

READING COMPREHENSION IN DIGITAL AND PRINTED TEXTS

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Abstract

Recent studies have yielded contradictory results regarding how reading from print or from the screen influences reading comprehension. This study examined 12-year-old students' ($N = 142$) reading comprehension using printed text and digital text. The results indicated that performance was similar for printed text and digital text, even when gender, decoding skills, preference for school tasks on paper, screen, or both, and self-concept as a reader and computer user were controlled for. Regardless of the reading medium, students with better decoding skills and a higher self-concept as a reader performed better, boys outperformed girls, and students equally willing to study with books and computers outperformed students who preferred computers. The results of this study highlight the benefits of flexible use of both printed texts and digital texts for reading comprehension. As students are getting as used to studying via computers as they are to studying from books, the emphasis on the medium of studying seems to become less important. The topic of this study is of great relevance in a modern school context where ICT use has become a part of daily schoolwork worldwide.

Keywords: reading comprehension, printed text, digital text, self-concept, decoding skills

1. INTRODUCTION

Recent studies have reported contradictory results regarding whether reading traditionally in print or digitally on screen of a computer or a tablet is better for reading comprehension. Many researchers have argued that students comprehend printed texts more effectively than digital texts (e.g. Ackerman & Lauterman, 2012; Jeong, 2012; Mangen, Walgermo & Brønneck, 2013) and that students also prefer

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printed texts (e.g. Ackerman & Lauterman, 2012). Opposite results arguing for the benefits of reading digitally on reading outcomes (Kerr & Symons, 2006) as well as for the preference for digital medium (Singer & Alexander, 2017a) have also been reported. In addition, some studies have found no association between the reading medium and learning (e.g. Rockinson-Szapkiw, Courduff, Carter & Bennett, 2013). Recently, number of large-scale assessments (TIMSS, PIRLS, PISA) have shifted from paper to screen. In the latest PISA results, digital reading performance was highly correlated with print reading performance, although there were also countries or economies where mean performance in either digital or print reading was comparatively better (OECD, 2015).

To contribute to the ongoing discussion, this study examined 12-year-old students' reading comprehension in relation to the medium of the text: print or digital. Further, although reading comprehension is influenced by various factors (Snow, 2002), the importance of decoding skills, students' self-concepts as readers and computer users, as well as preferred reading medium (print, digital, or both) have not yet been widely studied in relation to reading comprehension in the field of reading digitally. In this study, it was investigated how these factors together were associated with the difference in reading comprehension scores of different mediums.

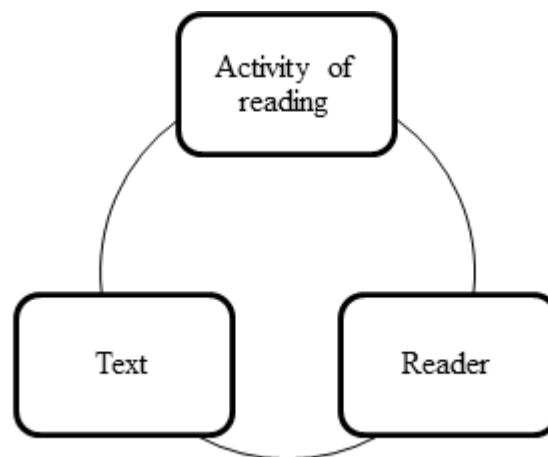
ICT which refers to *information and communication technology*, i.e. the use of computers and tablets, is used extensively by adolescents for many purposes, such as entertainment, communication and music-related activities in their leisure time (Leino, 2014). Thus, for teachers, an educational challenge is to harness youths' ICT skills for studying. For this purpose, in Finland, which is the context of this study, the government has stressed ICT use in schools as one of the main educational strategies, and the current Finnish core curriculum has emphasized the use of ICT in learning and teaching (National Board of Education, 2014). Since ICT use in educational contexts includes reading comprehension, it is important to study whether the medium through which the text is read is associated with reading comprehension and learning in general.

