add a different dimension into classroom."

According to Sawyer's (2005) theory about learning science, an important approach to enhance the learning process is to implement strategically regulated repetition, which means contents need to be exposed to learners repeated but via diverse vehicles and formats. In the 2D animation, when students flip to a new letter, they first saw the image of the letter, then they heard the pronunciation of the letter in a word, which created a multisensory experience. However, AR features added a more dimensions and layers of repetition relying on children's spatial perception in virtual environments; students were now able to view the picture book but also the virtual animated letters from multiple angles and distances (see Figure 2). This feature helped students in the experimental group learn more letters and be more highly motivated, since according to the teachers, this layer of repetition is "both fun and education, which was a treat for us."

Figure 2. Students interact with the AR book sets

Different from other AR research for older age groups and different subject areas (Cheng & Tsai, 2014; Lever & Sénéchal, 2011). the learning outcomes about the effects of AR in this study were not as salient. Teachers from both experimental and control groups in their interviews have mentioned that 2D animations and AR features all provided intriguing and attractive multi-media environment to students that can foster their learning performances and motivation. Both versions were presented with vivid animations and narration in a self-paced manner, which is beneficial in cultivating meaningful multimedia learning (Mayer, 2002). This explains why the post motivation scores of experimental groups were significantly different from pretests while not significantly different from control groups posttests. These findings provided implications for promoting the designing AR incorporated educational applications. Although AR features grant students an innovative way to revisit the learning content, the effectiveness of AR might vary based on the nature of the content. For learning more complex contents, AR's potential in enhancing students' learning would be better manifested. Specifically, the authors of this paper see a potential for future research to investigate more geometry and science-related content that can take more advantage of the difference between the 2D and 3D capabilities of AR picture books.

Limitation

One of the limitations in this study is student sample; this group of students, based on pre-tests, had shown a high prior knowledge on their letter recognition preassessments, which was also confirmed by their teachers via interviews and surveys. On average, during interviews, teachers estimated that children in PK were able recognize 13 letters at the time of the study in spring 2018. However, the students in this study were found to recognize 20 letters. The small range of measurable growth might mask a potentially significant research outcome. In the next stage of research, we are looking for enrolling students with more diverse levels of prior knowledge in letter recognition abilities or investigating other content altogether. Another potential limitation is teacher bias during interviews or surveys due to the infeasible direct data collection from young children, thus the motivation data was collected through teachers' perspective via the form of Likert-scale questionnaires. Furthermore, when conducting the study, we noticed that some data may not represent special needs students in a fair manner; particularly students who may have speech production or visual impairments.

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