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Interactive e-book reading vs. paper-based reading: Comparing the effects of different mediums on middle school students' reading comprehension



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ABSTRACT

This exploratory study compared the effects of two different mediums of reading—interactive e-book reading and paper-based reading—on learners' reading comprehension. A specific focus was placed on literal vs. inferential comprehension. Thirty Korean middle school English language learners were randomly assigned to an interactive e-book reading (treatment) group or a paper-based reading (control) group. A pre-test and five comprehension tests were administered to both groups over a total of six reading sessions. A survey was also conducted to investigate students' perceptions of how helpful interactive e-book features were in aiding their reading comprehension. Results from the reading comprehension test scores showed no statistical differences between the groups across the five tests. Analysis of literal and inferential questions also showed no significant difference overall. Findings from the survey data along with researcher observation notes suggest that interactive features that are not designed to aid students' understanding can distract students from the task of reading which may hinder their comprehension. The overall results of this study suggest that it may not be the medium of reading, but how students engage with each medium that can affect their comprehension of text.

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1. Introduction

Most, if not all, second language (L2) learners of English have at some point in time engaged in reading, listening to stories, and watching videos in the target language to foster their L2 development (Bada & Okan, 2000). With advances in technology over the years, new opportunities have arisen through computer-assisted language learning (CALL) in which audio, video, and text can be integrated through digital platforms. This has led to the development of interactive e-books which include highly interactive multimedia features that allow readers to engage in various ways with electronic text. As the number of users of smartphones, individual computers, and tablets has increased, the number of users of interactive e-books has also steadily increased (Smeets & Bus, 2013). Thus, in recent years a great deal of research has looked into ways in which interactive e-books may benefit students' L2 learning process (Biancarosa & Griffiths, 2012; Chen et al., 2013; De Jong & Bus, 2004; Moreno & Mayer, 2007; Wood et al., 2018).

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To date, various positive effects of interactive e-books on students' L1 and L2 reading performance have been reported with benefits including vocabulary growth (Korat & Shamir, 2007; Smeets & Bus, 2015), improvements in reading comprehension (Kao et al., 2016; Marzban, 2011a, 2011b; Takacs & Bus, 2016), and the enhancement of phonological awareness (Korat, 2009, 2010). However, negative effects have also been found relating to students' reading comprehension as a result of eye fatigue from reading on a screen (Jeong, 2012), and formed habits of skimming and scanning screen content (Lenhard et al., 2017; Singer Trakhman et al., 2018). As it currently stands, understanding the impacts of interactive e-books on L2 learning is still a work in progress. Furthermore, when comparing the benefits of interactive e-book reading to paper-based reading, it is still unclear whether one form is better than the other, and in what capacity (Jeong, 2012).

To further understand the effects of this new digital-reading platform, this small-scale exploratory study examined the effects of reading interactive e-books on Korean middle school English learners' reading comprehension in comparison with paper-based reading. Particular attention was given to literal and inferential comprehension. Additionally, students' perceptions of the helpfulness of various interactive features in assisting their reading comprehension were investigated. The findings of this study contribute to a deeper understanding of the effects of interactive e-books on L2 learners' reading comprehension and provide stakeholders with meaningful information about users' perceptions of the roles certain interactive features play in aiding their understanding.

2. Literature review

2.1. Conceptualizing reading comprehension

Reading comprehension has been defined in various ways over the years. Kucer (2005) puts forth that reading comprehension is achieved when readers have understood a text and can discuss various aspects of what they have read in detail. Torres and Constain (2009) describe reading comprehension as "a complex problem-solving process in which the reader makes sense out of a text not just from the words and sentences on the page, but from ideas, memories, and knowledge evoked by those words and sentences as well as experience" (p.56). Others have defined reading comprehension in more general terms, stating that it is simply the understanding of the meaning of written material—getting the correct message as a final result from interacting with what one has read (Nutall, 1982; Torres & Constain, 2009). In this paper, the researchers adopt Grabe and Stoller's (2011) general definition of reading comprehension, "the ability to understand information in a text and interpret it appropriately" (p.11).

2.1.1. Levels of reading comprehension

Reading comprehension is often separated into four different levels of comprehension: literal, inferential, applied, and evaluative. Nation (2009) details that "Literal comprehension is understanding what the text explicitly states, inferential comprehension is students' ability to draw inferences from the text, applied comprehension is students' ability to use what they have read in the text for other purposes in addition to understanding, and evaluative comprehension is students' ability to respond critically to the text" (p. 34). All of these levels of comprehension require the learner to grasp a general understanding of the text; however, some require the student to do more with that understanding than others. For instance, inferential comprehension is considered to be more challenging than literal comprehension because it requires readers to go beyond the surface level of words and deduce meaning that is not explicitly stated (Alderson, 2000).

As Day and Park (2005) explain, applied and evaluative questions are difficult to judge as correct or wrong because they are open-ended, can include learners' creative and critical thinking beyond the text, and can be considered correct if they reflect the reader's reaction to reading. Thus, to avoid difficulty in judging students' answers, the researchers chose to focus their attention on assessing students' literal and inferential comprehension in this study.

2.1.2. Factors affecting reading comprehension

Although the concept of reading comprehension is rather simple to grasp, the various factors and processes involved in it make the task quite complex. As Leaser (2007) states, comprehension is understood as a multifaceted interactive process between the reader and the input. Therefore, a range of factors related to the features of a text and individual cognitive processes can greatly impact the level of comprehension a reader obtains.

Some of the most commonly reported features of a text that have been found to affect a reader's comprehension include the provision of a text with related visual content (Jenkins & Pany, 1981), frequency of a given form in the input, and salience of form (Gass, 1997), topic familiarity (Chang et al., 2019), the genre of a text (Tompkins, 2006), and text coherence (Sweet & Snow, 2003; Tompkins, 2015). Also, a text's readability—lexical density and syntactic complexity—can influence reading comprehension (Alderson, 2000; Sadeghi, 2007; Tompkins, 2015). That is, lengthy and complex sentences, short and poorly connected sentences, or challenging vocabulary can impede reading comprehension (Pearson & Camperell, 1981, pp. 27–55; Vacca et al., 2015). In addition, expository texts have been found to be more challenging to understand compared to narrative texts because the former tend to include diverse content in complex structures, whilst the latter often include simple descriptions of events in familiar storylines (Alderson, 2000).

Numerous reader dependent factors have also been found to directly influence their L2 reading comprehension abilities. Grabe and Stoller (2011) categorize these various factors into two parts: lower-level processes and higher-level processes. They use the term lower-level processes to refer to linguistic skill-oriented processes while higher-level processes include

comprehension processes that make use of the reader's background knowledge and inferencing abilities. As they explain, lower-level processes work together to process the meanings of words and grammatical information in a text. Simultaneously, higher-level processes work to link what is being read to the reader's background knowledge, and, at the same time, monitor comprehension and use of reading strategies. A more detailed summary of the lower-level and higher-level processes is presented in the following [Table 1](#).

Table 1
Lower-level and higher-level processes.

Metaphorical level of working memory processes	Process specification	Description
Lower-level processes	Lexical access	The recognition and calling up of the meaning of a word.
	Syntactic parsing	The storing of words together to allow for the extraction of basic grammatical information.
Higher-level processes	Semantic proposition formation	The process of combining the meaning of words and grammatical information into basic clause-level meaning units.
	Text model of comprehension	Linking ideas, main points, and supporting ideas to form a meaningful representation of what is read.
	Situation model of reader interpretation	The interpretation of information from a text based on the reader's own background knowledge, feelings, and goals.
	Background knowledge use and inferencing	The use of background knowledge and inferencing to understand the meaning of what is read.
	Executive control processes	The monitoring of one's comprehension and use of strategies to repair comprehension problems and re-establish goals.

Note. Adapted from "Teaching and researching reading (2nd ed.)", by Grabe, W., & Stoller, F., 2011, p. 14, Pearson Education.