1.1 Reading comprehension and motivation

Reading skills are crucial for academic success. Reading can be defined as decoding and comprehension of a text (Gough & Tunmer, 1986; Language and Reading Research Consortium, 2015; Tunmer & Hoover, 1992). Reading comprehension (Figure 1), for its part, is a dynamic and multifaceted process in which a reader, a text, and the activity of reading are in interaction (Smagorinsky, 2009; Snow, 2002). The goal is to understand and draw meaning from written text (Singer & Alexander, 2017b). A reader brings into the process his or her cognitive capacity, knowledge, experiences, and motivation, which includes his or her self-concept as a reader (Ford, 1992; Guthrie & Klauda, 2014; Pintrich, 1999; Snow, 2002; Wigfield & Guthrie, 1997; Winne, 1985), and actively connects the meanings of the text with their prior

knowledge (Singer & Alexander, 2017a). Features of the text being read, such as the vocabulary, structure and genre, also influence the process (Rose & Martin, 2012; Snow, 2002). The activity of reading includes decoding the text, processing it linguistically and semantically, and self-monitoring its comprehension (Kinnunen & Vauras, 2010; Snow, 2002). It is likely that the medium through which the text is being read influences all of the aforementioned aspects of the reading comprehension process. However, there is still not enough research done on how digital versus print medium influences comprehension (Singer & Alexander, 2017b). Thus, influence of the reading medium on reading comprehension needs more attention in research.

Figure 1. Components of the reading comprehension process
adapted from Snow, 2002



According to previous research, in addition to being a part of the activity of reading, motivation also more directly predicts reading skills, the amount of reading and reading comprehension (e.g. Morgan & Fuchs, 2007; Stutz, Schaffner & Schiefele, 2016; Wigfield & Guthrie, 1997). One aspect of motivation that has been associated with reading comprehension in several studies is a student's perception of his or her competence as a reader, referred to in different studies as *reading self-efficacy* or *self-concept as a reader* (Anmarkrud & Bråten, 2009; Bandura, 1982; Bråten, Ferguson, Anmarkrud & Strømsø, 2013; Pintrich, 1999). Positive self-concept as a reader favorably influences both reading performance and the interest the reader shows toward reading tasks (Viljaranta, Tolvanen, Aunola & Nurmi, 2014).

The relationship between motivation and reading comprehension makes it important to examine the influence of motivation on reading in print and digitally. However, research concerning students' preference for either printed texts or digital

texts has yielded contradictory results. According to some research, students prefer printed texts more than digital texts (Ackerman & Lauterman, 2012; Aydemir & Oeztuerk, 2012; Jeong, 2012; Solak, 2014; Woody, Daniel & Baker, 2010). For example, in Woody et al.'s (2010) study, university students preferred traditional books over e-books even when they were accustomed to using e-books. Also, Ackerman and Lauterman (2012) reported that students preferred printed texts over digital texts when the aim of reading was comprehension of the content. However, in Singer and Alexander's (2017a) study, the students preferred digital texts. Moreover, Ciampa (2012) argued that digital texts especially motivate children who are just learning to read. These contradictory results make it necessary to further study the relationship between preference of the reading medium and reading comprehension.

1.2 Reading comprehension in printed texts and digital texts

Recent studies have argued that the medium through which the text is read influences reading comprehension. Mangen and colleagues (2013) compared the reading comprehension scores of 10th graders aged 15 to 16 years ($n = 72$): one-half of the students read printed texts while the other half read the same texts in PDF format on a computer screen. Students who read the printed texts performed significantly better than the students who read the digital texts. However, each group was given only one medium to read. Thus, there is no clear evidence of how the individuals would have performed when reading both printed texts and digital texts. Jeong's (2012) study also argued for the benefits of reading on print. This study investigated 56 sixth graders' (10–12 years old) reading comprehension. All of the participants completed both printed and digital comprehension tasks. Reading comprehension scores were significantly better when reading printed texts compared to digital texts. In addition, students reported preferring printed texts over digital texts. When participants read digital texts, they had significantly more eye fatigue than when they read in print. In Solak's (2014) study, seven university students who read printed texts outperformed seven others who read digital texts. However, because of the small sample size, the result must be interpreted cautiously.

Opposite results, however, have also been obtained, in which digital reading has been shown to lead to better comprehension results than reading in print. In Kerr and Symons' (2006) study, for example, 60 fifth graders (approximately 12 years old) each read two expository texts: one on paper and one on screen. When they read the digital texts, they had better scores in comprehension compared to when they read the printed texts. However, reading printed texts was faster than reading digital texts.

