COMPARING TWO TYPES OF TEXT-TRACKING DESIGN FOR YOUNG LEARNERS' E-BOOKS

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ABSTRACT

This study examined the impact of e-book text-tracking design on 4th graders' (10-year-old children's) learning of Chinese characters. The e-books used in this study were created with Adobe Flash CS 5.5 and Action Script 3.0. This study was guided by two main questions: 1) Is there any difference in learning achievement (Chinese character writing, lexical comprehension, and lexical usage) between groups with different e-book text-tracking designs? 2) Is there any difference in learning motivation (attention, confidence, relevance, satisfaction) between groups with different e-book text-tracking designs? This study was an experimental design where the independent variable was text-tracking design for e-books: word-based tracking or line-based tracking. A sample of forty-nine 4th graders participated in the study and participants were randomly assigned into these two groups. They were asked to do a pre-test, and then they read their assigned e-books for forty minutes. After they finished reading, they were given a post-test and motivation survey. The result showed that students in the line-based tracking design group performed better in Chinese character writing and lexical comprehension. There was no significant difference in learning motivation between groups. This study hopes to contribute to e-book design principles for young learners and serve as a reference for elementary school teachers and e-book publishers.

Keywords: Text-tracking Design, E-books, Visual-audio Design, Instructional Multimedia.

INTRODUCTION

The e-book is a new kind of reading resource for children. It has two main effects on early literacy learning. One is its effect on traditional adult-child storybook reading in the everyday lives of young children. The other effect is the cultivation of children's literacy concepts and skills in a digital age (Roskos, Brueck, & Widman, 2009). Many e-books for children are programmed to be interactive and include multimedia effects such as written text, oral reading, oral discourse, music and sound effects. The electronic format is better equipped than the paper book format to focus children's attention on text features. The superiority of the accompaniment of oral reading with written text is supported by Mayer's multimedia modality principle. This principle argues that learning will be enhanced if textual information is presented in an auditory format rather than the usual visual format. To understand the modality effect, researchers conducted studies on the combination of audio and text in e-book design. For example, in Koroghlanian & Sullivan's study (2000), they provided students audio and texts with different densities. The results showed that there was a significant difference in learning efficiency among groups. It showed that the way audio and text are combined impacts learning outcomes.

Most e-books for children have integrated auditory information and written text by providing visual markings, or the so-called text-tracking function; that is, the printed text changes by highlighting and coloring as it is narrated. Some e-books allow the reader to follow the text tracking in each screen as many times as they like and tracking of the text appears in units of sentences, phrases or separate words (Korat, 2010). Studies show that young children benefit from reading highlighted texts in e-books (De Jong & Bus, 2004). For the design of text-tracking, researchers claimed that the unit of text tracking may influence children's improvement in word reading. For example, highlighted text at the word level is thought a better support for word reading than sentences or phrase (Korat, 2010). However, empirical evidence for this argument is limited, especially for elementary learners.

Text-tracking design for children is different from that for adults. For children who have an undeveloped phonological loop, attention control and working memory, it is necessary to explore how to equip the e-book textual information with audio information. One question emerges for e-book designers: what is the best way to design the interface in order to present the textual information and spoken information together for children? Due to limited resources on this issue, this research aims to explore this question in order to shed light on children's e-book audio-visual design. There are several research questions in this study: 1) Is there any difference in learning achievement between groups with different text-tracking design (word-based tracking and line-based tracking)? 2) Is there any difference in learning motivation between groups with different e-book text-tracking design (word-based tracking and line-based tracking)? This study targeted 4th graders as a sample. It is hoped that the research can contribute to multimedia learning theories, and also help practical educators and instructional designers to create better e-books.

