Computers & Education 72 (2014) 302–312

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Children and parents' reading of an augmented reality picture book: Analyses of behavioral patterns and cognitive attainment

Kun-Hung Cheng [a,*], Chin-Chung Tsai [b]

[a] Digital Content Production Center, National Chiao Tung University, #1001, University Rd., Hsinchu 300, Taiwan
[b] Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, #43, Sec.4, Keelung Rd., Taipei 106, Taiwan

ARTICLE INFO

Article history:
Received 12 September 2013
Received in revised form
6 December 2013
Accepted 6 December 2013

Keywords:
Elementary education
Cooperative/collaborative learning
Teaching/learning strategies
Virtual reality

ABSTRACT

Previous studies on augmented reality (AR) book learning have not provided an in-depth examination of the learning process, especially the interaction involved in child–parent shared book reading. Choosing an AR picture book to introduce its artistic work, this study aimed to explore how children and parents read the book through a series of analyses of behavioral patterns and cognitive attainment. A total of 33 child–parent pairs voluntarily participated in this study. Based on the indicators of the child–parent reading behaviors generated through content analysis, four behavioral patterns of AR picture book reading were identified: *parent as dominator, child as dominator, communicative child–parent pair,* and *low communicative child–parent pair.* The relationships between the child–parent reading behaviors and the children's cognitive attainment were further identified. Specifically, the child–parent behaviors of "*parent as dominator*" and "*low communicative child–parent pair*" were likely associated with simple description of the appearance of the artistic work by the children (low-level cognitive attainment). Conversely, the "*child as dominator*" and "*communicative child–parent pair*" behaviors resulted in the children explaining the artistic work they had seen or using their imagination to describe the content of the book (high-level cognitive attainment).

1. Introduction

Augmented reality (AR) technology, which allows users to see a physical space with virtual elements (or information) superimposed on it in real time, was developed for several applications in the 1990s, such as aircraft cable assembly guidance (Caudell & Mizell, 1992), surgical training (Bajura, Fuchs, & Ohbuchi, 1992), and laser printer maintenance demonstrations (Feiner, MacIntyre, & Seligmann, 1993). However, AR research did not gain popularity because of the restrictions of AR devices (i.e., head-mounted displays and backpack computers). Only recently has such research begun to come to fruition due to the maturity of AR technology. In 2012, a variety of enabling technologies for AR applications, such as smartphones and other handheld devices (Gervautz & Schmalstieg, 2012), advanced projector-camera systems (Mine, Van Baar, Grundhöfer, Rose, & Yang, 2012), and AR-extended professional devices (e.g., x-ray scanners) (Navab, Blum, Wang, Okur, & Wendler, 2012), were reported in a number of studies. Considering its likely advantages for education, the application of state-of-the-art AR technology has been suggested for its potential (Duh & Klopfer, 2013; Martin et al., 2011) and significance (Cheng & Tsai, 2013; Wu, Lee, Chang, & Liang, 2013).

Several AR studies in education have indicated the enhancement of students' motivation for learning with the AR technology (e.g., Di Serio, Ibáñez, & Kloos, 2013; Martín-Gutiérrez & Contero, 2011). Recently, the benefits of AR in learning effectiveness were also reported. For example, an AR learning system could help learners to acquire better understanding on physics (Enyedy, Danish, Delacruz, & Kumar, 2012; Lin, Duh, Li, Wang, & Tsai, 2013), electromagnetism (Ibáñez, Di Serio, Villarána, & Kloos, 2014), environmental reservation (Kamarainen et al., 2013), and construction engineering (Behzadan & Kamat, 2013). Through the mobile AR guidance, the students engaged more in gallery experience and performed better on painting appreciation (Chang et al., 2014). Researchers also considered the AR

* Corresponding author. Tel.: +886 3 5712121x50161.
E-mail addresses: kuhu@mail.nctu.edu.tw (K.-H. Cheng), cctsai@mail.ntust.edu.tw (C.-C. Tsai).

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http://dx.doi.org/10.1016/j.compedu.2013.12.003

technology to be integrated in the physical classroom environment (Bujak et al., 2013) and proposed AR design principles for classroom (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). That is, the affordances of AR environments have been emphasized in learning and teaching. Since AR has been applied in a variety of educational context, this study was focused on the combination of AR technology and traditional book reading. As the abstract concepts of a paper book probably misunderstood by readers, the authenticity supported by AR may lower the complexity of learning materials and visualize the unobservable objects or concepts (Wu et al., 2013). The further exploration of learning through book reading with AR is the attempts of this study.