Other studies have reported no differences between the mediums through which texts are read. In a study by Noyes and Garland (2003), no differences were found in reading time or comprehension between the group that read printed texts and the

group that read digital texts. Again, each group was given only one medium to read. Rockinson-Szapkiw and colleagues (2013) compared the education course grades of 538 students and found no significant difference between the groups that read printed books and the groups that read digital books. However, the students who read digital books perceived that they had learned the topics better than those who read printed books. Turunen, Alisaari, Poskiparta, and Lindeman (2018) compared primary school students' ($N = 1705$, 7-12 years old) reading comprehension, and they found no significant differences between the group that read the printed texts, the group that read digital texts, and the group that read printed texts but answered the questions digitally. In Singer and Alexander's (2017a) study of potential comprehension differences between students who read printed texts and digital texts, students perceived that they understood digital texts better than printed texts. Nevertheless, in comprehension tests, there was no difference across the mediums when the questions were concerned with identifying the main idea of the text. In addition, contrary to students' perceptions of digital reading as producing better outcomes, when the questions asked for more detailed information, reading the printed text resulted in greater understanding. Also, in Woody et al.'s (2010) study, students studied printed books more precisely than digital books, although there were no differences in learning outcomes between the printed book users and the digital book users.

The mixed results of the previous studies may be due to several factors. For example, there has been variation in the measures assessing comprehension (see also Singer & Alexander, 2017b). In previous research, students mainly responded to multiple-choice questions (e.g. Ackerman & Lauterman, 2012; Jeong, 2012; Mangen et al., 2013; Noyes & Garland, 2003), while open-ended questions have only been used in a few studies (e.g. Kerr & Symons, 2006; Solak, 2014). Assessment, however, should be multifaceted in order to measure the learners' reading comprehension more adequately. The contradictory results could also have resulted from the various designs of the studies (see also Singer & Alexander, 2017b). For example, age groups and sample sizes have been heterogeneous, with most studies having concentrated on university students (Noyes & Garland, 2003; Rockinson-Szapkiw et al., 2013; Singer & Alexander, 2017a; Solak, 2014) and only some on school-aged children (Jeong, 2012; Kerr & Symons, 2006; Mangen et al., 2013; Turunen et al., 2018). Moreover, because of the limited sample sizes, some of the results must be read cautiously (i.e., Solak, 2014). Additionally, in some studies, some students read printed texts while others read digital texts, which complicates the interpretation of the results.

The disadvantages of digital texts have been explained by arguing that their inflexible PDF format as well as the necessity to scroll through long texts on a screen may hinder reading comprehension (Chesser, 2011; Mangen et al., 2013). Furthermore, reading digital texts is speculated to be cognitively more challenging than reading printed texts because a backlit computer screen causes eye fatigue and possibly interferes with memory retrieval: Older studies, in particular, have reported

that reading digitally results in higher cognitive load than reading in print (e.g. Garland & Noyes, 2004; Wästlund, Reinikka, Norlander & Archer, 2005). The rapid development of computers challenges these findings as being outdated. Ackerman and Lauterman (2012) argued that reading texts digitally and in print differs metacognitively: There is more self-monitoring included in the latter process, especially if the reading time is limited. It is also argued that printed texts' advantages are based, for example, on paper being a more familiar study medium or the opportunity to physically handle the pages and hold the text, as well as the ability to write notes on the paper and underline the text. As the use of user-friendly mobile devices, computers, and applications has increased—and, at the same time, as they have become a part of everyday life—these arguments have become somewhat antiquated. Since the use of computers is increasingly common among school-aged children, and since computers have advanced considerably in recent years, up-to-date information about whether reading digitally impacts on reading comprehension within this age group is needed.

1.3 The present study

The aim of the present study was to investigate whether students, aged approximately 12 years old, performed differently on reading comprehension on a printed test than on a digital test. In addition to examining how reading comprehension is related to the reading medium, i.e. printed texts or texts read digitally, this study also examined how several other factors are associated with this relationship as well as to reading comprehension in general. These factors were gender, decoding skills, self-concept as a reader and as a computer user, and students' preference for school tasks on paper, screen, or both. The pedagogical rationale behind this was to explore whether there are student groups who would benefit from one medium more than the other one.

