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A comparison of the influence of electronic books and paper books on reading comprehension, eye fatigue, and perception

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Abstract

Purpose – This paper aims to assess the usability of electronic books (e-books) and paper books (p-books) with objective measures, including user comprehension, eye fatigue, and perception.

Design/methodology/approach – A total of 56 sixth-year public school students participated in this study. This paper was conducted in the following order: pre-CFF measurement, p-/e-book reading, post-CFF measurement, quiz, and questionnaire. A standard CFF device, a computer with a monitor for reading e-books, p-books, desks, and chairs were provided.

Findings – This paper found that there is a significant "book effect" on quiz scores; compared to e-books, p-books appear to enable better reading comprehension. Regarding eye fatigue, students had significantly greater eye fatigue after reading e-books than after reading p-books. Students were satisfied with the e-book, but they preferred p-books.

Research limitations/implications – Students would show satisfaction with e-books and acknowledge their usefulness, but still prefer p-books. However, a clearer understanding of this paradox in perception is needed. Further studies should try to explore the students' perceptions of e-books.

Practical implications – Surprisingly, though, Korean students studied herein, who have had a higher level of exposure to technology than those in other countries, did not show positive behavioral intentions toward e-books. Overall, the responses from the Korean students suggest that there was general satisfaction with reading e-books on screen. However, this study also found a discordance in the students' perceptions of e-books. In this study, most students grew tired of reading on the screen; this tiredness could have an adverse effect on both reading comprehension and the perception of e-books. In further analyzing user responses, many of the critical remarks were found to refer to the screen/text size or clarity rather than to the e-book itself.

Originality/value – Although this study suggests that students in general are not yet ready to entirely give up p-books, e-books are becoming increasingly common. However, great challenges remain in terms of making e-book content more available and in enabling improved comprehension and reducing eye fatigue.

Keywords Electronic book, E-books, Paper book, Reading comprehension, Eye fatigue, Students' perception of electronic books, Students, Perception, South Korea

Paper type Research paper

1. Introduction

Following the rise to prominence of electronic book (e-book) technology in the late 1990s, e-books have been a popular topic in recent years (Langston, 2003). E-books can effectively support an academic mission by saving time, adding value as a collective online reference, and enabling dynamic and cost-effective collection management (Cox,

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2004). An e-book comprises a digital body primarily of text with a defined scope. The term "e-book" is used to describe a text analogous to a book that is digitally displayed on the screen of a computer, a personal digital assistant, or a specifically designed reader; it may comprise text, graphics, video, animation, and/or sound. The e-book is a new platform for accessing digital information that capitalizes on the benefits of electronic reading while providing many of the advantages of paper books (p-books) (Landoni and Hanlon, 2007). E-books have some advantages over printed books, such as settings and particular purposes. On the positive side, two of the most popular reasons for using e-books include their "searchability" and the fact that they are available 24 hours a day.

E-book readers can find specific content more easily and more efficiently than in a p-book (Shelburne, 2009). An e-book, for example, usually has fairly short articles that can be displayed on a few screens, and reading at a computer monitor is acceptable to most users under e-library systems (Dennis *et al.*, 2008). By enabling individuals to find information and to determine whether a book's content is appropriate without having to make a trip to the library, an e-book's time-saving benefits are clear. In additions, students like the lightness and portability of e-book devices, as well as navigation capability, ease of use, storage capacity, and the use of e-ink for displaying content on the screen (Gibson and Gibb, 2011). Futurist Kelly (2006) anticipated that, in the near future, "all new works will be born digital" (p. 43). A 2009 study by Shelburne at the University of Illinois found that the overall lifetime usage of the Springer e-book collections at the University of Illinois Library as of February 2009 was 124,026 chapter downloads. This includes 3,992 chapter downloads from August 2006 through December 2006, 26,675 for 2007, 82,622 for 2008, and 10,737 in January 2009. The e-book has taken its place beside its print counterpart as an accepted method of accessing the published word, and it is now seen as a normal element of any library collection. It may be true that more and more of what we read will be digitalized.

However, despite likely improvements in e-books, there is still a debate over the effects of this mode of reading. E-books present an exciting but also controversial topic for users. This issue has to do with poor legibility, intrinsic complexity, and poor design (Dillon, 1994; Nielsen, 2000). These features contribute to an increase in one's cognitive load because it is more demanding on an individual's attention and comprehension (Sweller, 1994). In most of the studies reported thus far, measurements of reading time or the amount of errors found in proofreading tasks have been used to assess surface legibility. Reading on a standard computer display is more error prone and is approximately 20 percent slower than reading on paper (Nielsen, 2000). Although inexperience with an e-book is less likely than before, there are some concerns about using an e-book as reading material. Carlson (2002) indicated that the difficulty of navigating through an e-book is one of the biggest complaints from its users. After studying 27 libraries and information science students' use and experience with e-books, Chu (2003) indicated that the primary reason for not using e-books was the difficulty of moving within an e-book. According to a study by Hernon *et al.* (2006), moving from page to page on an e-book is tedious, and it is difficult to find specific chapters in the text or to locate particular words. These difficulties have a negative impact on students' perceptions of e-books. Through previous studies, we find that users have been hampered by poor legibility or interface difficulties while reading an e-book on screen.

