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A systematic review of research on reading in English on screen and on paper

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The introduction and wide use of devices, especially mobile ones, has changed the way learners read and do research for a variety of reasons, and this trend has attracted a number of studies conducted regarding reading on screen and on paper in addition to those dealing with the students' behavior in using online resources to print ones. This paper aims at identifying the major findings and trends in reading research by describing the current state of knowledge and practice in the studies comparing reading on screen and on paper and to provide guidance for practitioners by analyzing and summarizing the existing research. The current review adopted a systematic review as the research methodology as well as the article selection and screening process. The articles published between 2009 and 2017 were reviewed, and 37 articles were included in the analysis. The review revealed that the research on onscreen and paper-based reading focused on comparing the learners' performances in reading activities in both contexts and sharing preliminary findings and students' views. However, the findings are inconclusive as mixed findings were produced as to the effects of reading on screen and on paper. Moreover, the review also indicates that practitioners are also interested in examining the factors and affordances in reading on screen. As a result, there is still further research needed to establish the factors affecting reading and comprehension while reading on screen and on paper.

Keywords: reading, on screen, paper, traditional

1. Introduction and aim of the review

Much has been written about the influence of new technological developments such as easy access to both mobile devices and the Internet and the effects of these new developments on business, social life, and new learning and teaching habits. In line with this new trend, the introduction and widespread use of technological devices, especially mobile ones, has changed the way learners read and do research due to a variety of reasons such as easy access to information on any subject without being limited to any physical hindrance. While providing opportunities to teachers and learners, new technological developments have also attracted a number of studies conducted on reading on

screen and on paper in addition to the ones dealing with the students' behavior in using online resources and print ones. However, as the empirical studies included in this review indicate, it also seems that learners and teachers, in addition to other stakeholders such as parents and schools are not well prepared for the pull and push of technology.

As such, this paper aims at identifying the major findings and trends in reading research by describing the current state of knowledge and practice in the studies comparing reading on screen and on paper and to provide guidance for practitioners by analyzing and summarizing the existing research.

2. Theoretical background

Every reading process is a transactional event involving the interaction of readers with the text at a specific time and context (Rosenblatt 1988). In addition to factors, the context, which involves cultural, social and physical environments, plays an important factor in readers' conception of meaning and construction. The context might be the cultural elements included in the text, or the social values required constructing t meaning from the text. However, in most cases, the physical environment, or in other words, the medium or the device through which the text is presented to readers, affects the transaction.

Many factors contribute to the reading process and the comprehension of the message intended in the text. It sometimes seems that the meaning constructed from the text and the comprehension of this meaning is to a large degree based on the context. Cognitivists view this process a successful combination of the physical world – the medium/device in reading and consider the interactions available through the context between people and the environment. This transaction occurs in reading, between the text and readers through the paper and electronic environments. A number of studies have reported that the transaction using the paper environment led to better results compared to electronic formats such as reading on a computer screen (e.g. Fortunati & Vincent 2014; Martin-Beltrán et al. 2017). Numerous studies have also indicated special difficulties regarding readability of the text on screen, especially on tablet or mobile phone screens (e.g. Pölönen et al. 2012; Martinez & Rio 2015). These studies have revealed that the differences in screen size, resolution, image quality, navigation and taking notes (annotation) profoundly affected the transaction between the text and the reader, thus indicating the fact that the physical environment plays an important role in the reading process (Tracey & Morrow 2002). While such difficulties present significant issues regarding text readability, recent improvements and developments in technology also require a reconsideration of the opportunities provided to readers in term of the transaction in the paper and electronic environments. While it is not possible to change character size, text direction, or the size of the page in the paper environment, as indicated by Cheng (2013), reading performance is also affected by these factors, and new technology enables readers to make these adjustments easily and in ways that traditional paper resources cannot. The question is, however, to what extent, these different physical environments or formats affect comprehension of the text and what other factors might contribute to the transaction process.