One such factor is gender. Researchers have observed differences in reading comprehension between girls and boys: In some contexts, girls have been found to be more knowledgeable than boys about effective ways to understand, remember, and summarize texts (OECD, 2010; Vettenranta et al., 2016). The gender differences in reading and reading engagement for the favour of girls in Finland were some of the widest among the countries participating in PISA 2009 (Brozo et al., 2014; OECD, 2010; Vettenranta et al., 2016). However, Rasmusson and Åberg-Bengtsson (2015) have shown that boys have better digital reading skills than girls, explained by their experiences in using computers for playing games. In this study, it was investigated whether differences exist between genders in reading comprehension while reading in print and digitally.

Another factor was decoding skills. Good decoding skills support comprehension (Andreassen & Bråten, 2010; Cain, 2009; Torppa et al., 2016). In order to examine reading comprehension of the students with different decoding skills levels, it was considered beneficial to include this factor to the analyses. In addition, context-

specific aspects of self-concept have been linked to reading comprehension (e.g. Bråten et al., 2013), and thus, factors related to self-concept were added in the analyses. Additionally, since motivation more generally has an essential role in reading comprehension (Stutz et al., 2016), students' preference for school tasks on paper, screen, or both, was chosen as one of the factors. The specific research questions were as follows:

- 1) Is there a difference between students' reading comprehension when reading in print or digitally?
- 2) Are gender, decoding skills, students' preference for school tasks on paper, screen, or both, and self-concept as a reader and a computer user associated with the difference between reading comprehension when reading in print or digitally?
- 3) Are gender, decoding skills, students' preference for school tasks on paper, screen, or both, and self-concept as a reader and a computer user associated with reading comprehension in both of the mediums?

2. METHODS

2.1 Participants

Data for the present study were drawn from a sample of 142 Finnish fifth graders (54.2% males) from four different schools and seven classrooms in one city. The target population of this study was fifth graders and their teachers in one municipality. From this population, based on previous knowledge of the teachers' use of ICT in their classrooms, potential participant candidates were selected based on the frequency of the ICT use varying from occasional use to daily use. Eight fifth-grade teachers were contacted and asked to participate in the study. Seven of the teachers agreed to take part. After that, permission to participate was sought from the guardians of their students ($N = 169$), 142 of whom agreed (84.6% of the original sample). The mean age of the students was 12 years ($M = 143.6$ months, $SD = 5.6$ months).

In a preliminary questionnaire, two of the teachers reported using ICT with their students daily during almost every lesson; four teachers reported weekly ICT use; and one teacher reported using ICT on a less than weekly basis. The teachers reported that their students used ICT in a variety of ways, including information retrieval, story writing, educational games, tasks and applications, presentations, photography, and for different kinds of projects. Thus, despite variation between classes in the frequency of ICT use, all students had some experience with it. Almost all of the students in this study (97.2%) had access to a computer, tablet, or smartphone at home; 74.6% of the students had access to all three devices at home; and 31.7% of the students had their own computer, tablet, and smartphone. Only three students did not have their own devices, but they still had access to them at home.

2.2 Procedure and measures

The data collection took place in the spring of 2015 in natural classroom circumstances. Data were collected by trained researchers during two different two-hour lessons within one week for each class. During the first lesson, the students answered a paper questionnaire that measured the students' preferences regarding school tasks on paper, screen, or both, and their self-concepts as readers and computer users. In addition, they completed a reading comprehension test either in print or digitally. During the second lesson, the students completed both a test measuring their decoding skills and the other reading comprehension test.

2.2.1 Reading comprehension skills

Reading comprehension was tested with two different expository texts for science learning (Vauras, Kajamies & Kinnunen, 2018). To increase the reliability of the study, the texts were chosen to be as similar as possible in their difficulty level and length, and presented in visually equivalent format. Text 1 (Disappearing forest) had 222 words and Text 2 (Deteriorating air) had 229 words. The texts were quite short and could be read on a single sheet of paper or without having to scroll down on the screen. It was considered beneficial that the students would have a holistic perception in reading both in print and digitally (Mangen et al., 2013). The length and the type of the texts were designed to be similar with regular science learning tasks for fifth graders. Further, the reading situations were designed to imitate the typical individual science learning tasks at the classroom including the guidelines given to the students. The digital text and tasks related to it were in html format since this is the typical format used in modern e-textbooks and is considered to be more flexible e-learning material than PDF files (Chesser, 2011).