The lower-level and higher-level cognitive processes presented in the table above should be viewed as a network of information and related processes that are constantly being engaged while trying to comprehend what one is reading ([Grabe & Stoller, 2011](#)). This is something that is commonly referred to as 'working memory'. Working memory connects information from one's long term memory with new information coming in ([Cain et al., 2004](#)), and therefore is necessary for coherently processing text ([Joh & Plakans, 2017](#)). While working memory is acknowledged as crucial for reading comprehension to be achieved, as [Sweller et al. \(1998\)](#) explain, our working memory has a limited capacity of dealing with 2–3 pieces of information at a time. Thus, according to [Sweller's \(1988\)](#) cognitive load theory, if the total mental activity (aka. cognitive load) imposed on the working memory exceeds its limits, a reader's comprehension may be negatively affected.

In recent years, with the increase in multi-media learning, researchers have cautioned that the processing demands evoked by the stimulation of word, pictures, and tasks may exceed the processing capacity of the cognitive system resulting in cognitive overload ([Mayer & Moreno, 2003](#)). Additionally, if learners are involved in cognitive tasks that are not related to the instructional goal of the task, and/or additional information or material is given that is not needed to obtain the goal, learners may suffer extraneous processing overload, also referred to as extraneous cognitive processing or extraneous cognitive load ([Sweller, 1999](#)). Therefore, the design of interactive e-books and the features they offer should be taken into consideration when discussing learners' reading comprehension of input consumed via that medium.

With so many textual factors and cognitive processes involved in comprehending what one has read, at present, it is uncertain whether readers are able to comprehend e-books with interactive features any better than paper-based books without them. It is also unclear exactly how the design of different interactive e-book features may impact learners' reading comprehension. Thus, this study contributes to gaps in both of these areas by comparing the effects of interactive e-book reading with paper-based reading, and reporting researcher observations as well as learners' perceptions of the helpfulness of different interactive features in facilitating reading comprehension.

2.2. Interactive e-book features and reading comprehension

E-books have come a long way since Michael Hart initiated project Gutenberg and the digitization and archiving of cultural works in 1971 ([Hart, 1992](#)). In the beginning, e-books were nothing more than text that had been converted to digital form. Nowadays, however, the majority of educational computer-based e-books include interactive features as a way to provide an exciting learning experience and help improve students' reading performance ([Guernsey et al., 2012](#)). These interactive e-books have the potential to change the way our students read and comprehend what they read ([Schugar et al., 2013](#)) as the features are responsive to them as they engage with text ([Moreno & Mayer, 2007](#)).

In recent years studies have started to emerge which look at how interactive e-books affect different levels of reading comprehension. [Kao et al. \(2016\)](#) found that high interactive e-books may positively contribute to students' literal and evaluative comprehension but not inferential comprehension. They explained that high interactive features (features which included guidance, prompt, and feedback) might help students easily locate necessary information while focusing on texts and discover causes and effects to accurately answer evaluative questions. On the other hand, [Danaei et al. \(2020\)](#) concluded that popular e-book features such as animated pictures and narration could enhance students' inferential comprehension

since the features made students focus on the story and enabled them to infer more easily from visual and auditory clues. Considering the mixed results of previous studies, further research is required that investigates the roles that interactive features play in facilitating different levels of reading comprehension. The sections below outline common interactive features and empirical findings on their impact on reading comprehension.

2.2.1. *Animated pictures*

Animated pictures are one of the most popular interactive features in e-books (Guernsey et al., 2012). Not to be confused with video, animated pictures are simple animations of storybook pictures. For example, if the text reads "Dad clapped his hands.", the accompanying picture may have an automated simple animation of the dad clapping once. Previous research indicates that readers can comprehend text better with the presence of animated pictures (Biancarosa & Griffiths, 2012; Bus et al., 2015; De Jong & Bus, 2004; Korat, 2009; Korat & Shamir, 2007; Takacs et al., 2015) because students can more easily understand by connecting visual information, and animated actions with words (Danaei et al., 2020; Mayer, 2009; Smeets & Bus, 2013). De Jong and Bus (2004) found that even though learners' attention focused on the animations when they presented themselves, they could also focus on the story and their reading comprehension was not compromised. Thus, if animated pictures are closely related to the text being read, they can play an important role in aiding students' reading comprehension (Takacs et al., 2015).

2.2.2. *Text-to-speech with highlighting*

A text-to-speech feature enables text to be read aloud by a human or a computer-generated voice which can assist beginner readers or those who cannot read by themselves, in developing early reading skills (Biancarosa & Griffiths, 2012). A text-to-speech feature is often paired with a highlighting feature, where words in a text are emphasized on screen in synchrony with the voiced read-aloud (Smeets & Bus, 2013). This feature directs the reader's attention to the words being read (Biancarosa & Griffiths, 2012; Zipke, 2017) which helps the reader follow the text as it is being spoken. Danaei et al. (2020) found students' reading comprehension can be supported by text-to-speech because the feature enables students to fully focus on understanding texts by sparing them the trouble of phonetically decoding unknown words.

2.2.3. *Page control buttons*

Page control, the most basic interactive function, allows readers to go to the next or the previous page. This allows learners to control the speed of their reading and move back and forth whenever they want (Shamir et al., 2008). Considering the noted importance of repeated reading (Nation, 2009; Vacca et al., 2015) and actively reading back and forth (Singer Trakhman et al., 2018) on learners' reading comprehension, page control buttons can play a significant role.

2.2.4. *Hotspots*

Hotspots refer to a function that is activated when users click pictures, words, or sentences (Korat et al., 2014; Korat & Shamir, 2007; Smeets & Bus, 2015). When clicked, pop-ups or animations are initiated to aid learners' understanding by providing additional information to the text which is not originally available (Korat et al., 2014). This can include dictionary features such as the activation of a gloss when students click on a word to help them understand the meaning (Homer et al., 2014; Smeets & Bus, 2015). Such dictionary hotspot features have been found to make a noticeable contribution to vocabulary learning and growth, which can facilitate learners' reading comprehension (Constantinescu, 2007; Khezrlou et al., 2017; Korat et al., 2013; Marzban, 2011b).

Although hotspots support students' reading comprehension, De Jong and Bus (2002) found that when students read e-books with hotspots, some of them (especially lower level students) became distracted and played with hotspots. This led to the students reading e-books with hotspots comprehending less than students reading paper-based books. In contrast, other studies found that although students played with hotspots, they could comprehend as much as those who read paper-based books. This was possibly because the hotspots were specifically designed by the developers not to distract students by limiting the number of hotspots, making hotspots relevant to the stories, and allowing students to explore them only after reading (De Jong & Bus, 2004; Korat, 2009; Shamir et al., 2008).

2.2.5. *Games*

As Li (2017) discusses, games are also widely used in interactive e-books as means for promoting learning as they often incorporate the opportunity to practice language, apply what is learned from the content of the reading, or demonstrate comprehension of what is read through game-based activities. However, research into how games affect students' reading comprehension has produced mixed results (Bus et al., 2015). De Jong and Bus (2002) found that when games irrelevant to what students were reading were available without any restrictions, students' understanding of the text was negatively influenced. What is interesting in their study was that games had such a strong appeal that students became absorbed in playing games and spent less time reading and using hotspots. On the other hand, other studies found that games can help enhance students' reading comprehension (Homer et al., 2014; Zipke, 2017). According to Bus et al. (2015), games can have positive results if the games do not distract students away from the main task of comprehending the text, and programs have built-in features that limit the use of game features.

Summarizing the research on interactive e-book features concerning students' reading comprehension to date, interactive e-books must be designed carefully to include features closely related to facilitating students' comprehension of what they

are reading. At the same time, restrictions on the features should be imposed (such as when and how long) to avoid students being distracted by the features which can result in a negative impact on their reading comprehension (Bus et al., 2015; Kao et al., 2016; Sargeant, 2015; Takacs & Bus, 2016; Zipke, 2017). Nevertheless, it is hard to exclude the possibility that some interactive features can be harmful no matter how carefully they are designed (Takacs et al., 2015). The reason for this is, considering that students frequently and repeatedly shift from reading to engaging with interactive features, students' reading comprehension can be compromised due to extraneous cognitive processing which can overload a reader's working memory and interfere with their reading comprehension (Mayer, 2009).