Of course, the proponents of e-books have commented that the move from paper to screen is evolutionary and inevitable. In addition, the majority of prior research has focused on the technological development of e-book systems, such as information storage, information retrieval, and system integration, rather than on the users' experience, such as user comprehension, eye fatigue, and perception with an e-book. There have been some recent studies related to users, but the user experience continues to receive less attention, and comprehension, eye fatigue, and perception have only been investigated separately. In this work, we attempt to assess the usability of e-books and p-books with objective measures including user comprehension, eye fatigue, and perception. In this paper, our ultimate goal is to suggest improvements for e-books.

2. Research questions

Although e-books are a popular topic that has grown more prominent in recent literature, limited data are available regarding how students actually read, understand, and perceive e-books. Additionally, many studies have examined students' e-book use and nonuse without focusing on school students who are regular users. Consequently, the present study assessed the usability of e-books and p-books with objective measures including reading comprehension, eye fatigue, and perception. The research questions are as follows:

RQ1. Are the comprehension scores of students different when reading an e-book vs a p-book?

RQ2. Is the eye fatigue of students different when reading e-books vs p-books?

RQ3. How do students perceive an e-book's usefulness; what is their satisfaction with e-books; and what are their behavioral intentions regarding future e-book use?

3. Literature review

3.1 Reading comprehension

A number of research studies have used reading comprehension, accuracy, and speed to investigate the effect of e-books and p-books on reading performance. The debate has been largely fueled by the seemingly irreconcilable differences between critics such as Birkerts (1994) and Sanders (1994), who believe that e-books ultimately diminish the personal growth of individuals, and advocates such as Spiro and Jehng (1990), who believe that navigating online texts can build cognitive flexibility.

A study by Macedo-Rouet *et al.* (2003) presented findings from 47 undergraduate university students. It revealed that e-book readers obtained slightly lower comprehension scores than p-book readers. Interestingly, the researchers found that the comprehension decrease was limited to questions concerning complementary documents, or documents that were not immediately visible on the computer screen but had to be selected through a menu. They reported that e-book readers needed time to perform mouse clicks to go from one page to another and needed to use the scroll bar while reading (Macedo-Rouet *et al.*, 2003). In a more recent UK study, Grimshaw and Dungworth (2004) investigated 9-10 year-old students' use of e-books and compared it to their use of p-books. The researchers found no significant difference between the reading comprehension scores of children reading the electronic versions and those

reading the printed versions. In a study by Kang *et al.* (2009), the reading accuracies for both book types were similar. Although the reading efficiency of the p-book users was somewhat higher than that of the e-book readers, there was no significant "book effect" on reading performance. In concentration and reading rates, Grzeschik *et al.* (2011) indicate that users do not suffer from reading texts on e-book. Another study has shown that paging and scrolling increase reading time and decrease information memory when combined (Van Oostendorp and Van Nimwegen, 1998).

On the negative side, prior studies have reported a loss of comprehension when reading online and impaired information visibility on screen. Nielsen (2000), who has been studying e-book reading habits for two decades, asserted that e-book "reading" is not even the correct terminology because of the poor legibility, intrinsic complexity, and inadequate design of current e-books. According to a study by Mayes *et al.* (2001), who collected data from 50 students from the University of Bristol, reading from a p-book is significantly faster, and slower on-screen reading was a strategy conducted by participants to ensure that the content was comprehended. According to a study by Carusi (2006), readers' concentration becomes increasingly fragmentary when reading e-books, and the readers studied were easily distracted by surface features.

However, Egan *et al.* (1989) reported that students using digital hypertext to find specific information had a greater accuracy than students using a paper text. Dillon and Gabbard (1998) also affirmed that reading was better with an e-book than a p-book when performing substantial searches or manipulating and comparing visual details among objects. Matthew (1997) carried out experiments with elementary school students in the US to study the influence of electronic texts on reading comprehension. She compared students who read stories on a CD-ROM and students who read the print versions of the same books. She found that "students who read the CD-ROM versions of the books had significantly higher mean comprehension scores" (p. 269), as measured by their ability to retell the story. In a second experiment, she found that "when the same students read both electronic and print texts, the students' comprehension scores were higher when reading the electronic texts" (p. 270). Her work confirmed that of earlier researchers, including Miller *et al.* (1994). According to Prensky (2001), the changing propensities and cognitive abilities of young people, or "digital natives," predisposed them to engagements with the screen rather than lengthy perusals of static texts. In summary, previous studies of user comprehension comparing e-books and p-books have found that overall comparable performance between the two can be achieved, especially when the contents of an e-book are carefully designed to support students' use. As noted in Table I, given the great interest in this topic, there have not been vast numbers of e-book user studies conducted. However, in the last few years, several studies have been undertaken on this topic. In this study, we investigated the reading comprehension of students when reading e-books and p-books.

