

Increasing the Reading Attention and Reading Interest of Students with Reading Disabilities Using a Mobile Handheld

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Abstract

The purpose of this study was to explore what display modes, article types and reading methods (individual vs. collaborative reading) can help 3rd to 6th grade students with various subtypes of learning disabilities (LD) to read more attentively and with more interest via a handheld device. A reading system was developed including four display modes and four types of article. Nineteen students with various learning disabilities were involved in the reading tasks, with nine engaging in individual reading and ten in collaborative reading. The system was then modified based on the findings of the first phase. After modification, another 13 students with reading disabilities (RD) participated in individual reading tasks. The study collected qualitative (observations and interviews) and quantitative (system logs) data. The overall findings disclosed that, on average, the students were most concentrated on reading text with accompanying audio. They were, however, easily distracted in the pure audio mode. The easiest and most interesting text was the conversational style article. On the contrary, the most difficult and least interesting article appeared to be the fable. The students conducting collaborative reading, on average, spent more time reading the articles and answering the questions than the individual readers; the former did not reach significant difference but the latter did. The collaborative students, on average, made fewer mistakes answering the questions than the individual students, although the differences were not significant. Suggestions for designing an integrated reading system for students with reading disabilities are provided.

Keywords: article style, display mode, mobile device, reading disabilities

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Introduction

As of March 2014, the number of students with special needs in Taiwan, including in elementary, middle, and high schools, was 100,814. Among these students, those with learning disabilities (LD) numbered 28,557, accounting for 28.3% of the total number (Special Education Transmit Net, Taiwan, 2014). Reading disability (RD) is one of the various types of learning disability. Reading is the foundation of learning, and entails absorbance and comprehension of the content read. The reading process involves complex mental abilities, including word recognition, comprehension, fluency, and motivation (Breznitz, 2006). Therefore, when students have a reading problem, they are likely to encounter comprehension difficulties which will subsequently affect their reading fluency and motivation, and may eventually hinder their knowledge acquisition.

In the mobile century, handheld devices, such as cell phones and tablets, have become a prevalent medium for people to attain and convey information. The user interface of these devices is viewed as more humanized as it is based on a multi-touch design, and is enhanced with multimedia features, such as text, graphics, audio and video. However, many researchers and educators are concerned that the advanced technology may widen, rather than narrow, the digital divide because of unequal access to and use of multimedia technology (Gorard, 2003; Selwyn, Gorard, & Furlong, 2005). Some have contended that a reading support system to facilitate students with learning disabilities,

such as "reading to learn" as stated by Ko, Chiang, Lin, and Chen (2011), is a helpful approach to narrowing the learning gap between regular students and those with reading disabilities. A support system with more friendly presentation of the materials can also help increase the reading attention and reading interest of RD students, which can further improve their reading and learning performance (Meng, Wu, & Chen, 2013, 2014). In response to this suggestion, the purpose of this study is to explore what display modes, article types, and reading types (individual vs. collaborative reading) are conducive for 3rd to 6th grade students with various subtypes of learning disabilities to engage in reading via a mobile device. Subtypes of learning disabilities in this study consist of writing disabilities, reading/writing disabilities, recognition/writing disabilities, and mixed learning disabilities.

Literature Review

Intervention Approaches for RD Students

There are two intervention approaches for helping students with reading disabilities to overcome their reading difficulties: the remedial teaching oriented strategy and the compensation oriented strategy. The former emphasizes inherent ability enhancement, such as providing guidance to improve word recognition abilities and reading comprehension, while the latter focuses on providing external assistance, such as altering text structure, and providing audio, symbols, and/or concept maps. Some researchers view them as internal and external adjustment strategies, respectively (Lerner & Johns, 2012;

Polloway, Patton, Serna, & Bailey, 2013). Lerner and Johns (2012) categorized the teaching strategies for reading disabilities as follows: (a) strategies to improve word recognition, (b) strategies to improve fluency, (c) strategies to improve reading comprehension, (d) enjoyment and appreciation of reading, (e) multisensory methods, and (f) assistive and instructional technology for reading. Wang (2012) indicated that internal strategies tend to be helpful, although the effect is not significant. In contrast, providing external interventions such as designing a suitable mobile reading system may take effect more immediately.