Literature Review

An e-book is like a traditional storybook in several ways: it displays print and has book parts (e.g., table of contents, chapters, pages). However, it is also very different from traditional books in its multimedia supports (e.g., visual aids, auditory aids and animation) (Roskos, Brueck, & Widman, 2009). An e-book provides a new dimension that paper books cannot offer: in addition to reading information, it is also possible to listen to spoken information (Wittenman & Segers, 2009). Researchers claimed that learning would be more effective by synchronizing information in audio and visual format rather than the audio or visual information alone, and this argument was supported by Baddley's working memory model and Mayer's modality principle.

Baddley's working memory model consists of four distinct parts. Three parts, phonological loop, visual-spatial sketchpad and episodic buffer, are controlled by a fourth part, a supervisor system called the central executive. The phonological loop processes auditory information; the visuospatial sketchpad takes care of the visual and spatial information, and the episodic buffer integrates everything and adds time sequencing. The latter part is thought to have links to long term memory (Baddley, 2000). Baddley conducted empirical studies to provide evidence on the existence of phonological and visual-spatial system for memory processing, and this is broadly used to improve the effectiveness of instructional multimedia.

The cognitive theory of multimedia learning and the modality principle were built up based on the working memory model. Similar to the working memory model, multimedia learning theorists pose that there are two different channels through which information can enter the brain: a visual channel and an auditory channel. Presenting all the information to one channel will create cognitive overload, as working memory is limited. Learners retain more information and foster deeper learning when information is presented in two channels, and this is called the modality effect. Ginns (2005) has performed a meta-analysis on forty-three independent studies and found sufficient support for the modality effect. However, most studies invited adults as participants; few considered elementary learners as participants. Less is known about the modality effect in children.

The modality effect occurs only when learners are able to transfer textual, auditory and imagery information into two separate channels and make a connection. However, children are underdeveloped in cognitive abilities, and it might be difficult for children to integrate different sources of multimedia instruction. Researchers argued that there are two main reasons why young learners fail to read instructions in educational multimedia: 1) inadequate attention control, and 2) under-developed phonological loop (Mann, Schulz, & Cui, 2011). The first reason that accounts for children's learning difficulties with multimedia is their inability to adequately control their attention during multimedia learning. Unlike most entertainment multimedia, educational multimedia requires active listening and reading the instructions presented in the program. To learn in the multimedia environment, a student must consciously focus their attention to bind the separate features of a stimulus-such as the color, shape, word- into a unitary object, and mentally articulate their own version of the meaning in the text. But not all children have sufficient attention control to

well-integrate these stimuli. The second reason that accounts for children's learning difficulties with multimedia is insufficient mental articulation of spoken and screen text due to an under-developed phonological loop. The phonological loop system mediates the acquisition of syntax knowledge as well as the learning of individual words (Baddeley, Gathercole, & Papagno, 1998). Phonological loop is critical for on-screen text learning. On-screen text is fed into the phonological store by means of sub-vocal speech using an articulatory system, like an inner voice to an inner ear (Baddeley, Gathercole, & Papagno, 1998). For unfamiliar on-screen content, adults are able to articulate the sound of the words and hear the inner voice with their inner ear. They can quickly encode the information directly into their phonological store through their articulatory loop. However, young learners are not fully capable of mentally articulating on-screen texts. Their auditory memory consists of a phonological store without a developed phonological loop (Gathercole, Pickering, Ambridge & Wearing, 2004). Unarticulated material for young children is extraneous cognitive load (Kalyuga, Chandler, & Sweller, 1999).