3. Selection of the studies

The current review adopted systematic review as the research methodology as well as article selection and all literature searches were conducted using the electronic resources subscribed by the Library of Burdur Mehmet Akif Ersoy University, Turkey, and ULAKBIM (Turkish Academic Network and Information Center). Searches included the research-based articles published between 2009 and 2017. Moreover, these searches were limited only to peer-reviewed publications in English and the studies published as conference abstracts and other online resources such as blogs or personal website were not taken into consideration. The initial search was first conducted with the keywords, "reading online", "digital reading", "reading on screen", "reading on computer", "reading on mobile devices", "reading on paper", "reading in print", "reading print", and "reading electronic", which resulted in 110 documents. Beyond this initial search and results obtained, several specific criteria were used to ensure that only the studies comparing reading on paper and on screen were retained for analysis. For this reason, the following criteria were considered to finalize the studies to be considered for the current paper: (a) comparing reading on paper and on screen, (b) an empirical study, (c) analyzing text comprehension/retention and attitudes, and (d) going beyond self-report data. Based on the previous screening and these criteria, the articles published between 2009 and 2017 were reviewed, and 37 articles were included in the analysis. It is also due to note that several relevant articles in journals such as Reading in a Foreign Language and Reading Research and Instruction could not be included in the analysis, for either it was not possible to obtain the articles as the subscriptions of the databases did not include these articles/journals or the articles failed to meet the criteria that were followed.

4. Descriptive statistics

Several descriptive statistics were provided regarding the journals publishing the articles, countries, and the themes that the articles involved. Table 1 provides descriptive statistics on the journals in which the articles were published, and Table 2 provides descriptive statistics on the countries in which the articles were published/conducted. Table 3, on the other hand, includes statistics on the research themes of the studies.

Table 1: Descriptive statistics on the journals in which the articles were published

No.	Journal Title	Articles	Percentage
1	Computers & Education	14	37.8
2	Displays	5	13.5
3	Telematics and Informatics	3	8.1
4	International Journal of Educational Research	3	8.1
5	Computers in Human Behavior	3	8.1
6	Int. J. Human-Computer Studies	2	5.4
7	Library & Information Science Research	1	2.7
8	The Journal of Academic Librarianship	1	2.7
9	Internet and Higher Education	1	2.7
10	Procedia-Social and Behavioral Sciences	1	2.7
11	Procedia Computer Science	1	2.7
12	System	1	2.7
13	International Journal of Industrial Ergonomics	1	2.7

Table 2: Descriptive statistics on the countries in which the articles were published/conducted

No.	Country	Articles	Percentage
1	USA	8	21.6
2	Taiwan	5	13.5
3	China	4	10.8
4	Canada	3	8.1
5	Norway	2	5.4
6	Finland	2	5.4
7	Spain	2	5.4
8	Israel	2	5.4
9	France	2	5.4
10	Iran	2	5.4
11	The Netherlands	1	2.7
12	UK. Italy. Germany	1	2.7
13	Switzerland	1	2.7
14	Austria	1	2.7
15	Italy	1	2.7

Table 3: Descriptive statistics on the research themes of the articles

No.	Research Theme	Articles	Percentage
1	Evaluation of the usability and benefits of reading on screen and paper	7	18.9
2	Effects of reading on screen on reading comprehension	6	16.2
3	Attitudes and preferences towards reading on screen and paper	6	16.2
4	Exploring the strategies used by students while reading on screen	4	10.8
5	Factors affecting legibility and visual performance while reading on screen	3	8.1
6	Collaborative reading on screen	3	8.1
7	Effects of reading on screen and paper on test performance	3	8.1
8	Reading under different conditions	2	5.4
9	Effects of CALL techniques on reading comprehension	2	5.4
10	Effects of reading on screen on literacy	1	2.7

5. The categorization of the studies

Based on the common findings of the articles, the studies were grouped into four major categories as follows:

First category: Studies indicating that reading on screen is more effective or preferred.

Second category: Studies indicating that there is no difference between reading on screen and paper.

Third category: Studies indicating that reading on text/paper is more effective or preferred.