3.2 Eye fatigue

Human eyes may suffer physical injury from a reading environment that is not optimized for their benefit. Although computer screens do not damage vision, eye fatigue can still be experienced by e-book users. One of the disadvantages of reading an e-book on a backlit computer screen or other LCD or OLED device is that, over time, it places stress on the eyes and becomes fatiguing. For example, the longer one stares at a monitor, the slower the blinking rate. The failure to blink reduces the moisturization of

Results	Reference
Comprehension	
e-book > p-book	Dillon and Gabbard (1998), Egan *et al.* (1989), Prensky (2001)
p-book > e-book	Van Oostendorp and Van Nimwegen (1998), Nielsen (2000), Martin and Platt (2001), Mayes *et al.* (2001), Bonham *et al.* (2003), Macedo-Rouet *et al.* (2003), Carusi (2006), Doctorow (2004)
Not different	Gordon *et al.* (1988), Macedo-Rouet *et al.* (2003), Kang *et al.* (2009)
Eye fatigue	
e-book > p-book	Cushman (1986), Dillon (1994), Nielsen (2000), Kang *et al.* (2009)
Students' perception	
e-book > p-book	Anuradha and Usha (2006), Carlock and Perry (2008), Shelburne (2009)
p-book > e-book	Eveland and Dunwoody (2001), Martin and Platt (2001), Hernon *et al.* (2006), Levine-Clark (2006), Gregory (2008)
Not different	Chu (2003), Macedo-Rouet *et al.* (2003)

Table I.
Results of previous studies comparing e-books and p-books

the eyes and leads them to be more easily subject to irritation. Cushman (1986) found that visual fatigue is significantly higher when reading texts on a screen than on paper. In the current stage of technological development, the display of text on computer screens has been found to have a negative impact on surface legibility (Dillon, 1994). Texts and documents on screen have a lower surface legibility than printed documents. Macedo-Rouet *et al.* (2003) noted that students felt much more tired when reading on screen; this may be because of the display contrast and resolution of an e-book. Kang *et al.* (2009) conducted an experiment to measure students' eye fatigue and found that reading a p-book caused less eye fatigue than reading an e-book. In their study, the authors concluded that the eye fatigue from an e-book was due mainly to the low display contrast and resolution of the on-screen text.

3.3 Students' perception

In assessing the effectiveness of e-books, researchers have studied students' perception of e-books and p-books with mixed findings. In general, readers tended to feel disoriented when they read texts on screen. For example, e-book readers have trouble estimating the length of sentences, and they perceive that graphics or tables are harder to read on screen than on paper (Eveland and Dunwoody, 2001). Consequently, students tend to prefer to read from p-books rather than from e-books (Martin and Platt, 2001). Several studies have pointed out that there are difficulties with reading from a screen, navigation issues, and problems related to locating materials and searching in general with e-books, so students still prefer a paper copy that they can mark up with a pencil or marker. Hernon *et al.* (2006) examined "e-book use patterns" and found that students do not view an e-book in the same way that they viewed a p-book – something to read from cover to cover. A study by Levine-Clark (2006), with data collected from 2,067 university students, faculty, and staff, indicated that, although e-books are heavily used, students still report issues with reading materials on a screen for a prolonged period of time. Using a survey of 105 students in four undergraduate core courses, Gregory (2008) found that the students' perceptions of e-books were mixed; 66 percent indicated a preference for p-books, whereas 44 percent had a positive feeling toward both types of books.

In contrast, Macedo-Rouet *et al.* (2003) indicated that, even though the visibility of complementary documents is poorer in an e-book than in a p-book, there is a strong motivation for e-book use; in particular, satisfaction with e-books is generally very high. Several studies have also indicated that the positive perception of e-books is associated with accessibility and availability (Anuradha and Usha, 2006; Carlock and Perry, 2008). According to Shelburne (2009), the growing availability of e-books has begun to affect students' perceptions and attitudes toward them, and students consider e-books to be better than p-books. The growing availability of e-books to users has begun to affect user perceptions and attitudes toward e-books, especially as libraries have reached a critical mass in e-book collection numbers, creating more access and usage opportunities. Table I shows the results of this literature review.

4. Methods

4.1 Participants

A total of 56 sixth-year public school students participated in this study. A total of 29 of the students were male, and 27 were female (see Table II); the age range was 10-12 years ($M = 11.35$, $SD = 0.62$). All participants had at least one personal computer that was shared with either a brother or sister. Additionally, they used more than one e-mail account. Approximately 7 percent of them used e-mail every day, and 85 percent used e-mail at least once a week. Approximately 80 percent had mobile phones and exchanged text messages with their friends and/or family. The participants had no physical or mental problems and had at least 20/20 visual acuity (VA) with corrective lenses. VA is a quantitative measure of one's ability to identify black symbols on a white background at a standardized distance as the size of the symbols is varied. It is the most common clinical measurement of visual function; 20/20 vision can be considered nominal performance for human vision. Because tiredness may affect VA, the participants were instructed not to stay up late and not to take medication or any other substances that might affect the test results. The data were collected in the spring of 2008.