2.2.6. Additional factors affecting interactive e-book reading comprehension

In addition to extraneous cognitive processing, other factors that can lead to negative effects on students' reading comprehension of interactive e-books have also been identified. One major factor that has been noted is skimming and scanning reading habits formed over time through interaction with online texts (Liu, 2005). Earlier studies have reported that students who engaged in reading digital texts tended to skim and scan rather than read in full which compromises accuracy and attention to detail (Lenhard et al., 2017; Singer Trakhman et al., 2018). When asked to answer more challenging questions that required attention to specific detail, students reading digital texts performed worse than others reading printed texts, although there were no significant differences in their reading performance when students in both groups answered simpler questions that required a lower level of detailed understanding (Singer Trakhman & Alexander, 2017a). In addition to skimming and scanning habits, another factor that can affect reading comprehension is the speed in which readers engage with a text (Singer Trakhman & Alexander, 2017b). As Singer Trakhman et al. (2018) found, when reading digital texts, slower readers engaged in deeper thinking processes scored higher than their counterparts.

All in all, the previous studies found that interactive features, if designed thoughtfully, can play a positive role in enhancing students' reading comprehension, whereas extraneous cognitive processing and reading habits of skimming and scanning digital texts could harm students' reading comprehension. Still, it is not completely clear if interactivity employed in e-books has promising effects on students' reading comprehension, and if the effects are any better or worse than traditional paper-based reading. As outlined above, highly interactive programs may not trigger meaningful learning, and there are times when low interactivity can lead to active learning.

2.3. The current study

To date, most of the research has focused on the effects of interactive e-books on young learners (e.g., Chambers et al., 2006; Kao et al., 2016; Korat, 2009, 2010; Korat & Shamir, 2007; Schugar et al., 2013; Takacs & Bus, 2016) or college students (Chen et al., 2013; Marzban, 2011a). This has left the effectiveness of interactive e-books on middle school students underexplored. Additionally, some methodological problems identified in the previous studies result in additional gaps in the literature regarding this topic. Singer Trakhman and Alexander (2017b) outline some of the issues as follows:

1. A lack of sufficient information about the texts in terms of the length and type
2. A limited use of different question types and levels of difficulties
3. A failure to reflect various levels/types of comprehension (i.e., literal, inferential, evaluative, and applied)

The purpose of this small-scale exploratory study was to address the research gap and methodological limitations outlined by Singer Trakhman and Alexander (2017b) and provide recommendations for future research that this study inspires. Thus, the researchers aimed to investigate how interactive e-books affect middle school students' reading performance in comparison with paper-based reading on literal and inferential comprehension questions while providing clear explanations about the materials used. This includes details of the text characteristics (type, length, and difficulty) and question formats (true/false, multiple-choice, and open-ended questions). Furthermore, it also sought to examine middle school students' perceptions of how helpful specific interactive features were in aiding their comprehension of short stories. Thus, the following research questions formed the basis of this study:

1. How do different mediums of reading (interactive e-book reading vs. paper-based reading) affect students' performance on comprehension tests?
2. How does students' performance on literal and inferential reading test items differ depending on mediums of reading, interactive e-books vs. paper-based reading?
3. What interactive e-book features do learners find most and least helpful in aiding their reading comprehension when reading independently?

3. Method

3.1. Participants

A convenience sample of thirty Korean middle school students, who were attending a private supplementary English language institute, participated in this study. Different from the public-school setting in South Korea, private schools are more

often equipped with computer labs in which students can engage with various learning programs including interactive e-books. Those attending private supplementary English institutes are therefore the most likely to engage with the materials being examined in this study. Thus, the data collection site and participants were specifically chosen to obtain a representative sample of Korean middle students who are likely to interact with both paper-based and interactive e-books regularly. [Table 2](#) below presents the demographic information about the participating students ranging from the 1st year of middle school (USA grade 7 equivalent) to the 3rd year of middle school (USA grade 9 equivalent).

Table 2
Participant demographics.

Grade	Male	Female	Total
1st Year of Middle School	11	5	16
2nd Year of Middle School	0	6	6
3rd Year of Middle School	3	5	8
Total	14	16	30

Participants all had prior English language learning experience ranging from five to seven years, and prior experience with both English interactive e-books and paper-based reading. To measure participants' language reading level, *The Test of English for International Communication® (TOEIC) Bridge* mock tests was administered before formal data collection. The test results indicated their reading levels ranged from A1 to A2 in the Common European Framework of Reference (CEFR). According to the [Council of Europe \(2018\)](#), those that fall within an A1-A2 descriptor level are considered basic users. They can comprehend the main ideas of short, simple texts which contain familiar words and sentences and are related to their interests.

3.2. Materials

3.2.1. Interactive e-books and paper-based books

This study employed six interactive e-books developed by the online-based CALL program provider, [Knk International Homeschool](#) (n.d.), in South Korea, and paper-based equivalents. It should be noted that paper-based books were created by extracting the content and visuals from the e-books and printing them out, as published paper-versions of books are non-existent. Thus, the titles, contents, and reading levels of e-books and those of the corresponding paper-based books remained the same; the only difference between the two versions was the format. The series of fictional books (narrative) that were used in this study was centered on the character "Supergirl" with each book introducing a new adventure (e.g., settling conflicts between friends, helping teachers or neighbors in trouble). Both the digital and paper-based books consisted of eleven pages; pages in the paper-based versions mirrored those in the e-book versions. The titles of the books used in the current study were as follows: *Sara the Supergirl to the Rescue*, *Sara and the Messy Garden*, *A lesson for the Lazy Teammate*, *The Naughty School Kids*, *Cheer up, Dad*, and *Meow Kitty* ([Knk International Homeschool](#), n.d.).

The interactive e-books contained common multimedia and interactive features including, animated pictures, text-to-speech, a sentence-highlighting feature, hotspots (which initiate animated-pictures and sentence re-reading), a picture dictionary (which provides matching pictures for keywords before reading), page control buttons, 2 word-games (a word and picture matching game and a spelling and sound matching game which use the vocabulary from the picture dictionary), an incentive game (a reward game in which students raise a virtual dog), and a voice recorder (which allows students to record and playback their reading or pronunciation of specific words).

It is important to note that the incentive game was available on the home screen and was not a feature provided to the students as they read the story. However, students could easily access the game while reading e-books by clicking on the home screen button. The incentive game was not designed to facilitate comprehension of what students read, but rather to motivate them to do the reading by receiving rewards for interaction with the text and overall progress. Thus, students could collect coins by clicking hotspots and completing readings and then use the collected coins to feed and buy items for an interactive pet dog.

To ensure the texts used in this study were an appropriate level for students' independent reading (see [The Extensive Reading Foundation, 2011](#)), the readability of story texts was analyzed using the Lexile Analyzer ([lexile.com/analyzer](#)). Each of the e-book texts had 500 words on average, and the readability of the texts scored 500–600L in the Lexile measures, which accords with the A2 level in the CEFR ([University of Colorado Boulder, 2018](#)). Readability of the texts was equivalent to that of five different textbooks for Korean 1st year middle school students which also scored 500–600L.

Each of the six reading comprehension tests (pre- and five after reading session tests) was written based on the story read in each session and was specifically designed to measure literal (grasping the direct meaning of what the text describes as happening), and inferential (taking the information in the text and using it to determine what the text does not explicitly state) reading comprehension. The researchers collaborated to create ten questions for each reading: six literal and four inferential comprehension questions. The format of the tests and question types were designed by referring to middle school

public textbooks and mimicking the format students normally encounter. Thus, each comprehension test followed the same format of three true/false, five multiple-choice, and two open-ended questions and had a Lexile measure of 500–600, which corresponds to the A2 level in the CEFR (University of Colorado Boulder, 2018). As suggested by various scholars (e.g., Carr, 2011; Kirschner et al., 1996; Shohamy, 1984), to avoid students answering questions wrong as a result of misunderstanding the questions, test items, and examples were written in students' native language. Translated examples of the pre-test and Test 1 are provided in Appendix A.

3.2.2. Interactive feature survey

To gain insight into students' opinions on the interactive features of e-books, a 5-point Likert scale survey was developed and administered only to the students from the e-book reading group. The survey included eight items related to the helpfulness of the various interactive features available on the e-books. Students were asked to mark their level of agreement with each statement from 5 to 1 with 5 being *Strongly Disagree* and 1 being *Strongly Agree*. The survey was given to students in Korean to avoid any misunderstanding of what was being asked. A full translated version of the original survey is provided in Appendix B.