Meng et al. (2013) reported the following three findings regarding reading intervention approaches: (a) motivating students to learn demonstrated the most significant quality of multimedia reading and comprehension of online teaching material, (b) the most frequently used reading techniques by teachers of regular and special classes were reciting and pointing out life experiences similar to the content of the articles, and the most frequently used reading comprehension strategy was the article structure analysis strategy, and (c) teachers of both types of classes thought that “article structure analysis”, supplemented by the multimedia story structure assisting strategy (part of the multimedia reading comprehension assisting strategy), was the most effective, used along with the graphic organization strategy. According to the researchers, the teachers in the study revealed that the graphic prediction strategy appeared to be most effective when teaching special education classes of students,

whereas the graphic assisting strategy was most effective for regular classes of students.

Spencer, Wagner, Schatschneider, Quinn, Lopez, and Petscher (2014) evaluated a hybrid model of identification that incorporates response to instruction and intervention (RTI) as one of the key symptoms of reading disability. The one-year stability of alternative operational definitions of reading disability was examined in a large-scale sample of students who were followed up longitudinally from the first to the second grade. The results are consistent with some previous findings regarding limited stability for single-criterion-based operational definitions of reading disability. However, substantially greater stability was obtained for a hybrid model of reading disability that incorporates RTI with other common symptoms of reading disability. Here, several practical implications could be pointed out. First of all, school-based identification using the criteria of one or more symptoms including RTI seems to be promising due to its high stability. Secondly, given that schools across the nation are adopting RTI-based identification methods as a means of diagnosing students with learning disabilities, the above stability also has the potential to affect outcomes of targeted instruction and intervention practices. Finally, an increased variability in the identification of reading disability can influence the selection of students to take part in intervention programs (i.e., misidentification) as well as possibly distorting the potential effectiveness of such interventions.

Vaughn, Roberts, Schnakenberg, Fall,

Vaughn, and Wexler (2015) examined the results of reading comprehension for high school students with disabilities from a two-year randomized controlled trial with students identified in ninth grade and followed through 10th grade in their allotted condition group. Prior to the ninth grade, students with disabilities who met criteria of low reading comprehension (i.e., through failure on the state accountability test) were randomly assigned to one of three treatment conditions—reading without dropout prevention, reading with dropout prevention, dropout prevention without reading—or a business-as-usual condition. Students with disabilities in the reading treatments demonstrated significant gains on reading comprehension (Hedges' $g=.44$) compared to students with disabilities in the business-as-usual and dropout-prevention-without-reading conditions. The results support extensive (two-year) reading interventions for high school students with disabilities.

Integrating Multimedia into Presenting Learning Materials

As mentioned, electronic reading materials (e.g., e-books and interactive books) integrate multimedia into reading content (e.g., pictures, animations, audio and video) to more dynamically present the content and concepts conveyed. This type of dynamic presentation is helpful for increasing reading comprehension as it allows readers to discern the text messages through multiple approaches, rather than reading pure text (Chun & Plass, 1996; Hanley, Herron, & Cole, 1999). Many researchers have

urged that multimedia be integrated into instructional presentation. According to some earlier studies, text with multimedia presentation, such as audio and video, helps poor readers improve their reading performance (Lewandowski & Montali, 1996). Likewise, highlighting text as it is spoken helps learners increase their attention and memory (Allinder, Dunse, Brunken, & Obermiller-Krolikowski, 2001). Text-to-speech has been found to assist poor readers in completing reading tasks (Hecker, Burns, Elkind, Elkind, & Katz, 2002) and reduces the burden of decoding for poor readers, enabling them to concentrate on comprehension (Wise, Ring, & Olson, 2000). Some researchers have also found that students performed better on reading comprehension tests after reading paper books; however they appeared to be more satisfied with and curious about e-books (Jeong, 2012; Jones & Brown, 2011).

Meng et al. (2014) integrated the principals of RTI (response to intervention) into reading materials to improve the reading comprehension of second and third graders. They found that the materials incorporating multimedia helped the low-achieving students outperform their counterparts using general reading materials. Margolin, Driscoll, Toland, and Kegler (2013) reported that reading can occur effectively in a variety of presentation forms. The study conducted by Liu (2005) investigated the impact of four types of presentation modes on the reading performance of elementary fifth graders, including highlighting the text content character by character, highlighting the content sentence by

sentence, highlighting characters along with audio, and highlighting sentences along with audio. The researcher found that highlighting the content sentence by sentence allowed the students to increase their reading speed, but highlighting the content character by character and highlighting sentences along with audio enhanced their reading comprehension most significantly. Liu's (2005) study was, however, implemented via a computer rather than a mobile device.