To minimize the effects of order, both media and text orders varied. During the first lesson, the medium was paper for four of the classes, and screen for three of the classes. During the second lesson, the classes used the other medium. When the students read the text in print, they answered on paper; when they read the text digitally, they also answered digitally. The order of the texts varied in each class. Half of the students in the class read Text 1 first (Group A), while the other half read Text 2 first (Group B). Students sitting next to each other were given different texts. A simplified design of measuring reading comprehension is presented in Table 1 (see below).

The students had 10 minutes to read the text and were advised to use all time available for reading. After that, they answered the reading comprehension tasks which demanded retrieval of selected information from the text and making text-based inferences. The students were not allowed to use the text while answering the tasks. There were two different types of tasks. The first task included four open-ended questions (for example: In the text, three important reasons why air is deteriorating were given. What were they?). The second type included 17 cloze

tasks, in which students were supposed to fill-in the gaps in the text (for example: The air keeps rapidly _____). Reading comprehension was measured with these task types to gain deeper insight into students' reading comprehension skills than would be achievable with multiple-choice questions.

Table 1. Design of measuring reading comprehension

	Digital	Print
Group A	Text 1	Text 2
Group B	Text 2	Text 1

Students' answers were evaluated by two independent evaluators on the basis of their depth of understanding of the texts and their inference-making skills (Vauras et al., 2018). The total score of open-ended questions and cloze tasks was calculated by summing the scores of both tasks (min = 0, max = 45). The scales were reliable for both Text 1 ($\alpha = .82$) and Text 2 ($\alpha = .87$). A sum score of open questions and cloze tasks was used as an indication of reading comprehension skills. Both sum scores were normally distributed (Text 1: Kolmogorov-Smirnov $D = .06$, $p > .05$; Text 2: Kolmogorov-Smirnov $D = .06$, $p > .05$).

2.2.2 Decoding skills

Students' decoding skills were tested with the Finnish Standardized Reading Test (ALLU) (Lindeman, 1998: TL5A). In the decoding test, the task was to separate words (max. 214) from word chains of 2–4 words written together within a limited time (3 min 30 s). The sum score of decoding skills was the total number of students' correctly marked words. According to the test manual, the Kuder-Richardson coefficient of internal consistency (CR20) for the decoding test is .97 (Lindeman, 1998). The sum score was normally distributed (Kolmogorov-Smirnov $D = .07$, $p > .05$).

2.2.3 Preference of study medium

Students were asked which medium they preferred when studying during the lessons: computers and tablets, books and notebooks, or both equally.

2.2.4 Self-concept as a reader and as a computer user

Self-concept as a reader and as a computer user was evaluated with an adapted version of Nicholls' (1978) learner self-concept scale. Self-concept as a reader was assessed by asking students to rate their position in relation to their classmates in reading, and self-concept as a computer user by asking students to rate their position in relation to their classmates in using computers. Students were presented with a

sheet of paper with as many circles as there were students in the classroom, arranged in a line from the top to the bottom of the page. They were told that the circles represented the students in their class and that the one at the top of the page represented the student who was the best in reading or in using computers, and so on, down to the poorest performer. Students were told to “mark how good you are at reading/using computers compared to others in your class.” The students responded by marking the circle that represented themselves. Their choices were divided by the number of students in the class and then subtracted from 1. This resulted in two variables of what percent of the class each student perceived as weaker than himself or herself in reading and in using computers.