4.2 Instrument

4.2.1 Reading instrument. In the current study, we used children's stories that the participants had not previously read. The reading materials were prize-winning entries in the children's story category of the annual spring literary contest of the *Dong-A Daily Newspaper*, the largest popular Korean daily newspaper. We selected a collection of five stories (A, B, C, D, and E) that were first-place entries from 2004 to 2008 (www.donga.com/docs/sinchoon/2008/). We used both e-books and p-books for a total number of ten books (five e-books and five p-books). Each e-book was prepared in the same format as the p-book so as to minimize differences between the two. For each story, there was an average of 700 Korean words over four pages. The font was Arial, which is one of the most frequently used typefaces for Korean textual information. The size of each character in the e-books was about 4.25 mm × 4.25 mm, which was similar to the character size of the p-books. The reading material used in this study is illustrated in Figure 1. The contents of the e-book were displayed on a LG L1732S-SF monitor (see Table III). The p-books displayed reading passages in black and white. The aspect ratio and size of the p-books were similar to the viewing screen of the e-books. However, interface

	n	%
Gender		
Male	29	51.79
Female	27	48.21
Experience of computer usage		
1-3 years	5	8.93
3-5 years	38	67.86
6 years or more	13	23.21
The number of computers in home		
1	11	19.64
2	27	48.21
3 or more	18	32.14
The number of e-mail accounts		
1	21	37.50
2	28	50.00
3 or more	7	12.50
Frequency of e-mail use		
Never	2	3.57
Monthly	6	10.71
Weekly	39	78.57
Daily	9	7.14
Mobile phone		
Yes	45	80.36
No	11	19.64
Frequency of text message use by mobile phone (if you have it)		
Never	0	0.00
Monthly	0	0.00
Weekly	3	6.67
Daily	42	93.33

Note: $n = 56$

Table II.
Participants

manipulation differed between the two book types. The participants used their fingers to turn the pages of the p-books, while they used a keyboard and mouse to go to the next page or scroll up/down within the e-books.

4.2.2 Eye fatigue. Participants' eye fatigues were measured by critical flicker/fusion frequency (CFF) threshold. CFF is defined as the frequency at which a flickering light is in distinguishable from steady, non-flickering light; it is the lowest frequency of flickering light that is required to produce an appearance of steady light to an observer. However, temporal resolution quantified by the CFF must undergo a mathematical conversion if it is to be a predictor of visual acuity. Inevitably, the precision of the conversion will influence of the prediction. Despite this limitation, CFF is widely used as highly sensitive measurement to evaluate retina functionality and it is an effective for assessing the eye fatigue (Wang and Haung, 2004). In this study, the participants watched with both eyes separately through a binocular optic system and they should decide whether the target is flickering or steady. All participants' CFF scores were measured at the beginning of each reading session. After reading the p-book/e-book, their CFF scores were gauged again for