3.3. Procedures

The participants were randomly assigned to one of two groups through a lottery name draw so that each participant had an equal opportunity to be assigned to either the treatment or the control group. Both the e-book reading group and the paper-based reading group consisted of 15 participants each. As displayed in Fig. 1 below, after the random assignment, a paper-based pre-test was conducted to ensure the comparability of the two groups in their reading comprehension ability on Day 1 before the experiment (Mackey & Gass, 2015). In the pre-test, all of the participants individually read a written text for 20 min and then answered the 10 comprehension questions which took, on average, about 25 min. While answering questions, students were allowed to refer to the book to minimize the possible effects of forgetting what they had read on their reading performance (Nation, 2009). After the pre-test, the reading sessions were held over five consecutive days from Day 2 to Day 6 in a computer lab at the supplementary English language institute equipped with twenty individual desktop computers. Before the 1st reading session on Day 2, students in the treatment group were introduced to the available features of e-books.

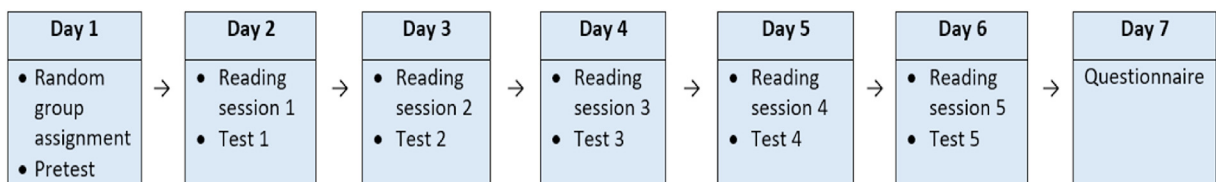


Fig. 1. Data collection procedures.

In each reading session, students in both groups read the same book for 20 min in the format their group was assigned to. Students reading an interactive e-book in the treatment group were free to choose and use whatever functions they desired. On the other hand, students in the control group simply read the equivalent paper-based version of the story. To provide further insights into students' interactions with interactive e-books vs. paper-based books, during each reading session the principal researcher acted as a non-participant observer and wrote field notes detailing how students were interacting with the different reading mediums. Immediately after each reading session, students in both groups were required to complete a reading comprehension test. During the tests, the principal researcher observed and monitored the students to prevent any form of cheating which could affect the internal validity of the results. Field notes were also written while observing which focused specifically on how the learners interacted with the different reading mediums. On Day 7, students in the treatment group responded to the survey.

3.4. Data analysis

For each comprehension question in the pre- and five reading comprehension tests (Tests 1 to 5), one correct answer accounted for one point; thus, the total maximum possible score was 10 across the tests. The two open-ended questions requiring simple short answers were scored independently by the researchers and their ratings were cross-analyzed to provide inter-rater reliability. Exact agreement between the researchers was 88.7%, which is considered acceptable (Mackey & Gass, 2015). The independent-samples *t*-test was performed in SPSS 22 to compare the scores of the pre- and reading comprehension tests between the two groups. The assumptions of the *t*-test (an interval-level dependent variable, independence of observation, normal distribution of data, and equal variances) examined before the main analysis indicated the

data (except Test 2 scores) did not meet the assumptions of normal distribution and equal variances. Consequently, bootstrapped Bias corrected accelerated (BCa) Confidence Intervals (CIs) for the *t*-test were employed (Larson-Hall, 2016). The bootstrapped BCa is a robust statistic that does not require the assumptions of normality and equal variances (Larson-Hall, 2016). Differences in the literal and inferential test scores depending on groups were analyzed by the same statistical technique because the assumption of normal distribution was not met in all tests. Effect sizes were measured using Cohen's *d* (specifically Glass's δ). The standard deviations (SDs) of the paper-reading group were used as standardizers (Glass, 1976; Olejnik & Algina, 2000).

Before the analysis, survey response data were reverse coded due to the fact that the original scales were in a different order. As aforementioned, smaller numbers originally indicated agreement while larger numbers represented disagreement regarding the effectiveness of the interactive features in facilitating reading comprehension. After the reverse coding, 1 indicated strong disagreement (Strongly Disagree) and 5 strong agreement (Strongly Agree), whereas 3 remained neutral (Neither Agree nor Disagree). 4 became representing Agree and 2 Disagree, respectively. The re-coded data were analyzed descriptively in SPSS.

4. Results

4.1. Differences in overall reading comprehension test scores between the interactive e-book readers and paper-based readers

Table 3 presents the descriptive statistics, BCa 95% CIs for the test score differences and effect sizes across the six tests. The mean scores of the paper-based reading group were slightly higher than those of the e-book reading group on the pre-test, Tests 1, 3, and 4. On the other hand, the mean of the e-book reading group was somewhat higher than that of its paper-based counterpart on Test 5. The scores of the two groups on Test 2 were equal.

Table 3
Descriptive statistics, BCa 95% CIs for test score differences, and effect sizes for overall comprehension scores.

Test	Mean (SD)		BCa 95% CI	Effect size (<i>d</i>)
	E-book reading (Treatment)	Paper-based reading (Control)		
Pre-test	8.87 (1.187)	9.07 (0.884)	-0.932-0.520	0.23
Test 1	7.93 (1.335)	8.53 (1.407)	-1.512-0.355	0.43
Test 2	8.20 (1.320)	8.20 (1.320)	-0.850-0.900	0.00
Test 3	9.07 (0.884)	9.47 (0.743)	-0.920-0.192	0.54
Test 4	8.00 (0.845)	8.47 (0.990)	-1.041-0.067	0.47
Test 5	8.40 (1.639)	7.53 (1.642)	-0.476-2.003	0.53

Note. *N* = 30 (15 for each group).

The BCa 95% CI for the mean difference of the pre-test scores indicates the two groups were not statistically different in reading comprehension ability before the treatment, as the CI includes 0. The magnitude of the difference was trivial (Plonsky & Oswald, 2014). Likewise, the test found no evidence of a statistical difference between the groups on any of the five reading comprehension tests; all CIs went through 0. This suggests that mediums of reading did not have any bearing on the students' performances on reading comprehension tests. However, the somewhat wide CIs indicate the estimates about the score differences are not precise due to the small sample size (Larson-Hall, 2016).

The effect sizes of Tests 1, 3, 4, and 5 were close to 0.4, and that of Test 2 was 0. This indicates the magnitudes of the score differences across the five tests were either small or nil (Plonsky & Oswald, 2014), meaning the reading comprehension scores were attributed to the mediums of reading to a small extent at the most.

4.2. Mediums of reading and its effects on literal and inferential reading comprehension

As Table 4 shows, the mean scores of the two groups on both literal and inferential questions across the six tests were equivalent or similar. The CIs for the pre-test indicate the two groups were comparable to each other regarding both literal and inferential reading abilities before the treatment. Similarly, the CIs on Tests 1 to 5 show the scores of the two groups were not statistically different regardless of the types of questions with small-sized effects. This suggests the mediums of reading exerted effects on the students' literal and inferential reading abilities to a small extent. However, the two groups' scores on the literal questions in Test 4 were significantly different with a medium-sized effect (Plonsky & Oswald, 2014), which shows the students' literal reading comprehension scores were dependent upon the different reading mediums to a noticeable extent on Test 4. It seems that their literal comprehension benefitted much more from a paper-based reading condition. Overall, the BCa 95% CIs were rather wide, which indicates the estimates about the score differences are not accurate possibly because of the small-sized sample (Larson-Hall, 2016).

Table 4
Descriptive statistics, BCa 95% CIs for the score differences in the literal and inferential questions, and effect sizes.