Fourth category: Studies examining the factors and affordances in reading on screen.

6. Major findings of the studies of each category

The major findings of the studies of each category were discussed in this section. Moreover, a summary was provided of the findings and the studies in Table 4.

Table 4: The major findings and the studies of each category

Findings	Studies
Reading on screen is more effective or preferred	(Korat 2010; Tveit & Magen 2014; Siegenthaler et al. 2011; Ji et al. 2014; Chen & Chen 2014; Fesel et al. 2015; Marzban 2011; Jan et al. 2016; Kao et al. 2016; Huang et al. 2009; Lysenko & Abrami 2014).
There is no difference	(Rockinson-Szapkiw et al. 2013; Hou et al. 2017; Daniel & Woody 2013; Porion et al. 2016).
Reading on text/ paper is more effective or preferred	(Woody et al. 2010; Kang et al. 2009; Farinosi et a. 2016; Berg et al. 2010; Mangen et a. 2013; Pölönen et al. 2012; Martinez & Rio 2015; Ackerman & Lauterman 2012; Taipale 2014; Martin-Beltrán et al. 2017; Holzinger et al. 2011; Fortunati & Vincent 2014; Macedo-Rouet et al. 2009).
Examining the factors and affordances in reading on screen	(Gil-Flores et al. 2012; Park & Kim 2017; Bowman et al. 2010; Lin et al. 2013; Lee et al. 2011; Khezrlou et al. 2009; Stone & Baker-Eveleth 2013; Li et al. 2013).

6.1. Studies indicating that reading on screen is more effective or preferred

In total, 11 studies found out that students benefited from or preferred reading on screen (Korat 2010; Tveit & Magen 2014; Siegenthaler et al. 2011; Ji et al. 2014; Chen & Chen 2014; Fesel et al. 2015; Marzban 2011; Jan et al. 2016; Kao et al. 2016; Huang et al. 2009; Lysenko & Abrami 2014).

The results that Korat (2010) obtained revealed that kindergarten and first-grade Israeli students whose age varied from 5 to 7 benefitted from reading an electronic version of a book on computer in terms of progress in word meaning. The 5 e-book reading treatments included reading the story with a dictionary option on the computer with oral reading and dynamic visual features whereas the control group received the regular literacy program which included learning alphabetic skills, word reading and writing, and reading stories. Furthermore, they stated that the treatment group took part in reading the e-book as well as the regular literacy program; therefore, the progress of the participants cannot be justified with only the treatment in the study and it is worth mentioning that the availability of e-books may not be the same for every classroom. In another study, Tveit & Magen (2014) reported that among Norwegian 15-year-olds, the majority stated that they preferred reading on e-book readers. The participants were asked to start reading a book and then continue reading it on an e-book reader and the questionnaire results showed that students who read more often preferred to read the print book whereas those who read less often preferred e-book readers. They also claimed that introducing digital reading in the classroom could promote reading skills of students who read less often. It is also noteworthy that students did not state any difference in their reading experiences after using e-books; in other words, they did not find e-books more relaxing or enter-