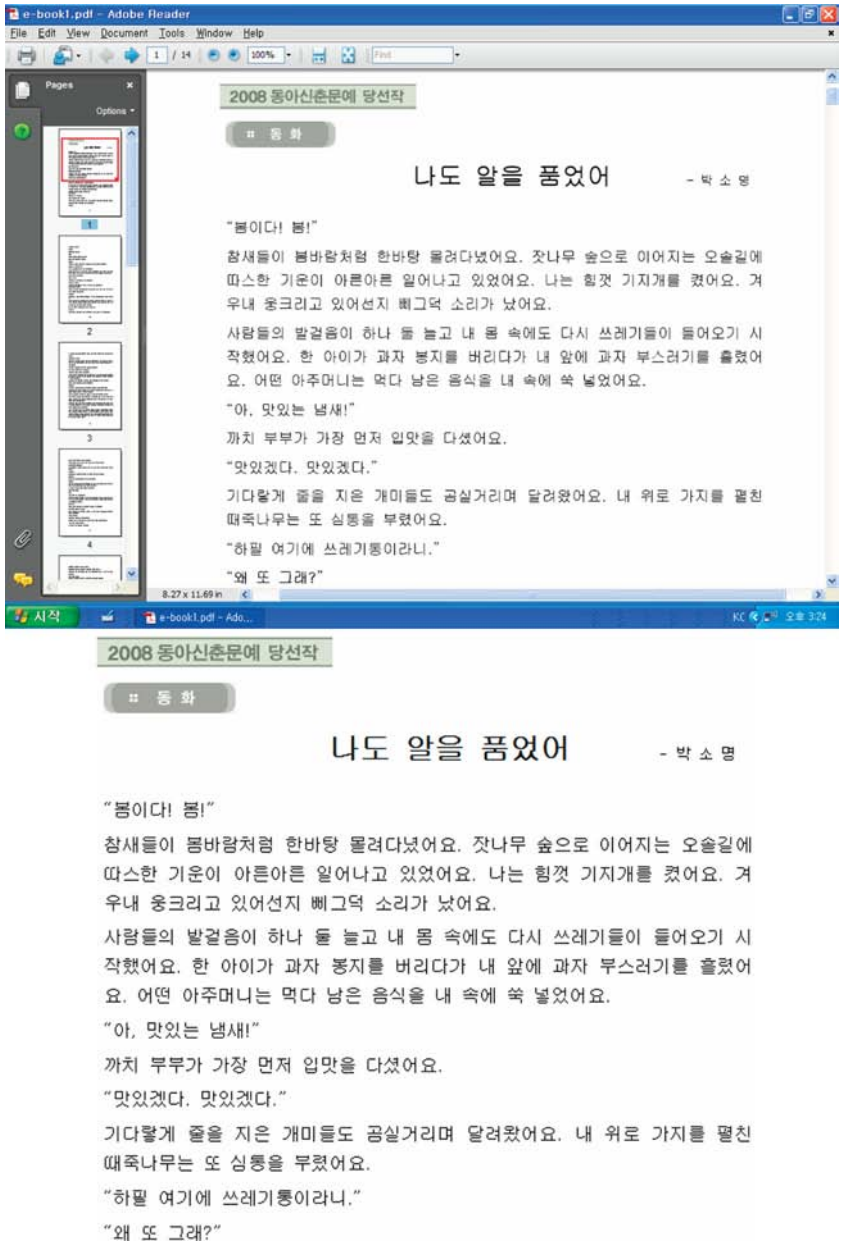

Figure 1.
An example of e-book (up) and p-book (down) in a story

comparison. In this study, the gap in CFF scores between before and after reading the p-book/e-book means that a drop in the sensory perception function.

4.2.3 Reading quiz. In this study, reading comprehension was assessed using reading quiz questions. Two teachers who majored in reading education developed

General	Display type (flat panel display/TFT active matrix)/width (39 cm)/depth (23.2 cm) height (40.6 cm)/weight (4.1 kg)
Display	Diagonal size (17")/dot pitch/pixel pitch (0.294 mm)/max resolution (1280 × 1024) color support (up to 16.2 million colors)/max sync rate (V × H) (75 Hz × 83 kHz) response time (8 ms)/signal input (VGA)
Image	Brightness (300 cd/m2)/image contrast ratio (600:1) image max H-view angle (160)/image max V-view angle (160)
Video input	Analogue video signal (GGB)
Expansion/connectivity	Interfaces (1 × VGA-15 pin HD D-Sub, HD-15)
Miscellaneous	Flat panel mount interface (built-in)/compliant standards (TCO'03, FCC Class B certified, CE, UL, TUV GS, cUL, ISO 13406-2, SEMKO)
Power	Form factor (internal)/voltage required (AC 120/230 V, 50/60 Hz) power consumption operational (35 watt)/power consumption stand by/sleep (1 Watt)
Environmental standards	EPA energy star compliant (yes)

Table III.
Technical details of the e-book monitor

multiple-choice questions whose answers could be found in the reading passages. A total of ten questions per story were developed for a total of 50 questions covering five story quizzes for stories A, B, C, D, and E. Three other teachers who taught some of the participants ensured the content validity of the five story quizzes. In the current study, a pre-test was conducted to examine whether the level of difficulty varied among the five story quizzes. The pre-test results showed no difference in the level of difficulty among the five story quizzes. In other words, each story quiz had the same level of difficulty compared to the others.

4.2.4 Feedback questionnaire. The questionnaire assessed three variables: satisfaction, usefulness, and behavioral intention. The items in the questionnaire were adapted from previous studies related to e-books (see Table IV). The participants' feedback on e-book use was measured using four items concerning satisfaction (reading tools, assisted learning tools, function, and colors), five items concerning e-book usefulness (font size and typeface, ease of using the menu, clarity of reading on the screen, and ease of finding important information), and five items concerning the participants' behavioral intentions related to the future use of e-books (increase in reading e-books, using e-books to assist learning, using e-books for information, and preference for e-books or p-books). The variables of usefulness, satisfaction, and behavioral intention were each assessed using a five-item list that the participants evaluated using a five-point Likert scale.

4.3 Procedure

This study was conducted after the purpose of the experiment was explained to the participants. A standard CFF device, a computer with a monitor for reading e-books, p-books, desks, and chairs were provided. To ensure data reliability, an e-book manual was provided to the participants. All of the participants completed both the p-book and e-book reading experiments. The p-book experiment was conducted first, and the e-book experiment was scheduled for one week later. The

Construct	Question	Source
Satisfaction	I am satisfied with the functions of the e-book	Murphy *et al.* (2003)
	I am satisfied with using an e-book as a learning assisted tool	Hernon *et al.* (2006)
	I am satisfied with using an e-book as a reading tool	Appleton (2004)
	I am satisfied with the colors used in the e-book	Macedo-Rouet *et al.* (2003)
Usefulness	The font size and typeface in the e-book were easy to read	Murphy *et al.* (2003)
	The sequence of the e-book on the screen was clear	Thong *et al.* (2002)
	It was convenient to scroll up/down within the e-book	Thong *et al.* (2002)
	It was easy to turn the pages in the e-book	Appleton (2004)
	It was easy to find important information in the e-book	Macedo-Rouet *et al.* (2003)
Behavioral intention	I intend to increase my use of e-books	Thong *et al.* (2002)
	I intend to use e-books to assist my learning	Hernon *et al.* (2006)
	I will read e-books to look for information I need	Macedo-Rouet *et al.* (2003)
	In five years, I will do most of my reading from e-books	Ebrary (2007)
	If given a choice between an electronic or print version of a particular book, I will choose the electronic version	Langston (2003)

Table IV.
Questionnaire items

experiment was conducted in the following order: pre-CFF measurement, book reading, post-CFF measurement, administration of the quiz, and administration of the feedback questionnaire regarding the e-book. First, the participants' CFF scores were measured as a baseline for comparison at the beginning of each reading session. Second, the participant was seated to begin reading. In each experiment, a sequence of stories was randomized for each participant. Each participant randomly chose two stories among the five for each book type. However, the participants were not able to choose the same story twice to prevent the participants from reading the same story for the p-book and e-book steps. The participants read two different stories in p-book format and in e-book format. Third, after completing the reading portion, the participants' CFF scores were gauged again. Fourth, each participant answered the quiz questions for the two stories that were read. After completing the e-book quiz, the participants were asked to complete the e-book questionnaire (see Figure 2). The administration of the each experiment was heavily standardized. For example, all e-book readings were done with the same standardized desktop and the same e-book software. Additionally, all participants read the e-books in the same classroom in which they had read the p-books a week earlier.