Test	Literal vs inferential	Mean (SD)		BCa 95% CI	Effect size (d)
		E-book reading (Treatment)	Paper-based reading (Control)		
Pre-test	Literal	5.20 (1.014)	5.20 (0.676)	-0.622-0.600	0.00
	Inferential	3.80 (0.561)	3.87 (0.352)	-0.403-0.297	0.20
Test 1	Literal	4.60 (1.121)	4.87 (1.125)	-1.000-0.467	0.24
	Inferential	3.33 (0.816)	3.67 (0.617)	-0.850-0.187	0.55
Test 2	Literal	5.00 (1.000)	4.93 (0.799)	-0.600-0.718	0.09
	Inferential	3.33 (0.816)	3.27 (0.799)	-0.493-0.661	0.07
Test 3	Literal	5.20 (0.862)	5.53 (0.640)	-0.857-0.200	0.52
	Inferential	3.87 (0.352)	3.93 (0.258)	-0.267-0.133	0.23
Test 4	Literal	4.47 (0.640)	5.07 (0.704)	-1.067-0.109	0.85
	Inferential	3.53 (0.743)	3.40 (0.737)	-0.373-0.632	0.18
Test 5	Literal	5.13 (0.990)	4.53 (1.060)	-0.084-1.273	0.57
	Inferential	3.27 (0.961)	3.00 (0.756)	-0.366-0.857	0.31

4.3. Interactive features most and least favored by students to aid reading comprehension

Table 5 presents the mean ratings with percentages of the students' perceptions of the effectiveness of the interactive features as aiding tools for their reading comprehension. In terms of mean ratings, the feature of sentence highlighting, which is synchronized with narration, was believed to be the most helpful function with the highest mean score (4.07), followed by the page control button (4.00), animated pictures (3.93), picture dictionary (3.73), text re-reading (3.67), word game (3.60), and voice recording (3.60). When it comes to the percentages, 80% of the students either agreed or strongly agreed that the page control button and animated pictures were important. 66.7% of them either agreed or strongly agreed sentence highlighting, picture dictionary, and text re-reading features facilitated their reading comprehension. Additionally, the word game and voice recording features were perceived as helpful tools by 60% of the students.

Table 5
Mean ratings of students' perception of the interactive features (N = 15).

Survey question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Mean
1. The sentence highlighting feature helped me to better understand the text.	0 (0%)	0 (0%)	5 (33.3%)	4 (26.7%)	6 (40.0%)	4.07
2. The page control button helped me to better understand the text.	1 (6.7%)	1 (6.7%)	1 (6.7%)	6 (40.0%)	6 (40.0%)	4.00
3. The animated pictures helped me to better understand the text.	0 (0%)	1 (6.7%)	2 (13.3%)	9 (60.0%)	3 (20.0%)	3.93
4. The picture dictionary helped me to better understand the text.	0 (0%)	2 (13.3%)	3 (20.0%)	7 (46.7%)	3 (20.0%)	3.73
5. The feature of text re-reading helped me to better understand the text.	0 (0%)	1 (6.7%)	4 (26.7%)	9 (60.0%)	1 (6.7%)	3.67
6. The word game helped me to better understand the text.	0 (0%)	1 (6.7%)	5 (33.3%)	8 (53.3%)	1 (6.7%)	3.60
7. The voice recording helped me to better understand the text.	0 (0%)	2 (13.3%)	4 (26.7%)	7 (46.7%)	2 (13.3%)	3.60
8. The incentive game helped me to better understand the text.	3 (20.0%)	5 (33.3%)	5 (33.3%)	0 (0%)	2 (13.3%)	2.53

In contrast, the incentive game was thought by the students to be the least helpful (2.53) in facilitating their reading comprehension. Specifically, more than half of the students (53.3%) expressed their disagreement regarding the effectiveness of the feature, and an additional one-third of them (33.3%) neither agreed nor disagreed.

5. Discussion

The first research question we set out to examine was how interactive e-book reading affects reading comprehension in comparison with paper-based reading. Despite the interactive e-book group having access to various features in the program that could facilitate their comprehension of the text, no statistical difference in students' reading comprehension was found between the two different mediums of reading. One possible reason is that, while observing students in the interactive e-book group, the principal researcher noted that some students were distracted by the interactive features. More specifically, the primary researcher observed that students reading e-books spent a portion of their time playing with interactive features

rather than engaging directly with the text (specifically the games and hotspot features) while those in the paper-based reading group tended to spend time reading and re-reading the texts several times. This resulted in the interactive e-book readers spending less time and attention on the texts overall than those in the paper-based group. As De Jong and her colleague (2002) pointed out, all levels of students may be distracted by games which can take the learner's focus away from the task of comprehending the text. This may have negated the comprehension benefits that may have been gained from the interactive features. In other words, it is possible that even with less time and attention spent on reading, students in the interactive e-book group were still able to obtain similar scores to their paper-based reading counterparts due to the comprehension benefits gained from playing with the interactive features. Further research would need to be carried out to investigate if this was, in fact, the case.

In addition, considering extraneous cognitive processing (Mayer, 2009), it is also possible that students' working memory was pushed beyond its capacity by students alternatively consuming reading texts and interactive features, especially if those interactive features were not aimed to, or pedagogically designed to facilitate learners' comprehension (Paas & Sweller, 2014). This may have been the case with the incentive game and the picture dictionary as the incentive game was simply not aimed to provide support for reading comprehension and therefore distracted students from focusing on reading and comprehending, and the picture dictionary was poorly designed to aid learners' comprehension. More specifically, the picture dictionary simply provided a matching picture for each word entry with some of the pictures being ambiguous and failing to clearly depict the meaning. The lack of clarity between the word and the meaning being presented in the accompanying picture may have caused confusion and led to additional extraneous processing in students, resulting in little to no gains in their comprehension of the interactive e-book text. From the results of this study, we cannot be certain that this was the case and therefore suggest further research be conducted which investigates the possible links between interactive features, extraneous cognitive processing, and reading comprehension.

Considering the second research question examining the difference in literal and inferential comprehension depending on the mediums of reading, the results revealed that there was no statistical difference in students' inferential comprehension depending on different reading mediums. On the other hand, a statistical difference in literal comprehension between the two groups was found in one of the five tests. The results are contrary to Kao et al.'s findings (2016), where students who read e-books with high interactivity performed better in literal and critical comprehension questions than students reading low-interactive e-books. The different results may be explained by a poorly developed interactive design. The interactive features in the research by Kao et al. (2016) were developed to have students actively engage in reading and think deeply whereas interactive features provided in the program used for this research did not. In line with the findings of De Jong and Bus (2002), poorly designed features in the interactive e-books used in this study may have led to less repeated reading and focus on reading texts which may account for the lack of increase in comprehension. Another possible reason might be that the majority of inferential comprehension questions adopted a multiple-choice format (3 out of 4). Thus, students may have been able to get the correct answer by the process of elimination or guessing rather than genuinely being able to make inferences based on their comprehension of the text.

The results of the third research question investigating what interactive features students find the most and the least helpful in relation to aiding their reading comprehension revealed that sentence highlighting was felt to be the most helpful interactive feature in the e-books used in the research, followed by the page control button, animated pictures, picture dictionary, text re-reading, word game, and voice recording. The average mean ratings of those features were higher than 3.6, which indicates that students felt those features were somewhat helpful in aiding their comprehension when reading e-books. The incentive game, however, was considered unhelpful as more than half of the students (53%) expressed disagreement that the feature aided their comprehension with the mean being 2.53. It is not surprising that the incentive game was thought to be the least helpful of the eight features because it was not designed to contribute to facilitating the reading process but rather aimed to entertain and motivate students. As previously mentioned, Moreno and Mayer (2007) argued that interactive games should be developed based on empirical findings of how people learn. It seems that the game did not follow their recommendation because it only promoted behavioral activity and did not reflect features such as coaching (providing explanations or advice), self-explanation (providing questions asking players to explain or select explanations from a menu), pre-training (providing pre-game activities), modality (presenting words in spoken form), and personalization (presenting words in conversational style) (Clark & Mayer, 2016).

Many researchers agree on the importance of careful consideration and planning in interactive e-book designs (Korat, 2010; Sargeant, 2015; Takacs et al., 2015; Takacs & Bus, 2016). When instructional design is poorly developed (i.e., layout, design, or features that distract from reading, or confuse students), students' limited working memory may be taken up by an extraneous cognitive load which can hinder their comprehension of the digital text (Mayer, 2014; Paas & Sweller, 2014). As we found in this study, games should be given careful consideration before adopting them in interactive e-books. It might be a good way for games to be accessible before or after reading to avoid negatively influencing the reading process. Thus, it is of primary importance that the instructional design is developed in a way that facilitates reading comprehension while at the same time reducing extraneous cognitive load (Paas & Sweller, 2014). In line with previous studies (see Biancarosa & Griffiths, 2012), we strongly believe that the teacher's role is critically important to provide guidance and support during interactive e-book reading. Teachers should be well aware of what features will be helpful and what will not aid students' reading comprehension and need to discourage students from using distracting features or features that do not aim to facilitate their understanding of what they are reading. Additionally, as Moreno and Mayer (2007) stated, materials developers need to consider what interactive features should or should not be included in these e-book programs based on empirical research.