Due to above reasons, children may not be able to synchronize different sources of media and may not be able to determine exactly about what the sound content is talking within the visual content. In such a case, not only will the auditory and visual channels fail to interact, but the learner will also have to use a considerable number of cognitive resources to determine where the audio and visual should be synchronized. It might be more helpful if strategies were used to synchronize two sources of content. Several approaches were presented to enhance efficiency of children's integration of multimedia while reading e-books. The first approach is the provision of synchronized pointer. Presenting a pointer synchronized with the audio and visual content controls the learner's point of fixation and thereby synchronizes the content temporally and spatially (Ando & Ueno, 2008). Studies have shown that learners' acquisition of deep knowledge is facilitated when a pointer is used in the presentation of multimedia content (Ando & Ueno, 2008). The other approach is the provision of visual marking. Visual marking, or the so-called text-tracking design, is one approach to synchronize different sources of media and improve children's attention for learning. It refers to printed text that changes by highlighting and coloring as it is narrated. The visual marking can be at the lower level or the higher level. Visual marking at a lower level emphasizes the word that is being narrated, and at a higher level it emphasizes the sentences, paragraphs, or sections that are being narrated (Duarte & Carrico, 2004). Taking e-books as an example, visual marking is one popular dynamic option. Some e-books allow the reader to follow the text tracking in each screen as many times as they like and tracking of text appears in units of sentence, phrases, or separate words. According to Ehri and Sweet (1991), children's orthographic knowledge might be supported by pointing to the text while reading. One focus of usability problems exist related to the synchronization of the content: the synchronized visual should guide the user to the text being narrated without distracting him or her from reading (Duarte & Carrico, 2004). For the design of text-tracking, researchers claimed that the unit of text tracking may influence children's improvement in word reading. For example, highlighted text at the word level is thought a better support for word reading than sentences or phrases (Korat, 2010). However, empirical evidence for this argument are limited, especially for elementary learners. This study consequently aims to explore the impact of the text-tracking unit on learning and to understand which text tracking unit is better in children's e-book design.

Design And Development Of An E-book For Chinese Character Learning

Learning objectives

A twenty-six-page e-book program was created to facilitate Chinese character learning. We picked up five characters from one popular fourth-grade textbook for Chinese language learning in Taiwan. The five characters were composed of similar phonological components, and we composed short passages with sentences using these five characters. Through reading of the e-book, students were expected to 1) write correctly the five characters (Chinese character writing), 2) understand the meaning of the five characters (lexical comprehension), and 3) use appropriately the five characters (lexical usage).

Program design and development

Adobe Flash CS5.5 Professional and Action Script 3.0 were used to create the e-book. The program was designed with

a 841px * 595px window (A4 size). The structure of the e-book was as follows: 1) opening animation, 2) cover page, 3) table of contents, 4) guidance to kids, 5) story, 6) review for new characters, 7) animation for characters, and 8) end of the story. This study created two versions of the e-book with different text-tracking designs; one is the word-based text-tracking and the other is line-based text-tracking.

Word-based text-tracking

The word-based version was designed by taking into consideration that word level exposure by highlighting will support better readability for children: each word in the text was colored stimulatingly with the narrators' reading. Figure 1 is a sample page of the textbook for the word-based tracking e-book.

Line-based text-tracking

The line-based version was designed by taking into consideration that line level exposure, and by highlighting it will support better readability for children: each line in the text was colored stimulatingly with the narrators' reading. Figure 2 is a sample page of the textbook for the line-based tracking e-book.

Method

Research questions

This research aimed to understand how e-book text-tracking influences outcomes in Chinese character learning. The independent variable was e-book text-tracking divided as two levels: 1) word-based text-tracking, and 2) line-based text-tracking. The dependent variables include: 1) learning achievement (character writing, lexical comprehension, and lexical usage), and 2) learning motivation (attention, relevance, confidence, and satisfaction). The research questions in this study were: 1) Is there any difference in learning achievement (Chinese character writing, lexical comprehension, and lexical usage) between groups who read e-books with different text-tracking designs? 2) Is there any difference in learning motivation (attention, confidence, relevance, satisfaction) between groups who read e-books with different text-tracking designs?

Figure 1. The snapshot for word-based text-tracking design

Figure 2. The snapshot for line-based text-tracking design

Participants

The data collection was conducted in the 2012 fall semester. Forty-nine fourth-grade (10-year-old) students were recruited from one elementary school in southern Taiwan. These participants were from three different classes but were randomly assigned to one of the two treatment groups.

Treatment

As mentioned above, there were two versions of the e-book with different text-tracking: 1) word-based text-tracking, and 2) line-based text-tracking. Students were randomly assigned into one group with a particular e-book version for all tasks.