taining. The fact that 65% of the participants stated that they own a tablet and the national average tablet ownership is 50% in Norway may have had an effect on these results. Using a different data collection instrument, Siegenthaler et al. (2011) tested the eye movements of Finnish readers whose age varied from 16 to 71 with regard to five different e-book readers and a printed book. The results indicated that the reading behavior and performance of the participants did not significantly differ between reading e-book readers and a printed book; however, they reported that the legibility of the e-book readers was high, meaning the participants did not have any difficulty using the e-book readers. They justify this claim by pointing out the text adjusting feature of e-book readers. Regarding the choices of using online or printed materials, Ji et al. (2014) found out that when presented with a choice of accessing course materials online or in print, almost half of the required assignments were read online, one-third were printed. Moreover, students also stated that they preferred online readings due to financial reasons but that they read more and learn more when the materials are printed. Chen & Chen (2014) developed and integrated a collaborative reading annotation system which enables the readers to create, modify or delete annotations on e-book readers. They tested their system with the participation of 53 Taiwanese students aged between 10 and 11 and the results of the experiment indicated that the experimental group showed greater comprehension and use of collaborative reading strategies such as finding the main idea, reviewing key ideas, predicting and monitor understanding when compared to the control group which had collaborative reading on paper. Fesel et al. (2015), on the other hand, compared different types of digital texts; linear digital text type which contained forward and backward buttons for navigating, digital text with an overview type which included overview at the top of the pages, hypertext type which contained blue underlined links, and hypertext with an overview type which included ten links in the text and ten links in the overview. In the study, eleven-year-old students were able to use the hierarchically structured and closed digital texts without needing support and that they followed a sequential approach in all digital texts. Moreover, the findings revealed same level of comprehension score for all the text types. Marzban (2011) reported that, in terms of reading comprehension, participants in the experimental group taught with the help of computer-assisted language learning techniques outperformed their counterparts who received only the traditional techniques. Jan, Chen, & Huang (2016) implemented two annotation filters into web-based collaborative reading system; high-grade annotation filter system which filters poor annotations with regard to their confidence level and master annotation filter system in which only the annotations which are written by five designated readers are shown in the user interface of the web-based collaborative reading annotation system. They found out that there was a statistically significant improvement among 16-17 year old students who used high-grade annotation filter in terms of reading comprehension while reading on screen compared to their counterparts.

Kao et al. (2016) reported that e-books with high interaction enabled participants to have the higher perceived motivation and to achieve better comprehension when reading stories on an e-book reader. Moreover, they observed that the group that was exposed to the high interactive e-book treatment showed significantly better performance when compared to the group which had a low interactive e-book system in terms of literal and

critical comprehension. The study also showed that the highly interactive functions in e-books improved the confidence and satisfaction of the participants. For the purpose of identifying online reading strategies, Huang et al. (2009) created an online program for reading in English. They found out that the participants generally depended on aids such as dictionaries, translators or they tended to highlight texts to facilitate their reading comprehension and these support strategies were dominant for their strategic use and played an important part in their comprehension. Lysenko & Abrami (2014) found out that two web-based pieces of software; an interactive, multimedia literacy software (ABRA) and a digital process portfolio (ePEARL) provided higher learning gains in vocabulary and reading comprehension for the participants.

6.2. Studies indicating that there is no difference between reading on screen and paper

In total, 4 studies reported that there was no difference between reading on screen and paper considering learner performance (Rockinson-Szapkiw et al. 2013; Hou et al. 2017; Daniel & Woody 2013; Porion et al. 2016).

Rockinson-Szapkiw et al. (2013) found out that undergraduate students ranging in age from 20 to 69 who used e-readers during their courses had significantly greater perceived psychomotor and affective learning than their counterparts who chose to read on paper. They also observed that there was no significant difference in cognitive learning or final grades among the groups, which suggested that reading on screen was as viable as reading on paper. Likewise, Hou et al. (2017) compared reading comics on paper, digital equivalent (one full-page view on a digital screen) and on disrupted view (broken structure view on a digital screen) on digital tablets. They reported that reading digital equivalent was similar to reading on paper and they were both better than reading on disrupted view in terms of reading comprehension, feelings of fatigue, and focusing on the content. In other words, the results indicate that reading on screen in one full-page view is a suitable match for reading on paper. Similarly, Daniel & Woody (2013) conducted an experiment on reading on screen versus reading on paper at home and in the lab, and the 19-year-old students participated in the study. The results indicated that the participants spent more time reading on screen. Additionally, they did not observe a significant difference in the participants' performance between the control and experimental group, suggesting that reading on screen is a viable substitute for reading on paper. Although Porion, Aparicio, Megalakaki, Robert & Baccino (2016) found that participants showed better performance while reading on screen than paper in terms of comprehension, the difference was not statistically significant. Moreover, they did not observe any effect between reading on screen or paper in terms of vocabulary memorization.