5. Results

5.1 Participants' reading comprehension

Table V shows the means and standard deviations of the quiz scores for each experimental condition. The students had a higher score after reading the p-books

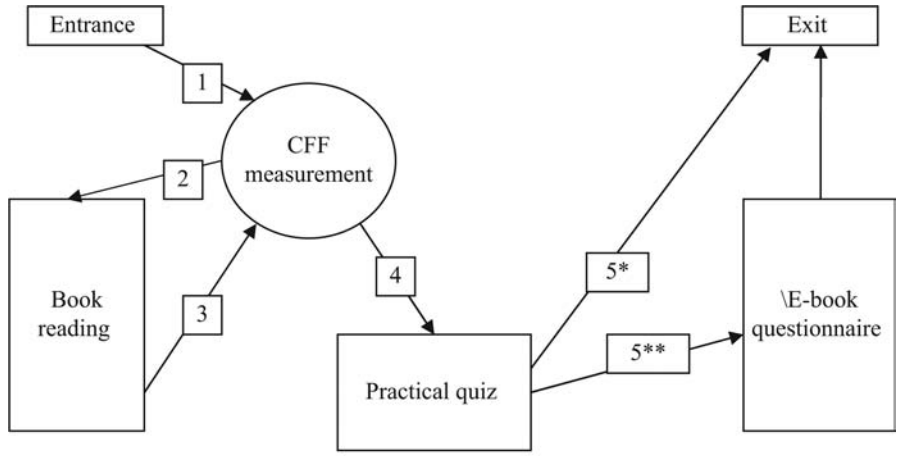

Figure 2.
Experiment procedure

					95 percent Confidence interval of mean			
	n	Mean	Stand deviation	Stand error	Lower	Upper	Minimum	Maximum
p-book	56	86.33	7.10	0.94	84.43	88.24	70.00	100.00
e-book	56	82.94	8.07	1.07	80.78	85.10	65.00	100.00
Total	112	84.64	7.76	0.73	83.18	86.09	65.00	100.00

Table V.
The distribution of the participants' quiz scores

(M = 86.23, SD = 7.10) than after reading the e-books (M = 82.94, SD = 8.07). One-way analysis of variance was used to determine whether the quiz scores of the participants were significantly different after reading the p-book and after reading the e-book. Table VI shows that there was a significant difference between the scores for the two experimental conditions ($F = 5.572$, $p < 0.05$). This result reveals that there is a significant "book effect" on quiz scores; compared to e-books, p-books appear to enable better reading comprehension. As with the previous studies mentioned, this result could possibly be attributed to two main factors: the display contrast and resolution of the e-books and the participants' more extensive experience with p-books.

5.2 Eye fatigue

In this study, the participants' eye fatigue was measured by CFF. The participants showed a decrease in CFF scores after reading both p-books and e-books. Table VII

	Sum of square	Df	Mean square	F	Sig.
Between groups	322.321	1	322.321	5.572	0.020
Within groups	6363.393	110	57.849		
Total	6685.714	111			

Table VI.
One-way ANOVA comparing quiz scores obtained after reading the p-book and after reading the e-book

shows the means and standard deviations of the participants' CFF reduction for each experimental condition. After reading the p-book, the participants' CFF was reduced by 1.63 Hz on average. In contrast, after reading the e-book, the participants' CFF was reduced by 3.04 Hz on average. One-way analysis of variance was used to determine whether this difference in CFF reduction was statistically significant. Table VIII shows a significant difference between the two experimental conditions ($F = 180.622$, $p < 0.001$). This result reveals a significant "book effect" on CFF changes for both book types. It seems that participants had significantly greater eye fatigue after reading e-books than after reading p-books. This may be explained by previous studies suggesting that lower luminance contrast in e-books may contribute to greater eye fatigue (Chi and Lin, 1998; Kang *et al.*, 2009; Martin and Platt, 2001; Wang and Haung, 2004).