Experimental procedures

All students had a 10-minute pre-test composed of 10 questions on characters, including 5 fill-in-the-blank questions and 5 multiple-choice questions. Then students were assigned into different treatment groups for reading the e-book. It took 30-40 minutes for students to finish

reading. After students finished reading, they were asked to do a post test. In addition, information about student motivation (attention, relevance, confidence, and satisfaction) was also collected.

Instruments

The instruments used in the study included 1) the achievement pre-test, 2) the achievement post-test, and 3) learning motivation survey. The achievement tests (consisting of the pre-tests and post-test) were designed with twenty items, ten items for character writing, five items for lexical comprehension, and five items for lexical usage. The character writing questions were composed of fill-in-the-blank items, and the lexical comprehension and usage questions were composed of multiple choice items. All questions aimed to test students' knowledge of the five Chinese characters. The pre-test and post-test were composed of similar questions, comparable in difficulty and format. Consequently, on both tests, each student had three separate scores for achievement. These test questions were verified with two experienced elementary school teachers for expert validity. The learning motivation survey used in the study was the Instructional Material Motivational Survey (IMMS) designed by Keller (2010). This survey was designed to measure reactions to self-directed instructional materials. This five-point scale survey was based on ARCS model with four indicators: Attention, Relevance, Confidence, and Satisfaction. This survey can be used with younger students who have the appropriate reading level. The validity for this survey was proven, and the Cronbach's alpha coefficients for factors of this survey ranged from .81 to .92 (Keller, 2010).

Results

Learners' pre-test scores were first examined to see if there was any prior-knowledge difference between groups. The results showed that no difference existed between groups. That is, students' prior knowledge to these characters was equal among two groups. Then ANOVA procedures were conducted for students' achievement scores and motivation scores. The descriptive statistics and ANOVA results on learning outcomes are presented in Table 1. Students in the line-based text-tracking group performed better in character writing ($F=4.60$, $p=0.4$) and lexical comprehension ($F=9.18$, $p=.00$). There were no significant differences in terms of lexical usage between groups.

The descriptive statistics and ANOVA results on learning motivation are presented in Table 2. There were no significant differences in all aspects of motivation.

Discussion

This study examined the impact of e-book text-tracking design on 4th graders' (10-year-old children's) learning of Chinese character. The treatment in this study is the text-tracking design: word-based text-tracking and line-based text-tracking. The findings show that the line-based text-tracking e-book worked better on enhancing character writing and lexical comprehension. The superiority of line-based text-tracking design may be due to several reasons. First, word-based text-tracking design may generate more cognitive load to learners than the line-based tracking did. In the word-based text-tracking design, since the audio and the text were presented simultaneously, learner had to listen to each word and watch it at the same time. Students may have spent all their time catching sounds and words, and understand nothing of the delivered content. In the line-based text-tracking design, students did not have to catch texts word by word. They could read the words at their

Dependent variable	Group	N	Mean	S.D.	F	p
Character writing	Word-based text-tracking	25	5.68	3.57	4.60	.04*
	Line-based text-tracking	24	7.42	1.77		
Lexical comprehension	Word-based text-tracking	25	6.88	3.37	9.18	.00*
	Line-based text-tracking	24	9.17	1.55		
lexical usage	Word-based text-tracking	25	5.12	4.13	1.08	.30
	Line-based text-tracking	24	6.17	2.76		

*$p<.05$

Table 1. Descriptive statistics and ANOVA results for learners' achievement scores

Dependent variable	Group	N	Mean	S.D.	F	p
Attention	Word-based text-tracking	25	3.29	.81	1.08	.29
	Line-based text-tracking	23	3.52	.69		
Relevance	Word-based text-tracking	25	3.37	.86	1.12	.27
	Line-based text-tracking	23	3.65	.86		
Confidence	Word-based text-tracking	25	3.42	.53	.60	.55
	Line-based text-tracking	23	3.51	.56		
Satisfaction	Word-based text-tracking	25	3.30	1.03	1.15	.26
	Line-based text-tracking	23	3.66	1.15		