Design of Reading Systems

Many researchers have found that designing a learning system with a game-oriented approach is more effective in terms of student learning. Chuang and Chen (2009) compared the impact of computer-assisted instruction and computer-based game teaching on the learning effect of elementary school students, and found that the latter significantly improved the students' learning memory and also reinforced their problem solving skills through helping them understand multiple available solutions. Similarly, the survey results reported by Attewell and Savill-Smith (2004) indicated that young people highly interested in mobile phone games improved their abilities in the areas of spelling, reading, and mathematics. Chuang, Lee, and Chen (2010) contended that digital console games helped children with learning disabilities to learn, especially those with attention disorders.

Goh and Kinshuk (2006) proposed a multidimensional adaptation framework for designing mobile learning platforms.

“Adaptation” refers to a system being capable of accommodating various needs of the users. The framework consists of five dimensions: the content dimension, the user model dimension, the device dimension, the connectivity dimension, and the coordination dimension.

- a.) The content dimension: this refers to the actual context and knowledge of the application, including the course module organization, and the granular level of the content, multimedia, and pedagogy.
- b.) The user model dimension: this denotes the learning model (e.g., module completed, weight and score), user preference (e.g., difficulty level and learning style), environmental aspect (the actual location where the learner uses the system), and motivation (e.g., urgency of use)
- c.) The device dimension: this includes the presentation capability (e.g., attributes that affect the final presentation, the media support types and their capabilities in presenting multimedia content) and the operational capability (e.g., attributes such as memory, CPU, operation platform).
- d.) The connectivity dimension: this includes real-time operation (i.e., allowing the user to operate in a real-time online mode), prefetching capability (e.g., device capability, network reliability and connecting type), and off-line synchronization (e.g., attributes of depth and encrypted cookies).
- e.) The coordination dimension: this represents the software and logic aspect of the application, the presentation, the interactivity and the navigation aspects.

Goh and Kinshuk (2006) contended that the framework was proposed based on the following four guidelines: (1) the system must be easy to develop, (2) it must be able to be repeatedly used, (3) it must lower the learning curve to the minimum, and (4) it must be able to be quickly developed.

Collaborative Learning

Wang and Chen (2008) investigated the impact of learning methods on students' learning performance, in which 139 junior high school students conducted an ICT (Information, Communication, and Technology) project using peer collaboration. The study results revealed that peer learning could enhance the comprehension ability of the students who had an imaginative learning style, and had a compensatory effect on the expressive style of the students. Huang, Yang, Huang, and Hsiao (2010) reported that collaborative learning positively affected knowledge network construction. Tseng, Hwang and Chan (2005) disclosed that using mobile devices as assisting teaching tools significantly helped student collaboration in the classroom. As mentioned, mobile devices have been reported as being able to help increase student learning interest and also facilitate their learning. However, students with learning disabilities are a highly heterogeneous group; therefore, whether the aforementioned learning methods are suitable for them requires further investigation. In this study, both the text display mode and reading approach suitable for students with learning/reading disabilities are examined.

Methodology

This study was conducted in two phases, with Phase I preparing, developing and implementing the system and Phase II modifying and implementing the system.

Preparation

Two educators who had experience of teaching students with learning disabilities and one mother who had a fifth-grade child with reading disabilities were consulted prior to developing a reading system for students with reading disabilities, using a mobile handheld device.

The Tool

The 7-inch tablet, rather than the smartphone, was selected as the mobile tool for this study as its screen size is more suitable for conducting reading. The Android system was adopted to design the reading materials as it is a free, open-source system.

The Reading System

Six components were considered when developing the reading system, including (A) reading materials, (B) display modes, (C) checkpoint questions, (D) feedback questions, (E) user interface, and (F) automatic system features. These components are described as follows.