Relating to previous literature on the topic, students' reading comprehension in this study may have also been affected by formed habits of digital text reading. As previously presented, students tend to read digital materials casually by casual browsing and scanning (Liu, 2005) and therefore, students' reading comprehension can be compromised (Lenhard et al., 2017; Liu, 2005; Singer Trakhman et al., 2018). Singer Trakhman et al. (2018) reported that students reading digital texts seemed to read books faster than those reading paper texts, and their overall comprehension scores were lower than paper-based reading group's. Like previous studies, the primary researcher also witnessed students read e-books quickly and then spend their time playing with interactive features.

We must caution at this point, however, that individual differences in reading skills—differences in abilities in lower-level processes and higher-level processes—can affect students' reading comprehension more than the medium in which they read the content (Singer Trakhman & Alexander, 2017b). For example, Alisaari et al. (2018) found that students with good decoding skills at the word level (lower-level processes) performed equally well on a digital comprehension test following on-screen reading as they did on a paper-based comprehension test following a paper-based reading. This finding lent support for previous studies that pointed out the importance of fast, automatic, and accurate word recognition for the comprehension of written discourse (Alderson, 2000; Grabe, 2009). Students who read digital texts slowly and engaged in in-depth thinking processes (higher-level processes) performed better in measures of reading comprehension than others who did not (Singer Trakhman et al., 2018). Similarly, Yeom and Jun (2020) reported that high-performing English language learners regardless of medium read through texts thoroughly utilizing reading comprehension strategies and background knowledge to aid their comprehension (higher-level processes). Interestingly, similar reading comprehension strategies (higher-level processes) seem to be applied in both mediums (Rockinson-Szapkiw et al., 2013; Song et al., 2020; Yeom & Jun 2020). Taken all together, it may be reasonable to conclude that how one reads rather than whether it is text on paper or digital text that is of crucial importance concerning students' reading comprehension.

Thus, in the case of interactive e-books where readers may have unknowingly picked up skimming and scanning habits during their everyday interaction with digital text, materials developers need to introduce research-based designs, features, and tasks that offset such formed habits. As Singer Trakhman et al. (2018) suggested, introducing designs that promote the slow reading of digital texts can promote deeper thinking which can ultimately lead to better comprehension. So, imposing longer time mandates for each portion of a text while also incorporating tasks that require students to read back and forth three or four times may be a way of counteracting students' digital reading habits. Or, setting a timer lock on the page function so that learners cannot simply skim and flip the pages as they wish.

Along with material developers, teachers must guide students towards effective ways of reading or engaging with interactive e-books. To do so, teachers need to understand how e-book reading habits may influence students' reading performance, promote slower reading practices when students engage with digital text, and involve students in tasks that require deeper cognitive processing while reading.

6. Conclusion

As CALL technology advances, English language learners are engaging more and more with interactive e-books. In this study, the impact of interactive e-books on students' reading comprehension and students' opinions on interactive features were investigated. The results did not find significant effects of interactive e-books on students' reading comprehension compared to paper-based reading overall, as well as when comparing literal to inferential comprehension. The results of the survey shed light on what interactive features students felt helped them to comprehend what they read. Although the majority of the features themselves were perceived to be useful to some extent, in some cases the design within those features could have hindered rather than aided students' comprehension. A good example of this is the picture dictionary which provided ambiguous pictures for keywords with no further support. This sort of design can lead to confusion in learners where they are trying to decipher the meaning of the words they do not know and are left having to guess the meaning based on the vague picture provided. Therefore, it is important that interactive e-book designers not only consider the features but the design within those features as well to ensure they support the reading comprehension process. To take this point one step further, it is imperative that the development of such materials is research-based. Furthermore, features that are included just for fun, or that distract students from the reading process should be reconsidered by developers of future interactive e-books as they can take away from the aims of reading and the fostering students' autonomous understanding of what they read.

This study aimed to contribute a better understanding of how middle school students perform when reading interactive e-books compared to paper-based reading and initiate further research on the topic. As aforementioned, the previous research on interactive e-book reading has mainly focused on either young learners or college students, and the research about how middle school students perform in reading interactive e-books has not been given proper attention. Moreover, this study addressed shortfalls that Singer Trakhman and Alexander (2017b) found in previous research by providing detailed information on texts (the type, the length, and the difficulty of texts) and question formats (true/false, multiple-choice, and open-ended questions), examining different levels of comprehension (literal and inferential comprehension) and considering students' language proficiency.

It should be noted, however, that this study has a few notable limitations. Therefore, caution should be exercised when interpreting the results. First, the sample size is small which raises a few concerns regarding the representativeness of the sample, generalizability of the research findings, and accuracy of the effect estimates (Larson-Hall, 2016). Nevertheless, we do

believe it is a starting point from which more research in this area can (and should) be conducted. To address the issues future research should determine the necessary sample size based on a targeted precision (Larson-Hall, 2016) and replicate the current study with larger samples. In addition, the current study took mainly a quantitative approach, focusing on the product of reading (test scores) as well as the survey data. The students could have been asked about their perceptions of beneficial interactive features after each reading session and reasons for using certain features. Thus, why the students perceived each of the interactive features to be useful for their reading comprehension remains unknown. Accordingly, future studies are needed to explore this topic by incorporating qualitative data collection techniques (e.g., interviews, diaries) and analysis methods to gain a fuller understanding (Alderson, 2000; Dörnyei & Taguchi, 2010). An additional limitation was in the reading comprehension test design. Since these tests were designed to mimic the current reading comprehension testing norms in middle school English classrooms in South Korea, the tests were predominantly multiple-choice questions and did not contain many open-ended questions. Future studies should incorporate a variety of open and closed-ended question types in order to gain deeper insight into students' reading comprehension.

The findings of this study provide various avenues for future studies. First, the results of this study shed light on students' reading comprehension ability depending on different mediums of reading. Nonetheless, a question of if the mediums of reading differentially affect the improvement of students' reading comprehension ability and in what capacity remains to be examined mainly due to the short duration of the experiment (i.e., the total amount of reading time was 100 min). As outlined in the literature review, reading comprehension is a complex task that involves various lower-level and higher-level cognitive processes; therefore, development in reading comprehension takes time (see Oakhill & Cain, 2007). Thus, longitudinal research investigations must be undertaken, employing longer and/or more reading sessions that look into effects on different levels of reading comprehension (i.e. literal, inferential, applied, and evaluative).

Second, as research into this area is still in its infancy, more studies must be conducted in a variety of contexts with a variety of interactive e-book materials. It would also be of interest to investigate whether training students to be actively involved in deeper processing while reading interactive e-books can lead to improvements in students' reading comprehension.

CRediT authorship contribution statement

Jongyun Lim: Conceptualization, Investigation, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **George E.K. Whitehead:** Conceptualization, Methodology, Supervision, Writing - original draft, Writing - review & editing. **YunDeok Choi:** Formal analysis, Writing - original draft, Writing - review & editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.system.2020.102434>.