1.1. AR book research

Along with the development of educational technology, researchers have continued to devote their efforts to exploring how technology such as interactive electronic storybooks (Smeets & Bus, 2012; Trushell, Maitland, & Burrell, 2003) assists students' learning through book reading. Nevertheless, traditional paper books are not likely to be replaced by electronic books due to their tangibility, which enables people to physically possess and touch them (Sellen & Harper, 2003). AR books, resembling printed books except that computer-generated graphics or information are superimposed on the pages, thus create an opportunity to enrich users' learning experiences beyond electronic book reading. This physical means of interaction may leverage users' knowledge from the real world, resulting in natural or intuitive uses of paper books with the aid of AR (Hornecker & Dünser, 2009). For learners with limited computer experience, the perceptions of seamlessness between the virtual and physical elements of the AR environment create unique educational benefits and new teaching/learning possibilities (McKenzie & Darnell, 2004). Through the interactions with synthetic audio-visual content, AR technology may enhance children's comprehension of book content (Dias, 2009). The examination of the effects of AR book reading on students' learning is thus likely to be an interesting issue to explore.

A variety of studies regarding the pedagogical applications of AR books have evaluated the usability of AR systems (Chang, Chen, Huang, & Huang, 2011; Sin & Zaman, 2010). The results of these studies mostly indicate students' agreement with their usefulness, ease of use, effectiveness, and satisfaction with AR book systems. Users have also exhibited positive attitudes toward the use of AR books (Billinghurst, Kato, & Poupyrev, 2001; Clark & Dünser, 2012). A few studies have further probed the effects of AR books on learning and, at least to a certain degree, have found improvements in students' cognitive attainment in areas such as spatial ability (Martín-Gutiérrez et al., 2010), conceptual change (Shelton & Stevens, 2004), and language skills (Liu, 2009). However, studies that involve the in-depth exploration of AR-related learning processes are limited (e.g., Lin et al., 2013). That is, although findings exist regarding what students obtain through AR-related learning, how students learn in the process of experiencing AR content is still not well understood.

1.2. Picture book reading for children and parents

In the context of preschool learning, it has been documented that picture book reading is beneficial for children's language development (Bus, van IJzendoorn, & Pellegrini, 1995), cognitive engagement (Elia, van Den Heuvel-Panhuizen, & Georgiou, 2010), and artistic thinking (Hsiao, 2010). How to support and facilitate children's picture book reading is thus worthy of further attention. During the picture book reading process, it is proposed that an adult, a child, and a book are the three main interactive components (Fletcher & Reese, 2005). Researchers have provided evidence that in picture book reading, parental reading behaviors such as pointing to pictures, labeling and commenting on pictures, or asking questions about the pictures or story are associated with children's language learning (Arnold, Lonigan, Whitehurst, & Epstein, 1994; Cronan, Cruz, Arriaga, & Sarkin, 1996).

Dialogic reading, another means of assisting children's learning, which is a shared picture book reading intervention for preschoolers, involves parents having a dialogue with children when reading a book together (Zevenbergen & Whitehurst, 2003). The PEER (*Prompt*, *Evaluate*, *Expand*, and *Repeat*) model is one of the dialogic reading strategies recommended for parents to implement with children aged 4–5. Specifically, the PEER model consists of four interaction-oriented behaviors: (1) *Prompt*: the adult prompts the child to pay attention to the content of the book (e.g., labeling objects in the book or talking about the story); (2) *Evaluate*: the adult evaluates the child's responses (e.g., praising the child's correct responses, offering alternative labels, or correcting incorrect responses); (3) *Expand*: the adult expands the child's responses (e.g., repeating what the child has said or adding information); (4) *Repeat*: the adult encourages the child to repeat the expanded utterances. Recently, the dialogic reading approach has been incorporated in tablet-based e-book reading and has been suggested as being beneficial for child–parent collaborative learning (Tseng, Liu, & Liu, 2012).

1.3. The purpose of this study

With regard to the role of parents in children's reading either with conventional media (e.g., paper books) or through information technology (e.g., AR books), how they behave or participate in the process of children's learning should be an essential research issue for investigation. However, few studies have endeavored to explore this issue in the field of AR book research. Previous studies have argued that children may benefit in peer-pair settings when reading AR books (Dünser & Hornecker, 2007; Hornecker & Dünser, 2009). This study assumed that incorporating parents into the process of children's AR book reading may yield different learning experiences and learning processes. In particular, through the lens of the dialogic reading model (Zevenbergen & Whitehurst, 2003), what interactive patterns may be exhibited when parents and children jointly read an AR book should be well understood. According to previous studies (e.g., Hornecker & Dünser, 2009), the behaviors of children and parents engaging in AR-related learning relate to the children's learning performance. For instance, those who are involved in more interaction sequences of AR book reading showed better ability of recalling story events. As a result, analysis of the child–parent learning process (i.e., behavioral patterns) and children's learning outcomes (i.e., cognitive attainment) within the context of reading an AR picture book constituted the basic research framework of the present study. The research questions are as follows:

1. How do children and parents behave and interact with each other during the AR book reading activity? Do they display different behavioral patterns across different child–parent pairs?
2. What is the cognitive attainment of children when engaging in the AR book reading activity?