*$p<.05$

Table 2. Descriptive statistics and AVOVA results for learners' motivation scores

own pace, and the visual marking became a reminder to tell learners where the narrator was. Moreover, in the line-based text-tracking design, it was possible for learners to rely on only visual information (or auditory information) since the narration appeared after the line turn colored. Since the text and audio are not shown at the exact same time, learners may have taken advantage of only one of the channels. For young learners who are cognitively underdeveloped, this process may have resulted in insufficient mental articulation during listening and reading. Learning with only one channel may cause less failure compared with learning with connections between the auditory and visual channel (Mann, Newhouse, Pagram, Campbell & Schulz, 2002). In addition, the highlighted speed in the word-based design may not have matched learners' reading speeds, and this could reduce the modality effect. The results might have been different if we had slowed down or sped up the narrator's speed in the word-based text-tracking book.

In terms of the motivation scores, researchers argue that spoken information provided with highlights or details about visuals would better increase student learning motivation, especially in attention focus (Mann, Newhouse, Pagram, Campbell, & Schulz, 2002). The motivation survey in this study shows that the mean scores for students in both two groups were above average, which means all students had a positive viewpoint on reading e-books with text-tracking functions. Student motivation scores in the line-based text-tracking group are all higher than those in the word-based text-tracking group; however, the difference did not reach the significant level. This indicates that two text-tracking approaches might not be different in terms of improving learning motivation, and what is the best approach to present narrations and texts together for improving learning motivation still needs to be explored. For example, other text-tracking approaches such as sentence-based tracking, section-based tracking and narration pointer should be designed and examined.

Last, there are different ways to design the auditory information for better learning. Based on Mann's Structured Sound Function (SSF) Model, there are five possible functions for conceptualizing auditory information: 1) temporal sound (temporal speech cueing), 2) point of view sound, 3) locale sound, 4) atmosphere sound, and 5) character sound. These different types of sounds fulfill different purposes in learning (Mann, 2008). Auditory information can serve as supplemental or reading context for young learners that have under-developed cognitive abilities. The auditory information provided in this study is temporal speech cueing, defined as spoken information provided about future or post events highlighting or detailing about static or moving visuals. Examples of temporal sound include instruction, navigational direction, hinting, feedback and reminders (Mann, 2008). This study only focused on the impact of narration with texts, and did not provide a comprehensive result due to the small scale of this study. More research needs to be done to examine the impact of different designs of auditory information on young learners, and this is the future direction of this study.

Conclusions

This study examined the impact of e-book text-tracking design on 4th graders' (10-year-old children's) learning of Chinese characters. Students were divided into two groups and provided with different books: 1) a word-based text-tracking version, or 2) line-based text-tracking version. The results show that students who used the line-based text-tracking version e-books performed significantly better in character writing and lexical comprehension.

Several limitations need to be acknowledged in the interpretation of these results. First of all, this research was conducted in a laboratory setting rather than in a real classroom situation; thus, students may have had different motivations and may have exhibited different behaviors than those experienced during an actual class. Second, this research was restricted to the learning of five characters for elementary students. Students may have had different responses if this particular unit and subject had been something else. Due to these limitations, the generalization of this study might be conservative. Though limitations exist, this study aims to give rise to more empirical studies by sharing the experiences of developing e-book text-tracking for elementary learning.

We will continue to conduct studies in the following directions: 1) exploring the impact of different audio types

(functions) on learning, 2) using an eye-tracking system to understand learners' visual attention while listening to audio, 3) understanding the role of narration pace on the modality effect, 4) confirming the modality effect on young learners aged 7 to 12. In addition, we will keep improving our e-book design and explore its effects in the future. The study had limited participants and a short duration; the results might have bias and cannot be generalized broadly. Further study with a larger sample size and diverse treatment groups will be conducted soon for providing better evidence.

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