References

- Alderson, C. J. (2000). *Assessing reading*. Cambridge University Press.
- Alisaari, J., Turunen, T., Kajamies, A., Korpela, M., & Hurme, T.-R. (2018). Reading comprehension in digital and printed texts. *L1-Educational Studies in Language and Literature*, 18. Retrieved from <https://11.publication-archive.com/download/1/5589>.
- Bada, E., & Okan, Z. (2000). Students' language learning preferences. *TESL-EJ*, 4(4). Retrieved from <https://tesl-ej.org/~teslejr/pdf/ej15/a1.pdf>.
- Biancarosa, G., & Griffiths, G. G. (2012). Technology tools to support reading in the digital age. *The future of children*, 22(2), 139–160. <https://doi.org/10.1353/foc.2012.0014>
- Bus, A. G., Takacs, Z. K., & Kegel, C. A. T. (2015). Affordances and limitations of electronic storybooks for young children's emergent literacy. *Developmental Review*, 35, 79–97. <https://doi.org/10.1016/j.dr.2014.12.004>
- Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology*, 96(1), 31.
- Carr, N. T. (2011). *Designing and analyzing language tests*. Oxford University Press.
- Chambers, B., Cheung, A. C. K., Madden, N. A., Slavin, R. E., & Gifford, R. (2006). Achievement effects of embedded multimedia in a success for all reading program. *Journal of Educational Psychology*, 98(1), 232–237. <https://doi.org/10.1037/0022-0663.98.1.232>
- Chang, W. H., Huang, T. H., & Liu, Y. C. (2019). Influence of an interactive e-Book on the reading comprehension of different ethnic groups using indigenous culture as content. *International Journal of Human-Computer Interaction*, 35(4–5), 323–332. <https://doi.org/10.1080/10447318.2018.1543079>
- Chen, C. N., Chen, S. C., Chen, S. H. E., & Wey, S. C. (2013). The effects of extensive reading via e-books on tertiary level EFL students' reading attitude, reading comprehension and vocabulary. *The Turkish Online Journal of Educational Technology-TOJET*, 12(2), 303–312. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1015469.pdf>.
- Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning* (4th ed.). Wiley.
- Constantinescu, I. A. (2007). Using technology to assist in vocabulary acquisition and reading comprehension. *The Internet TESL Journal*, 13(2), 122–133. Retrieved from <http://iteslj.org/Articles/Constantinescu-Vocabulary.html>.
- Council of Europe. (2018). Common European Framework of reference for languages: Learning, teaching, assessment. Retrieved from <https://rm.coe.int/cefr-companion-volume-with-new-descriptors-2018/1680787989>.
- Danaei, D., Jamali, H. R., & Mansourian, Y. (2020). Comparing reading comprehension between children reading augmented reality and print storybooks. *Computers & Education*, 153, 103900. <https://doi.org/10.1016/j.compedu.2020.103900>
- Day, R. R., & Park, J. S. (2005). Developing reading comprehension questions. *Reading in a Foreign Language*, 17(1), 60–73. Retrieved from <https://files.eric.ed.gov/fulltext/EJ689120.pdf>.
- De Jong, M. T., & Bus, A. G. (2002). Quality of book-reading matters for emergent readers: An experiment with the same book in a regular or electronic format. *Journal of Educational Psychology*, 94(1), 145–155. <https://doi.org/10.1037/0022-0663.94.1.145>

- De Jong, M. T., & Bus, A. G. (2004). The efficacy of electronic books in fostering kindergarten children's emergent story understanding. *Reading Research Quarterly*, 39(4), 378–393. <https://doi.org/10.1598/rrq.39.4.2>
- Dörnyei, Z., & Taguchi, T. (2010). *Questionnaires in second language research: Construction, administration, and processing* (2nd ed.). Routledge.
- Gass, S. M. (1997). *Input, interaction, and the second language learner*. Lawrence Erlbaum Associates.
- Glass, G. V. (1976). Primary, secondary, and meta-analysis of research. *Educational Researcher*, 5(10), 3–8. <https://doi.org/10.3102/0013189x005010003>
- Grabe, W. (2009). *Reading in a second language: Moving from theory to practice*. New York: Cambridge University Press.
- Grabe, W., & Stoller, F. (2011). *Teaching and researching reading* (2nd ed.). Pearson Education.
- Guernsey, L., Levine, M., Chiong, C., & Severns, M. D. (2012). Pioneering literacy in the digital wild west: Empowering parents and educators. Retrieved from https://joanganzcooneycenter.org/wp-content/uploads/2012/12/GLR_TechnologyGuide_final.pdf.
- Hart, M. (1992, August). The history and philosophy of project Gutenberg by Michael Hart. Project gutenberg. https://www.gutenberg.org/wiki/Gutenberg:The_History_and_Philosophy_of_Project_Gutenberg_by_Michael_Hart.
- Homer, B. D., Kinzer, C. K., Plass, J. L., Letourneau, S. M., Hoffman, D., Bromley, M., Hayward, E. O., Turkay, S., & Kornak, Y. (2014). Moved to learn: The effects of interactivity in a Kinect-based literacy game for beginning readers. *Computers & Education*, 74, 37–49. <https://doi.org/10.1016/j.compedu.2014.01.007>
- Jenkins, J. R., & Pany, D. (1981). Instructional variables in reading comprehension. In J. T. Guthrie (Ed.), *Comprehension and teaching: Research reviews* (pp. 163–202). International Reading Association.
- Jeong, H. (2012). A comparison of the influence of electronic books and paper books on reading comprehension, eye fatigue, and perception. *The Electronic Library*, 30(3), 390–408. <https://doi.org/10.1108/02640471211241663>
- Joh, J., & Plakans, L. (2017). Working memory in L2 reading comprehension: The influence of prior knowledge. *System*, 70, 107–120. <https://doi.org/10.1016/j.system.2017.07.007>
- Kao, G. Y. M., Tsai, C. C., Liu, C. Y., & Yang, C. H. (2016). The effects of high/low interactive electronic storybooks on elementary school students' reading motivation, story comprehension and chromatics concepts. *Computers & Education*, 100, 56–70. <https://doi.org/10.1016/j.compedu.2016.04.013>
- Khezlrou, S., Ellis, R., & Sadeghi, K. (2017). Effects of computer-assisted glosses on EFL learners' vocabulary acquisition and reading comprehension in three learning conditions. *System*, 65, 104–116. <https://doi.org/10.1016/j.system.2017.01.009>
- Kirschner, M., Spector-Cohen, E., & Wexler, C. (1996). A teacher education workshop on the construction of EFL tests and materials. *Tesol Quarterly*, 30(1), 85–112. <https://doi.org/10.2307/3587608>
- Knk International Homeschool. KnK CAPPYTOWN. n.d. [Online learning program]. Retrieved from www.cappytown.com.
- Korat, O. (2009). The effects of CD-ROM storybook reading on Israeli children's early literacy as a function of age group and repeated reading. *Education and Information Technologies*, 14(1), 39–53. <https://doi.org/10.1007/s10639-008-9063-y>
- Korat, O. (2010). Reading electronic books as a support for vocabulary, story comprehension and word reading in kindergarten and first grade. *Computers & Education*, 55(1), 24–31. <https://doi.org/10.1016/j.compedu.2009.11.014>
- Korat, O., Levin, I., Atishkin, S., & Turgeman, M. (2013). E-book as facilitator of vocabulary acquisition: Support of adult, dynamic dictionary and static dictionary. *Reading and Writing*, 27, 613–629. <https://doi.org/10.1007/s11145-013-9474-z>.
- Korat, O., & Shamir, A. (2007). Electronic books versus adult readers: Effects on children's emergent literacy as a function of social class. *Journal of Computer Assisted Learning*, 23(3), 248–259. <https://doi.org/10.1111/j.1365-2729.2006.00213.x>
- Korat, O., Shamir, A., & Segal-Drori, O. (2014). E-books as a support for young children's language and literacy: The case of Hebrew-speaking children. *Early Child Development and Care*, 184(7), 998–1016. <https://doi.org/10.1080/03004430.2013.833195>
- Kucer, S. B. (2005). *Dimensions of literacy* (2nd ed.). Lawrence Erlbaum.
- Larson-Hall, J. (2016). *A guide to doing statistics in second language research using SPSS and R* (2nd ed.). Routledge.
- Leeser, M. J. (2007). Learner-based factors in L2 reading comprehension and processing grammatical form: Topic familiarity and working memory. *Language and Learning*, 57(2), 229–270. <https://doi.org/10.1111/j.1467-9922.2007.00408.x>
- Lenhard, W., Schroeders, U., & Lenhard, A. (2017). Equivalence of screen versus print reading comprehension depends on task complexity and proficiency. *Discourse Processes*, 54(5–6), 427–445. <https://doi.org/10.1080/0163853X.2017.1319653>
- Li, L. (2017). *New technologies and language learning*. Palgrave Macmillan.
- Liu, Z. (2005). Reading behavior in the digital environment. *Journal of Documentation*, 61(6), 700–712. <https://doi.org/10.1108/00220410510632040>
- Mackey, A., & Gass, S. M. (2015). *Second language research: Methodology and design*. Routledge.
- Marzban, A. (2011a). Improvement of reading comprehension through computer-assisted language learning in Iranian intermediate EFL students. *Procedia Computer Science*, 3, 3–10. <https://doi.org/10.1016/j.procs.2010.12.003>
- Marzban, A. (2011b). Investigating the role of multimedia annotations in EFL reading comprehension. *Procedia-Social and Behavioral Sciences*, 28, 72–77. <https://doi.org/10.1016/j.sbspro.2011.11.015>
- Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge University Press.
- Mayer, R. E. (2014). Cognitive theory of multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 43–71). Cambridge University Press.
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38(1), 43–52. https://doi.org/10.1207/S15326985EP3801_6
- Moreno, R., & Mayer, R. E. (2007). Interactive multimodal learning environments. *Educational Psychology Review*, 19(3), 309–326. <https://doi.org/10.1007/s10648-007-9047-2>
- Nation, I. S. P. (2009). *Teaching ESL/EFL reading and writing*. Routledge.
- Nuttall, C. (1982). *Teaching reading skills in a foreign language*. Heinemann Educational.
- Oakhill, J. V., & Cain, K. (2007). Introduction to comprehension development. In K. Cain, & J. Oakhill (Eds.), *Children's comprehension problems in oral and written language: A cognitive perspective* (pp. 3–40). New York: Guilford.
- Olejnik, S., & Algina, J. (2000). Measures of effect size for comparative studies: Applications, interpretations, and limitations. *Contemporary Educational Psychology*, 25(3), 241–286.
- Paas, F., & Sweller, J. (2014). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 27–42). Cambridge University Press.
- Pearson, P. D., & Camperell, K. (1981). *Comprehension of text structures*. *Comprehension and teaching: Research reviews*. Retrieved from <https://files.eric.edu/gov/fulltext/ED203299.pdf#page=35>.
- Plonsky, L., & Oswald, F. L. (2014). How big is “big”? Interpreting effect sizes in L2 research. *Language Learning*, 64(4), 878–912. <https://doi.org/10.1111/lang.12079>
- Rockinson-Szapkiw, A. J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *Computers & Education*, 63, 259–266. <https://doi.org/10.1016/j.compedu.2012.11.022>
- Sadeghi, K. (2007). The key for successful reader-writer interaction: Factors affecting reading comprehension in L2 revisited. *Asian EFL Journal*, 9(3), 198–220. Retrieved from https://www.researchgate.net/profile/Massoud_Yaghoubi-Notash3/publication/43480419_Examining_gender-based_variability_in_task-prompted_monologic_L2_oral_performance/links/555a3b9708a6efd2d8281fd8/Examining-gender-based-variability-in-task-prompted-monologic-L2-or-al-performance.pdf#page=198.
- Sargeant, B. (2015). What is an ebook? What is a book app? And why should we care? An analysis of contemporary digital picture books. *Children's Literature in Education*, 46(4), 454–466. <https://doi.org/10.1007/s10583-015-9243-5>
- Schugar, H. R., Smith, C. A., & Schugar, J. T. (2013). Teaching with interactive picture e-books in grades K-6. *The Reading Teacher*, 66(8), 615–624. <https://doi.org/10.1002/trtr.1168>