5.3 Participants' perception of e-books

The feedback questionnaire's reliability was evaluated using the inter-item consistency measure of Cronbach's alpha (α). The alpha reliability was 0.80. The participants' perceived satisfaction, usefulness, and behavioral intentions regarding the e-book are presented in Table IX. The participants expressed only mid-level positive attitudes toward e-books in perceived usefulness (M = 3.51, SD = 0.63), perceived satisfaction (M = 3.33, SD = 0.65), and perceived behavioral intention (M = 2.97, SD = 0.62). For example, approximately 47 percent of the students agreed (agreed or strongly agreed) with the statement "I am satisfied with using an e-book as a reading tool"; only 19.64 percent disagreed (disagreed or strongly disagreed) with the same statement. In addition, approximately 52 percent agreed that "the font size and typeface in the e-book were easy to read," and 11.96 percent disagreed. However, only 7.98 percent of the students agreed with the statement "if given a choice between an electronic or print version of a particular book, I would choose the electronic version," whereas around 50 percent disagreed with this statement. In summary, the students were generally satisfied with the e-book. Nevertheless, they preferred p-books to e-books. Although

Table VII. The distribution of participants' CFF reduction

	n	Mean	Stand deviation	Stand error	95 percent Confidence interval of mean		Minimum	Maximum
					Lower	Upper		
p-book	56	1.63	0.53	0.07	1.49	1.77	0.78	2.62
e-book	56	3.04	0.57	0.07	2.88	3.19	1.79	4.32
Total	112	2.33	0.89	0.08	2.17	2.50	0.78	4.32

Table VIII. One-way ANOVA comparing participants' CFF scores

	Sum of square	Df	Mean square	F	Sig.
Between groups	55.253	1	55.253	180.622	0.000
Within groups	33.649	110	0.306		
Total	88.902	111			

Items	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	M	SD
Satisfaction						3.33	0.65
I am satisfied with the functions of the e-book	3.57	19.64	41.07	19.64	16.07	3.25	1.06
I am satisfied with using an e-book as a learning assisted tool	1.79	16.07	39.29	30.36	12.50	3.35	0.96
I am satisfied with using an e-book as a reading tool	0.0	19.64	33.93	32.14	14.29	3.41	0.96
I am satisfied with the colors used in the e-book	3.57	12.50	44.64	28.57	10.71	3.30	0.95
Usefulness						3.51	0.63
The font size and typeface in the e-book were easy to read	1.79	10.71	35.71	32.14	19.64	3.57	0.98
The sequence of the e-book on the screen was clear	3.57	14.29	30.36	35.71	16.07	3.46	1.04
It was convenient to scroll up/down within the e-book	1.79	12.50	33.93	33.93	17.86	3.53	0.99
It was easy to turn the pages in the e-book	1.79	16.07	32.14	28.57	21.43	3.51	1.06
It was easy to find important information in the e-book	5.36	14.29	30.36	26.79	23.21	3.48	1.15
Behavioral intention						2.97	0.62
I intend to increase my use of e-books	3.57	19.64	46.43	25.00	5.36	3.08	0.90
I intend to use e-books to assist my learning	8.93	10.71	51.79	21.43	7.14	3.07	0.98
I will read e-books to look for information I need	7.14	17.86	44.64	17.86	12.50	3.10	1.07
In five years, I will do most of my reading from e-books	5.36	25.00	42.86	23.21	3.57	2.94	0.92
If given a choice between an electronic or print version of a particular book, I will choose the electronic version	12.50	32.14	39.29	10.71	5.36	2.64	1.01

Note: From 1 which means "strongly disagree" to 5 which means "strongly agree"

Table IX.
Percentage of agreement and disagreement with the feedback items for e-books

the students recognized e-books as useful reading material, they seemed to have no immediate intention to replace p-books with e-books.

6. Discussion

The purpose of this paper was to compare e-books with p-books in terms of students' reading comprehension, eye fatigue, and perceptions. First, this study investigated whether sixth-grade students' comprehension was different after reading e-books and p-books. Although previous studies have reported no significant differences between e-books and p-books (Macedo-Rouet *et al.*, 2003; Kang *et al.*, 2009), the current study shows that the students performed better with p-books than with e-books. We found some possible reasons for this result: reading on a screen might require more concentration than on paper, and e-book reading is more error prone than p-book reading.

Second, reading from a screen is not the same as reading from a p-book. This study found that the students' CFF scores were different for e-books and p-books. We found that the students experienced more eye fatigue when reading e-books than when reading p-books. Eye fatigue can cause students to grow tired and may even cause nervousness. We found that sustained or intentional reading of digital texts on screen displays was difficult in part because of hardware limitations and ergonomics: stationary computer screens require static reading positions, and poor type representation impedes reading and causes eye fatigue. We found that eye fatigue can reduce concentration, which may also affect comprehension. Therefore, special glasses may be the best way to help e-book users. The time spent in front of a screen is a factor in determining whether special glasses are required. Special lenses can save an e-book user from eyestrain problems. We

suggest placing the screen about 10-15 degrees below the e-book users' horizontal line of vision. The screen should be 18-30 inches from the user's eyes, and the eyes should be level with the top of the monitor (Reeves, 1992).

Third, the students expressed that e-books are useful reading devices. Most students reported that the e-book was easy to read. For example, regarding the e-books' usefulness, they found that the font size and type were easy to read, that the screen sequence was clear, and that the tasks of scrolling up and down, moving pages, and finding information were easy and convenient. The current study also found that most students were satisfied with e-books as a reading or learning tool. The results from this paper partially support those of previous studies showing that students have a positive perception of e-books (Anuradha and Usha, 2006; Carlock and Perry, 2008).