2.3 Statistical analyses

The focus of this study was to evaluate whether students performed differently in reading comprehension tasks in print than digitally. Firstly, the difference between Text 1 and Text 2 were evaluated by comparing the mean scores of printed and digital tests with a paired samples *t*-test before creating reading comprehension variables for printed and digital tests. Secondly, the correlations and descriptive statistics of the study variables were calculated. Thirdly, analysis of variance (ANOVA) for repeated measures was conducted in order to take into account the dependence of the two tests of each other (i.e. same participants conducting both tests) when comparing reading comprehension in print and digitally. Fourthly, several covariates were added to the model predicting the difference between printed test and digital test scores. The covariates were gender, decoding skills, students’ preference for school tasks on paper, screen, or both, and self-concept as a reader and as a computer user. Finally, between-subject effects were evaluated in order to evaluate the effect of the covariates on reading comprehension in both printed and digital tests.

3. RESULTS

3.1 Descriptive statistics and correlations

The first step in the data analysis was to compare Text 1 and Text 2. In a paired sample *t*-test, the difference in the means of the total scores of Text 1 ($M = 22.4$, $SD = 8.8$) and Text 2 ($M = 22.4$, $SD = 9.1$) tests did not differ statistically significantly from zero ($t = -0.75$, $df = 134$, $p = .94$). Texts correlated statistically significantly with each other ($r = .71$). Therefore, the texts were considered to equally evaluate reading comprehension, and it was possible to calculate separate sum scores for reading comprehension in print (RCpaper: $M = 22.5$, $SD = 8.8$) and reading comprehension digitally (RCscreen: $M = 22.3$, $SD = 9.0$). Both variables were normally distributed (RCpaper: Kolmogorov-Smirnov $D = .06$, $p > .05$; RCscreen: Kolmogorov-Smirnov $D = .06$, $p > .05$).

The second step was to uncover the correlations and descriptive statistics of the study variables (Table 2). Reading comprehension test scores for the two mediums correlated statistically significantly with each other. Results from the decoding test correlated moderately and positively with both comprehension tests. Students' self-concept as a reader correlated moderately and positively with reading comprehension and decoding test scores. Self-concept as a computer user did not correlate statistically significantly with any of the other measures.

Table 2. Correlations and descriptive statistics of the study variables

Variable	1	2	3	4	5	M	SD
1. RCpaper	-					22.48	8.79
2. RCscreen	.71 ***	-				22.28	9.02
3. Decoding	.26 **	.33 ***	-			124.07	30.03
4. Self-concept as a reader	.30 ***	.35 ***	.29 ***	-		0.64 ^a	0.21
5. Self-concept as a computer user	-.09	-.11	-.04	.02	-	0.73 ^a	0.21

Note. *** $p < .001$; ** $p < .01$; * $p < .05$

^a Percentage perceived by each student as weaker than himself or herself.

Boys (RCpaper: $M = 22.5$, $SD = 8.3$; RCscreen: $M = 22.3$, $SD = 8.5$) and girls (RCpaper: $M = 22.4$, $SD = 9.3$; RCscreen: $M = 22.3$, $SD = 9.7$) did not differ statistically significantly from each other in either the printed, $F(1, 137) = .006$, $p = .94$, partial $\eta^2 = .000$, or digital test scores $F(1, 137) = .002$, $p = .96$, partial $\eta^2 = .000$.

When asked which medium they would rather use when studying during their lessons, most of the students preferred computers and tablets over books and notebooks (60.1%), 32.6% viewed both mediums equally, and only 7.2% preferred books and notebooks over computers and tablets. There were statistically significant differences between these groups in both RCpaper, $F(2, 133) = 3.9$, $p = .02$, partial $\eta^2 = .055$, and RCscreen, $F(2, 133) = 3.5$, $p = .03$, partial $\eta^2 = .050$ scores. Students viewing both mediums equally performed better in reading comprehension (RCpaper: $M = 25.2$, $SD = 8.9$; RCscreen: $M = 25.0$, $SD = 10.7$) than students who preferred computers and tablets (RCpaper: $M = 21.2$, $SD = 8.2$, $d = .47$; RCscreen: $M = 20.9$, $SD = 7.5$, $d = .44$). They were also better than students who preferred books and paper notebooks on the printed test (RCpaper: $M = 19.1$, $SD = 10.7$, $d = .62$), but not statistically significantly on the digital test (RCscreen: $M = 19.5$, $SD = 10.7$, $d = .51$). There was no statistically significant difference between students who preferred books and paper notebooks and students who preferred computers and tablets on either test.