A. Reading Materials

Although various types of text, such as expository and narrative, are regularly used in educational settings, this study purposefully

chose four types of text suitable for elementary students with learning disabilities, as the reading materials:

- a. Conversation-style text: the title of the reading material is “Intellectual property rights,” which is educational material presented via two children’s conversations.
- b. Story-style text: the title is “The childhood of the master inventor” which tells the story of Edison’s childhood.
- c. Narrative-style text: the title is “Grown up with the green spirit” which is about cabbages grown on a farm.
- d. Fable-style text: the title is “Laughter of the mask kingdom”.

The length of the texts was between 454~537 Chinese characters, including punctuation. Each text was broken down into four sections with two to three paragraphs in each.

B. Display Modes

Four different display modes were designed to present the reading materials:

- a. Plain text: this mode displays the material content all at once, allowing the students to read in a linear fashion and at their own pace.
- b. Text highlighted character-by-character: this mode displays the content all at once but then highlights the characters one by one. Its aim was to help students focus on the highlighted character.
- c. Text with audio: in this mode, the content is displayed all at once and then it is read aloud character by character.
- d. Text embedded with phrase explanations:

in this mode, one to three key phrases in each section are hyperlinked to annotations to help the students comprehend the meaning of the phrases.

C. Checkpoint and Feedback Questions

To imitate game-oriented design, a checkpoint (i.e., a multiple-choice question) related to the reading content was included at the end of each section. The purpose was to examine the students’ understanding of the content they had just read. The students had to answer the question correctly in order to continue to the next section.

When the students finished reading the four texts, three feedback questions followed, which asked them about the appropriateness of the font size, the difficulty of the articles, and their interest in the articles.

D. User Interface

Four options were designed to facilitate student reading, including Setup, Read, Pause, and Reread. There were two sub-options in the Setup option: choosing the font size and choosing the display speed. There were three font sizes available for selection: small (28 scale independent pixels, sp), medium (32 sp), and large (36 sp), which were available in all four modes. There were two speeds for selection: 0.5 second and 1.0 second, which was only available in the text highlighted character-by-character mode. The Pause option was for temporarily stopping the highlighting until the Read option was pressed. The Reread option allowed the students to reread the content from the very beginning.

Snapshots of the developed system are displayed below. Figure 1 demonstrates the system portal page, Figure 2 shows the sequence of the four articles, each with a

different display mode, Figure 3 demonstrates a page of one article, and Figure 4 is an example of a checkpoint question