- Shamir, A., Korat, O., & Barbi, N. (2008). The effects of CD-ROM storybook reading on low SES kindergarteners' emergent literacy as a function of learning context. *Computers & Education*, 51(1), 354–367. <https://doi.org/10.1016/j.compedu.2007.05.010>
- Shohamy, E. (1984). Does the testing method make a difference? The case of reading comprehension. *Language Testing*, 1(2), 147–170. <https://doi.org/10.1177/026553228400100203>
- Singer Trakhman, L. M., & Alexander, P. A. (2017a). Reading across mediums: Effects of reading digital and print texts on comprehension and calibration. *The Journal of Experimental Education*, 85(1), 155–172. <https://doi.org/10.1080/00220973.2016.1143794>
- Singer Trakhman, L. M., & Alexander, P. A. (2017b). Reading on paper and digitally: What the past decades of empirical research reveal. *Review of Educational Research*, 87(6), 1007–1041. <https://doi.org/10.3102/0034654317722961>
- Singer Trakhman, L. M., Alexander, P. A., & Silverman, A. B. (2018). Profiling reading in print and digital mediums. *Learning and Instruction*, 57, 5–17. <https://doi.org/10.1016/j.learninstruc.2018.04.001>
- Smeets, D. J. H., & Bus, A. G. (2013). Picture storybooks go digital: Pros and cons. In S. B. Neuman, & L. B. Gambrell (Eds.), *Quality reading instruction in the age of common core standards* (pp. 176–189). International Reading Association.
- Smeets, D. J. H., & Bus, A. G. (2015). The interactive animated e-book as a word learning device for kindergartners. *Applied Psycholinguistics*, 36(4), 899–920. <https://doi.org/10.1017/s0142716413000556>
- Song, K., Na, B., & Kwon, H. J. (2020). A comprehensive review of research on reading comprehension strategies of learners reading in English-as-an additional language. *Educational Research Review*, 29, 100308.
- Sweet, A. P., & Snow, C. E. (2003). Reading for comprehension. In C. E. Snow, & A. P. Sweet (Eds.), *Rethinking reading comprehension* (pp. 1–11). Guilford Press.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257–285. [https://doi.org/10.1016/0364-0213\(88\)90023-7](https://doi.org/10.1016/0364-0213(88)90023-7)
- Sweller, J. (1999). *Instructional design in technical areas*. ACER Press.
- Sweller, J., VanMerirenboer, J. J. G., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10(3), 251–296. <https://doi.org/10.1023/A:1022193728205>
- Takacs, Z. K., & Bus, A. G. (2016). Benefits of motion in animated storybooks for children's visual attention and story comprehension. An eye-tracking study. *Frontiers in Psychology*, 7, 1591. <https://doi.org/10.3389/fpsyg.2016.01591>
- Takacs, Z. K., Swart, E. K., & Bus, A. G. (2015). Benefits and pitfalls of multimedia and interactive features in technology-enhanced storybooks. *Review of Educational Research*, 85(4), 698–739. <https://doi.org/10.3102/0034654314566989>
- The Extensive Reading Foundation. (2011). *Guide to extensive reading*. Retrieved from <https://erfoundation.org/wordpress/guides/>.
- Tompkins, G. (2006). *Literacy for the 21st century: A balanced approach* (4th ed.). Pearson Education.
- Tompkins, G. (2015). *Literacy in the early grades: A successful start for PreK-4 readers and writers* (4th ed.). Pearson Education.
- Torres, N. G., & Constatin, J. J.Á. (2009). Improving reading comprehension skills through reading strategies used by a group of foreign language learners. *How*, 16(1), 55–70. Retrieved from <https://dialnet.unirioja.es/descarga/articulo/5249670.pdf>.
- University of Colorado Boulder. (2018). Reading metrics explanations and justifications. Retrieved from <https://www.colorado.edu/flatironsforum/2018/05/14/reading-metrics-explanations-and-justifications>.
- Vacca, J. A. L., Vacca, R. T., Gove, M. K., Burkey, L. C., Lenhart, L. A., & McKeon, C. A. (2015). *Reading and learning to read* (9th ed.). Pearson Education.
- Wood, S. G., Moxley, J. H., Tighe, E. L., & Wagner, R. K. (2018). Does use of text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of Learning Disabilities*, 51(1), 73–84. <https://doi.org/10.1177/0022219416688170>
- Yeom, S., & Jun, H. (2020). Young Korean EFL learners' reading and test-taking strategies in a paper and a computer-based reading comprehension tests. *Language Assessment Quarterly*, 1–18. <https://doi.org/10.1080/15434303.2020.1731753>
- Zipke, M. (2017). Preschoolers explore interactive storybook apps: The effect on word recognition and story comprehension. *Education and Information Technologies*, 22, 1695–1712. <https://doi.org/10.1007/s10639-016-9513-x>