3.2 Reading comprehension in paper tests and e-tests

In order to answer the Research Question 1 about a possible difference between students' reading comprehension when reading in print or digitally, we ran repeated measures ANOVA. There was no statistically significant main effect of test type (RCpaper vs. RCscreen), $F(1, 134) = .49, p = .48$, partial $\eta^2 = .004$, indicating that students performed equally well in reading comprehension when the test was performed digitally or in print.

When looking at the Research Question 2 about whether gender, decoding skills, students' preference for school tasks on paper, screen, or both, and self-concepts as readers and computer users are associated with the difference between reading comprehension when reading in print or digitally, we added several covariates to the model. There was no statistically significant interaction between test type and gender, $F(1, 124) = .008, p = .93$, partial $\eta^2 = .000$, decoding skills, $F(1, 124) = .64, p = .43$, partial $\eta^2 = .005$, preference, $F(2, 124) = .03, p = .97$, partial $\eta^2 = .001$, self-concept as a reader, $F(1, 124) = .48, p = .49$, partial $\eta^2 = .004$, self-concept as a computer user, $F(1, 124) = .20, p = .65$, partial $\eta^2 = .002$, or between gender and preference, $F(2, 124) = 1.36, p = .26$, partial $\eta^2 = .021$. This indicates that none of the variables influenced the difference between RCpaper and RCscreen scores.

To answer the Research Question 3 about whether gender, decoding skills, students' preference for school tasks on paper, screen, or both, and self-concepts as readers and computer users are associated with reading comprehension in both of the mediums, we looked at between subject effects in repeated measures ANOVA. We found that students' decoding skills, $F(1, 124) = 7.6, p = .007$, partial $\eta^2 = .058$, self-concept as a reader, $F(1, 124) = 15.2, p < .001$, partial $\eta^2 = .109$, gender, $F(1, 124) = 4.2, p = .04$, partial $\eta^2 = .033$, and preference, $F(2, 124) = 4.0, p = .02$, partial $\eta^2 = .061$ did statistically significantly influence performance on both comprehension tests. Students with better decoding skills and a higher self-concept as a reader performed better in reading comprehension on both printed tests and digital tests. Students with better decoding skills and a higher self-concept as a reader performed better in reading comprehension on both printed tests and digital tests. In addition, controlling for all other variables, boys ($M = 23.9$) performed better in reading comprehension on both tests than girls ($M = 19.5$). Further, students equally willing to study with digital and printed texts ($M = 25.0$) outperformed students preferring digital texts ($M = 21.2$) on both tests. The difference between the students who preferred digital materials and those who preferred printed texts was not statistically significant.

4. DISCUSSION

Previous research has yielded contradictory results about the association between reading medium (printed vs. digital text) and reading comprehension, with some studies favouring the printed format (Jeong, 2012; Mangen et al., 2013; Solak, 2014)

and others favoring reading digitally (Kerr & Symons, 2006; Noyes & Garland, 2003). To contribute to this ongoing discussion, the current study investigated the association between reading medium and reading comprehension on a sample of Finnish fifth graders. No differences were found in the students' reading comprehension when reading a text and replying to questions in print versus digitally on a computer screen. Several control variables were examined, such as gender, decoding skills, preference for the study medium (books and notebooks, computers and tablets, or both), as well as self-concepts as readers and computer users, yet none of these influenced the difference in comprehension between reading in print and digitally. This is in line with studies conducted in recent years that also did not find a difference between the two mediums (OECD, 2015; Rockinson-Szapkiw et al., 2013; Singer & Alexander, 2017a).

Students with better decoding skills and a higher self-concept as readers performed better in reading comprehension on both printed and digital tests. This finding is in line with previous studies, which have shown that good decoding skills (Cain, 2009; Torppa et al., 2016) and self-concept as a reader (e.g., Bråten et al., 2013) are linked to better reading comprehension. Surprisingly, although there were no gender differences in the raw test scores, controlling for all other variables, there was a difference between boys and girls in reading comprehension in the opposite direction than what has regularly been reported (OECD, 2010; Vettenranta et al., 2016). This is possibly due to both a larger variance in reading comprehension in girls found in the present sample and the analysis having taken into account other factors, such as decoding skills.