Figure 1. The portal page

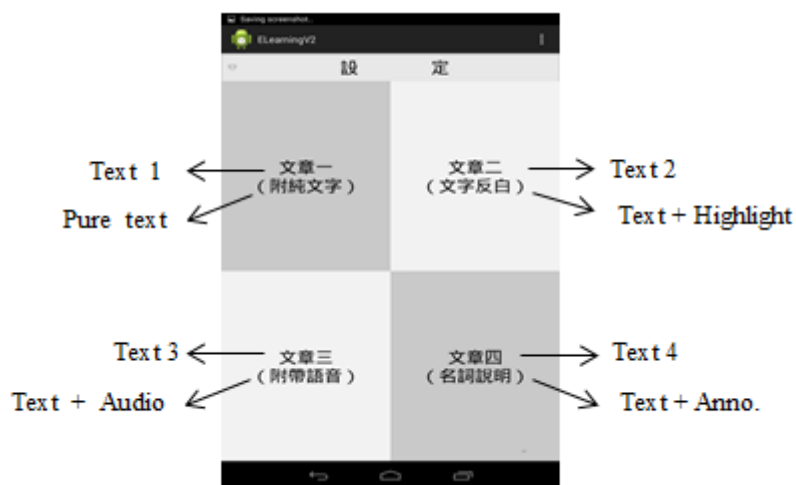


Figure 2. Four texts/modes



Figure 3. A text article

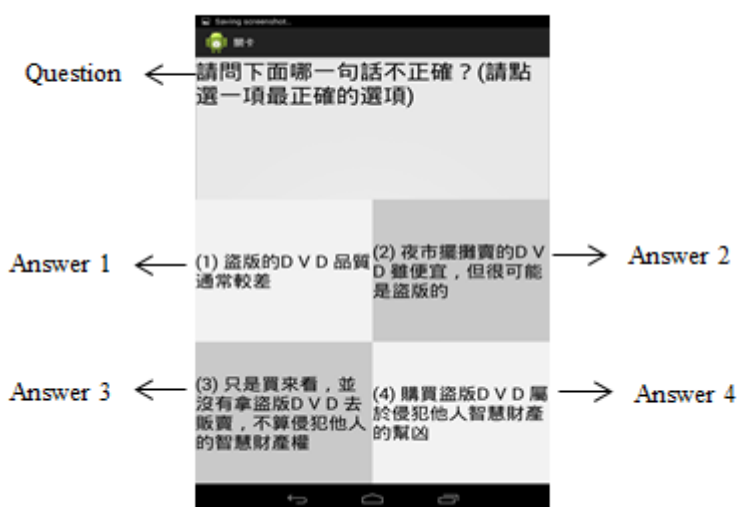


Figure 4. A checkpoint question

E. Automatic System Features

The reading system automatically kept track of the following information:

- The time the students spent reading each section
- The time spent correctly answering each checkpoint question
- The number of errors made prior to correctly answering the question
- Selections of the three feedback questions.

The Study Subjects

The study subjects were selected based on the following criteria:

- Students certified as having a learning disability by a special education accreditation institute;
- Third to sixth graders currently enrolled in an elementary school;
- Excluding those who have visual or hearing impairment, emotional disorders, or mental retardation;
- An IQ of 70 or above.

In the first phase, a total of 19 students from seven schools participated in the study. It is noted that students with learning disabilities, rather than reading disabilities only, participated in the reading task. Table 1 shows the number of participants, categorized by disability type and grade.

Table 1. Disability types of the subjects – by grade

Grade / Disability type		Total / Sub-total
3		12
	Reading disabilities	1
	(Mixed) learning disabilities	7
	Writing disabilities	1
	Reading/writing disabilities	1
	Recognition/writing disabilities	1
	Regular	1
4		4
	Reading disabilities	1
	Mixed learning disabilities	1
	Writing disabilities	1
	Reading/writing disabilities	1
5		3
	Learning disabilities	3
Total		19

In the second phase, 13 students with reading disabilities attending two different suburban schools were involved in the study. Table 2 lists the number of participants by grade.

Table 2. The number of subjects by grade for Phase 2

Grade	Sub-total
3	3
4	2
5	3
6	5
Total	13

Reading Procedures

At the beginning of the reading intervention, each student was instructed that they would play a reading game, in which they would encounter a number of checkpoints, and that they must answer each of the questions correctly in order to pass the checkpoints and continue their reading, and that they would be rewarded with a small gift after successfully completing the four articles.

On the portal page, the observer would help the student type in the basic information, including school name, grade, and student name. Next, the student could click the first article randomly matched with one of the display modes when s/he was ready. It is noted that whichever text and display mode were matched, they would not appear again as it was the intent of the study to ensure that each student read all four texts and experienced all four display modes.

It was also the aim of this study to explore whether collaborative reading, as opposed to individual reading, was beneficial for the students with reading disabilities in terms of

understanding the articles. Therefore, some of the students of the same grade were paired to conduct the reading together. The pairing was, however, based on individual students’ willingness, rather than mandatory assignment. The paired students shared a tablet computer and read the four articles together; they were also expected to answer the checkpoint questions collaboratively.

Data Collection and Data Analysis

Both quantitative and qualitative data were collected. The quantitative data consisted of the reading performance automatically kept in the system logs, as mentioned in the *Automatic system features* section, and the three feedback questions. The feedback questions asked the students about their perceptions of the difficulty of the articles, their level of interest in the articles, and the appropriateness of the font size. The first two questions used a 5-point Likert scale with 1 indicating “very difficult/not at all interesting” and 5 “very easy/very interesting”, while the third question used a 3-point Likert scale with 1 indicating

“too small”, 2 “appropriate”, and 3 “too large”.

The qualitative data consisted of observation records kept by the observers (two trained elementary teachers, one for each phase) and a brief interview with the students after finishing the reading. A rubric form was created for recording the students' actions and responses during the reading process, including their proficiency of using the mobile device, preference for display mode, preference for article type, and overall behavior during the process.

The quantitative data were analyzed using SPSS, whereas the qualitative data were analyzed using content analysis. Both the quantitative and qualitative data were triangulated to strengthen the reliability and validity of the study findings.