However, this paper provides interesting insights into user satisfaction with the usefulness of e-books and behavioral intentions that were not observed in previous studies. Based on the results of the current study, we suggest that, although most students are satisfied with using an e-book and perceive it as a useful reading tool, they do not intend to choose e-books if given a choice between an electronic or print version of a particular book. It might seem paradoxical that students would show satisfaction with e-books and acknowledge the usefulness of e-books but still prefer p-books to e-books. Of course, by studying students who have grown up with print on paper, we can understand such a phenomenon. As mentioned by Brown (2001), the students in the current study are also users of print on paper who enjoy their freedom in navigating the text. They dominate the text, with a simple overview, scanning at will any portion or section, leafing through pages, setting down to read at any point significant to mind and eye, randomly coursing through footnotes and bibliographic citations.

The current study heavily supports the general belief that most people still prefer to read lengthy texts on paper. Today's commonly used digital equipment and software cannot compete with printed paper as a medium for sustained reading. This paper finds that there are barriers to e-book adoption. Still, although this study suggests that students in general are not yet ready to entirely give up p-books, e-books are becoming increasingly common. There are increasing signs that print on demand will become much more popular and economical. Schools continue to respond to the changing needs of students who are increasingly comfortable with technology. We are guardedly positive about the future of e-books, arguing that, "in time", perhaps not very much time, the problems of the presentation of text on screen may be solved, and e-books may become as easy and pleasant to read as p-books (Blades, 2005). We feel that the future of reading will involve e-books and that this will bring some interesting changes to the manner in which we read. E-books provide us with new ways to read; this is not necessarily a welcome novelty for all, as our habits from the past often subvert the inventions that move us to the future. We strongly believe that we will see a migration toward e-books over the next ten years, given the power that comes with the ability for digital content to be updated in real time. Ultimately, there will be more choices for information users.

7. Conclusion

This paper evaluated the usability of an e-book compared with a p-book. However, the intent of this paper was not to choose between print and electronic materials; rather, as

Garrod (2003) observed, new media such as e-books add to our choices rather than substituting one form for another.

Surprisingly, though, the Korean students studied herein, who have had a higher level of exposure to technology than those in other countries, did not show positive behavioral intentions toward e-books. Overall, the responses from the students suggest that there was general satisfaction with reading e-books on screen. However, we also found a discordance in the students' perceptions of e-books. In this study, most students grew tired of reading on the screen; this tiredness could have an adverse effect on both reading comprehension and the perception of e-books. In further analyzing user responses, many of the critical remarks were found to refer to the screen/text size or clarity rather than to the e-book itself. Given the results of this study, we suggest that improvements in the legibility of e-books are critical to making them more usable and efficient. This suggests that improvements in device capabilities could enhance users' overall impressions of e-books. Although the device capabilities of e-books are the domain of e-book developers, care must be taken to incorporate the input of behavioral scientists into the interface characteristics so that the acceptance of e-books can increase. Therefore, we hope that those who design e-books will take our findings into consideration. E-book designers should dedicate special attention to the issue of eye fatigue experienced by students when reading e-books. E-book designers should also prioritize navigational clarity.

E-book technology has a long way to go before it can equal the readability and richness of p-books; nevertheless, e-books have characteristics that, in some ways, supersede those of p-books, being more flexible and accessible than p-books. There is undoubtedly a role for e-books in school library. It is likely that e-book service will attract new users to library service and perhaps will better serve patrons with special needs (such as mobility impairments). Libraries of the future may be hybrid environments in which different media contribute to their evolving service and accommodate the developing needs and expectations of patrons. Many people are giving e-books an "A" in eco-friendliness. Indeed, e-books are better for the environment than printed books. Printed books are shipped long distances from warehouses to bookstores, using gasoline and creating pollution. They also use a large number of trees. In 2008, more than 125 million trees were used by the book and newspaper industries in the US alone (Harte, 2010). Along with environmental benefits, e-books offer convenient reading. Using only a home computer, readers can quickly get the e-books they desire. Inevitable technological progress promises new opportunities for implementing e-books. E-books should allow students to understand content and should obtain an advantage over the p-book format. Clearly, students are interested in using more e-books, but great challenges remain in terms of making e-book content more available and in enabling improved comprehension and reducing eye fatigue.

In this study, we did verify structural relationships among eye fatigue, comprehension, and the perception of e-books. Of course, until we have further studies with a larger, purposefully selected sample and perhaps a more uniform group of students, these relationships will remain pure conjecture. Therefore, further studies should try to uncover these complex relationships. Additionally, more qualitative variables such as students' culture, age, and gender are important in an educational context and can shed light on questions that were left open-ended in this study. Such studies might also begin to capture not only the essence of the e-book experiences but

also some of the important differences, such as how reading experiences vary based on the purpose and style of a text. An extension of our study could compare interactive and non-interactive versions of e-books to determine whether interactive features help students perform better while changing their perceptions about e-books. The effects of larger screens and side-by-side display conditions also merit further assessment. Larger-scale studies focusing on the multidisciplinary uses of e-books should be carried out to further examine how they can impact academics.

Indeed, to quote Shelburne:

> The next few years will be an exciting time in the world of e-books (Shelburne, 2009, p. 65).

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