Students who reported being flexible in their preference for a study medium, i.e. were equally willing to study with both printed and digital texts, were better in reading comprehension than students preferring only digital texts. Although the direction of the association cannot be determined, it nonetheless indicates that the versatile use of study media is likely to be beneficial for comprehension. Because no significant differences were found in the comprehension between different media, we suggest that both printed and digital texts should be flexibly used in the school context. Although there is a need to develop the use of technology in education, at the same time, it is also important to pay attention to unlimited and uncontrolled use of computers. There are concerns about the relation of the excessive use of digital devices and children's social and emotional well-being (OECD, 2015). On the other hand, the effective pedagogical use of new devices can be challenging for some teachers. Thus, it would be important to support teachers in developing and sustaining flexible practices. It is essential that students have opportunities to practice reading on both mediums, since both are needed in modern society.

4.1 Limitations and future directions

The study addresses interesting methodological and theoretical issues but there are some limitations to be considered. The sample was geographically local and rather

small. Future studies could utilize larger and randomly selected samples of different age-groups to be able to generalize the results.

Further, the texts used in this study were short and totally visible on screen or on one sheet of paper. This may have influenced the reading comprehension by enabling the students to have a holistic perception of the texts without turning the page or having to scroll through the text on the screen (e.g., Mangen et al., 2013; Rockinson-Szapkiw et al., 2013). Further, the digital text and printed text had an identical format which do not shed light on the importance of technological solutions like hypertext with or without graphical navigable overviews (Fesel, Segers & Verhoeven, 2018). At the moment, PDF is still a commonly used format of digital learning materials at the Finnish school context. Moreover, the length and the type of the texts used in the study imitated the science texts generally used in the fifth grade in Finnish schools. However, in the future, it would be beneficial that the learning materials would be further developed and hypertext features more widely used. Moreover, it would be valuable to study how more interactive digital learning environments are associated with reading comprehension, as suggested by Singer and Alexander (2017b). Additionally, the effective pedagogical use of digital materials requires that teachers are provided with enough opportunities for professional development.

In addition to reading comprehension, answering the open-ended and cloze tasks requires writing skills and prior knowledge. Although decoding skills were controlled for as a prerequisite for reading comprehension, spelling skills and prior knowledge were not. In the evaluation of the responses, only the content of the response was evaluated, not the spelling or the length or the form of the answer. Future studies should develop measures that would overcome methodological limitations of this study and carefully capture the multifaceted reading comprehension process (Smagorinsky, 2009).

In the future studies, it would be beneficial to examine, how elaborating on the text during the reading process is associated with reading comprehension both in printed and digital texts, as well as whether there is a difference between various reading strategies' benefits depending on the medium on which the text is written. The elaboration could be done by, for example, underlining, notetaking, and mind mapping. In digital texts, it is also possible to incorporate more support for the reading process than in printed texts. For example, by clicking on a problematic word, a reader could be able to see the definition of the word and hear it pronounced; additionally, different kinds of hints could be used to direct readers' attention to the main ideas of the text. Thus, in future research, it would be important to examine how reading comprehension might be influenced by offering this kind of support in digital texts and whether it would be beneficial, for example, for those students whose decoding or reading comprehension skills are relatively weak.

4.2 Conclusions

The results of this study can be interpreted to support the flexible use of both printed and digital texts for reading comprehension for both boys and girls, as well as for students with varying levels of decoding skills, preferences for study mediums, and self-concepts as readers and computer users. This is the case at least for shorter texts, although Singer and Alexander (2017b) suggested that with longer texts it seems that reading digitally results in poorer performance. Moreover, as computers, tablets, and smartphones are developing rapidly and becoming an essential part of children's everyday lives and school tasks, it is likely that the differences earlier studies have observed between reading in print and digitally are becoming smaller. As students are getting as used to studying via computers as they are to studying from books, the emphasis on the medium of studying might become less important.

The topic of this study is of great relevance in a modern school context. For example, in Finland, ICT use has recently been considered as one of the main educational strategies and a core component of the national curriculum (National Board of Education, 2014). However, in the midst of political and social pressure to increase the use of ICT in schools, teachers should remember the importance of utilizing diverse methods and materials and thus supporting the reading comprehension skills of their students.

AUTHORS' NOTE

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