Findings (Phase I)

Among the 19 students who participated in the first phase, nine were engaged in individual reading. For identification purposes, they are labeled as I1~I9. The other 10 students were paired to conduct collaborative reading. Three of the five pairs were formed by two 3rd-graders (identified as C1a/C1b, C2a/C2b, and C3a/C3b), one by two 4th-graders (identified as C4a/C4b), and one by two 5th-graders (identified as C5a/C5b).

The results revealed that many of the students were excited when they saw that the reading tool was a tablet computer. The majority were also familiar with using the mobile handheld, possibly due to the popularity of smartphones. The students' preferences for display mode, comparisons of the modes, and

reading performance are described below.

The Display Modes

The interview data revealed that all of the students except one did not show a particular preference for the pure text reading mode, possibly because it did not have visual or audio effects. Likewise, they did not show special preference for the text embedded with the explanation mode. The observation data revealed that only four of the students ever clicked the embedded links to the phrase explanations. Some would rather seek the observer's help when encountering problems, although the observer was instructed not to provide content-related assistance.

Nine out of the 19 students preferred the text with audio mode as the audio enhanced their reading. The observations revealed that many students followed the pace of the audio to read the content. Compared to the pure text mode, the audio pace allowed the students less time to read the article. It also appeared to have given them less time to comprehend the content, which was reflected by comparing the number of errors made by the students in the two modes when they answered the checkpoint questions.

Five of the students preferred the text highlighted character by character. Compared to the pure text mode, most of the students seemed to be more concentrated on following the pace of the highlighting to read the article. However, because the content was displayed all at once first and was then highlighted character by character, some students tended to be distracted by the displayed but not yet highlighted characters. In addition, to some

students, the 1-second per character highlighting speed appeared to be too slow, whereas 0.5-seconds was too fast. As a result, they gave up following the pace of the highlighting and instead read the article at their own pace. There was only one student who specifically stated that he disliked this reading mode.

Challenges Encountered

A challenge that a number of students, particularly the third graders, encountered appeared to be that they were unfamiliar with or were not able to recognize the characters in the articles. According to the observer's notes, phonetic symbols were necessary to assist the students, particularly the less advanced students, to recognize the characters. However, the text with audio mode seemed to alleviate this situation as it helped them recognize the characters. Other challenges reported include:

- The articles appeared to be lengthy to many students. Most of them lost patience after reading the first few sections of the material. Some seemed to click to the next page without completely reading the content of the current page. As a result, they seemed to guess the answers to the following checkpoint questions.

- The option buttons, such as setup, read, pause and reread, were not placed in the most noticeable areas to remind the students of their availability.

- A number of students did not access the key phrase explanations embedded in the text; moreover, the observer did not find that this display mode greatly enhanced the students' reading comprehension.

Reading Behaviors: Individual vs. Collaborative

It was found that five of the nine individual students had a habit of reading aloud the content. It occurred more commonly in reading the pure text article, but some also read aloud in the text highlighted mode, following the pace of the highlighting. Because of the reading-aloud behaviors, the observer was able to disclose that some students tended to skip characters and/or lines when reading. There were four students who read the content silently; among them, two used a finger to point to the characters as they read. This was reportedly a reading habit required by their school teachers. Four of the students once used the explanation feature embedded in the article. However, referring to the explanations, according to the reading results, did not seem to help them comprehend the content.

As for the collaborative reading, the collaborative patterns among the five pairs varied. In the case of C1a/C1b, they took turns reading the material. According to the observation notes, C1b was rather playful when reading the articles and addressing the checkpoint questions. For example, when reading *The childhood of the master inventor*, he purposefully read Edison "hatched eggs" as Edison "hatched stinky duck eggs". The C2a/C2b pair appeared to have problems reading the content mainly because they could not recognize most of the characters. As a result, the observer had to read aloud the articles to them, except the one with audio. The other three pairs adopted the one-read-one-listen approach to conduct the reading.

The statistical analyses disclosed that the collaborative readers, on average, took longer to read the four articles than the individual readers, 289 vs. 241 seconds, although it did not reach significant difference (P value = 0.15). The average time the collaborative students spent answering the four questions was also longer than that of the individual students, 168 vs. 70 seconds, with a significant difference (P value < .001). Although the collaborative students, on average, made fewer mistakes than the individual students when answering the questions, 2.75 vs. 3.29 times, there was no significant difference (P value = .31).

Modifications

Based on the findings of Phase I, a number of modifications were made, which are categorized as article-related revisions and display-mode-related revisions. The article-related modifications include (a) reducing the article length, and (b) adding phonetic symbols.

- a. The length of the four articles were reduced from 454~537 characters to 350~400 characters. Accordingly, the number of sections in each article was reduced from four to three, corresponding to three checkpoint questions.
- b. Phonetic symbols were added to all characters, both in the content and the questions.

The modifications associated with the display mode consisted of the following six revisions:

- a. The explanation-embedded mode was replaced by a mere audio mode. The

reason for adding an audio mode was because audio seemed to have attracted most of the students' interest and concentration. Moreover, children in general like to *listen to* bed-time stories without actually reading the text. Thus, we were curious as to whether audio without text could better help students' concentration. The audio mode was created to imitate the bed-time story effect.

- b. In the text highlighted character by character mode, the characters were displayed only when highlighted, rather than displaying the text all at once and then highlighting it character by character.
- c. All the option buttons were enlarged and placed in more obvious locations.
- d. In the setup button, the speed options were altered from 0.5 and 1.0 second to 0.6, 0.75 and 0.9 seconds.
- e. The option buttons were simplified from four to three, with Read and Reread integrated as the Reread button.
- f. The analysis result of feedback question #3 showed that the students, on average, regarded the current font size as appropriate (average = 4.06 out of 5, std. = 0.19). Therefore, the font size sub-option in the setup option was deleted.
- g. A progress bar was added to inform the students of their current reading progress.

Figure 5 presents a snapshot of a revised page, where the bar below the content is the progress bar.

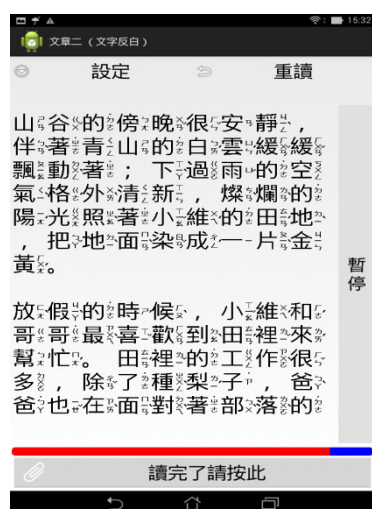


Figure 5. A modified page

Findings (Phase II)

The study findings in this phase are described according to three aspects, namely preference for display mode, comparison of the articles, and overall observations.

Preference for Display Mode

Based on the observation data, when compared to reading plain text, the students were more concentrated on reading the article highlighted character by character. Some read the characters following the pace of the highlighting. However, text with audio appeared to be the mode best able to help the students read the article, regardless of grade. They also seemed to be most focused when reading the content with audio playing along. There was only one 6th-grader who was somewhat irritated by the audio. Surprisingly, it

was found that, in the pure audio mode, the majority of the students were not able to concentrate on listening to the audio. They seemed to be easily distracted during the audio play, possibly because no text was displayed to focus their attention.

Comparisons of the Articles

Based on the feedback questions, it was found that the students, on average, felt that the most difficult article was article 4 “Laughter of the mask kingdom” (avg. = 3.52 out of 5), which they also felt was the least interesting (avg. = 3.83). The easiest article was article 1 “Intellectual property rights” (avg. = 4.17) and the most interesting was article 2 “The childhood of the master inventor” (avg. = 4.52). Most students appeared to prefer the conversational-style article (Intellectual property rights), although the main purpose was

to educate them. The fable story (Laughter of the mask kingdom) did not seem to entice the students, probably because the meaning of the story was beyond many students' comprehension. It is noted that the averages were calculated based on the total number of students involved in the two phases. There were 22 individual readers and five pairs of

collaborative readers; each pair of collaborative readers was counted as one. Although the article length varied in the two phases, the nature of the articles was the same in both phases. Table 3 displays the averages of the students' responses to the two feedback questions.

Table 3. The averages of the feedback questions

Items (N=23)	Article 1		Article 2		Article 3		Article 4	
	Avg.	Std.	Avg.	Std.	Avg.	Std.	Avg.	Std.
Q1	4.17	.887	3.87	.920	3.87	.968	3.52	1.082
Q2	4.43	.843	4.52	.790	4.30	.876	3.83	.984

Q1: Extent of difficulty of the article (1: very difficult, 5: very easy)

Q2: Extent of interest in the article (1: not at all interesting, 5: very interesting)

Comparisons of Reading Behaviors

It was found that there were differences between the middle (3rd and 4th) and high (5th and 6th) grades of students in their reading behaviors. The middle grade students tended to read aloud the articles in the plain text mode and also in the explanation embedded mode. Reading aloud and, in some situations, repeated reading of the phrases they did not understand seemed to help some of the students comprehend the content. The situation also occurred when they answered the checkpoint questions, especially when they had not yet chosen the correct answer. On the other hand, such reading behaviors were rare for the high-grade students, most of whom were inclined to read through the text and answer the questions silently. There was one 6th grader who would say “I got it” when she

comprehended something she initially did not catch.

Conclusions and Discussion

In the digital era, mobile reading, such as reading via tablet computers, has increasingly become a way for people, particularly youngsters, to intake knowledge. Compared to Liu’s (2005) research, this study designed more display modes (pure audio and annotation features), and most importantly, was conducted using a handheld device, rather than a traditional computer. The results reveal that interactive features embedded in the device can help attract students’ reading interest. Although attracting their reading interest does not necessarily enhance their reading ability, it is, however, the first step towards triggering their

reading behaviors. Once their reading interest is triggered, there is a possibility to sustain their reading and consequently to enhance their reading ability.

Even though there are numerous digital and audio books available in the market, this study found that pure audio mode does not suit students with learning/reading disabilities if the purpose is for learning as opposed to entertaining. Without text presented for them to follow, the students are easily distracted. Text with audio is a better display mode to help students with reading disabilities to engage in reading. Although the text with audio mode helped most of the students concentrate on reading, some, however, regarded the audio as irritating. In other words, preference for display mode among the students varied. More comprehensive display mode design is thus necessary.

The study results also indicated that collaborative reading did not help the students read as effectively as initially expected. Those who conducted collaborative reading did not compensate for each other's learning weaknesses. Rather, it prolonged their reading time and in some situations disturbed each other's pace. The reading behaviors of the middle and high grade students also varied. While the middle graders tended to read aloud the content, the high graders did not. Whether this is due to personal habits or maturity is worth further investigation.

Future Design

The reading system developed in this study consists of option buttons, such as pause,

reread, highlight speed options, and a progress bar, to facilitate student reading. However, each student's learning/reading situations vary; therefore, more subtle designs are necessary to accommodate readers with various learning conditions. Five suggestions for future design are provided as follows.

a. For those with visual interference problems

Because of the students' reading aloud behaviors, the study found that it is not uncommon that students with reading disabilities often skip characters and/or lines when engaging in reading. To avoid this problem, it is suggested that a character be highlighted only when a finger touches it. Such design would also allow the students to adjust their own highlighting (reading) speed.

b. For those with word recognition problems

When activating the audio feature, the audio must automatically stop when finishing reading a paragraph, rather than playing until the end of the text. This temporary pause would allow students to think about and digest what they have just read. The students can re-activate the audio by clicking the audio icon when they are ready to continue.

c. For those with word construction problems

To facilitate students' reading, it is suggested that embedded annotations be designed as a pull-down feature, rather than linking to a new page when clicking the annotations. Showing annotations on the same screen as the content allows the students to apply the explanations to the reading context. In addition, adding pictures

or drawings to the annotated phrases is also suggested as text explanations may not effectively help most students comprehend the meanings of the phrases.

- d. Providing encouraging messages at the checkpoint-questions

The design of checkpoint questions appears to not only help students recall what they have read but also make them feel excited when clicking the correct answer. To increase students' reading motivation, it is suggested that some encouraging statements be presented when they click both correct and incorrect answers.

- e. Integrating various features for reading into one display mode

Although this study examined only five display modes, it found that reading preference varies among readers. To benefit the students with reading disabilities, the display mode must suit each student's reading habits. To satisfy various reading preferences, it is suggested that multiple display modes, such as audio, highlight, and annotation, be embedded in all reading materials rather than one article with one display mode as demonstrated in the current study; this would allow individual readers to choose the one they personally prefer.

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