6.3. Studies indicating that reading on text/paper is more effective or preferred

In total, 13 studies found out that students preferred reading on text/paper or reading on text/paper is more effective (Woody et al. 2010; Kang et al. 2009; Farinosi et al. 2016; Berg et al. 2010; Mangen et al. 2013; Pölönen et al. 2012; Martinez & Rio 2015;

Ackerman & Lauterman 2012; Taipale 2014; Martin-Beltrán et al. 2017; Holzinger et al. 2011; Fortunati & Vincent 2014; Macedo-Rouet et al. 2009).

Woody et al. (2010) observed that when faced with the question of choice, university students preferred reading on paper over screen. Moreover, they concluded that previous experience with e-books did not lead to a preference for reading on screen and that the participants still chose reading on paper. Regarding the problems that the participants faced while reading on screen, Kang et al. (2009) found out that reading on screen caused higher eye fatigue and the reading efficiency was lower when compared to reading on paper. Moreover, the participants took shorter to read on screen; however, the accuracy (proportion of correct recall) level was not significantly different. Similarly, Farinosi et al. (2016) concluded that German, Italian and British students aging from 21 to 27 reported that they felt they had disadvantages caused by distractions caused by other tasks on the device and they had a headache, or they felt disconnected when the reading took too long. The participants also stated that reading printed text allowed them to better immerse themselves in the content.

Berg et al. (2010) conducted an experiment with the aim of comparing how undergraduate students use e-book readers and printed texts by having students complete information retrieval tasks. They found that undergraduate students used various strategies while reading on screen and paper. The findings indicated that for information retrieval tasks, students followed a linear strategy while reading on paper; they looked for keywords in the table of contents and scanned the related pages; however, on e-books they were not sure about how to approach the task as they struggled with the search option on the digital device and they abandoned this strategy when faced with a problem. They also reported that the physical properties of the reading on paper positively affected the interactions they had with the text. Moreover, their observations on how the participants interacted with e-books and did not easily navigate to complete information retrieval tasks comparing to printed texts indicated that the students were not able to use e-books more effectively than paper. Similarly, Mangen et al. (2013) revealed that 15-year-old students who read on paper outperformed those who read on screen in terms of reading comprehension. Pölönen et al. (2012) tested the usability of reading on three different near-to-eye displays, e-book reader, and paper. They found out that reading on paper was more comfortable than reading on near-to-eye displays and e-books for longer periods of time; reading on e-book caused eye strain after 20 minutes of reading, the near-to-eye displays had various problems such as display resolution, unnatural angle, and motion sickness. Moreover, they emphasized that the differences in screen size, resolution, and image quality were important factors that affected the reading experience. Martinez & Rio (2015) presented the claim that reading on screen might be problematic in terms of navigation, annotation, and visual memory issues, unlike reading on paper. They stated that reading on screen was not adequate for long or focused readings due to the distracting nature of the devices, they claimed that the advantages of traditional books can only be based on personal preferences and opinions, and that there was no evidence to support the idea that reading on paper is more advantageous than reading on screen.

Ackerman & Lauterman (2012) conducted an experiment that included reading on screen and paper in different circumstances; students read under time pressure (time

constraint without participants' knowledge), free regulation (working under no time constraint) and interrupted condition (time constraint within participants' knowledge). The participants who studied on screen under time pressure achieved lower than those who studied on paper. Under free regulation and without time pressure, efficiency was equal for both groups and no significant difference was observed in interrupted circumstances. The findings obtained by Taipale (2014) showed that when Italian and Finnish situations were examined, the results of the two nations showed similarities in perceived affordances of reading and writing on screen and paper, and the graduate students chose paper in both nations. For writing on screen, graduate students stated that positive affordances of writing on paper were superior to screen in terms of immediacy, personality, portability, flexibility in style. On the other hand, for reading on paper, features such as easier annotation and underlining, and varying postures were superior to reading on a computer screen.

Martin-Beltrán et al. (2017) examined the interactions of 4th graders and kindergarten students during collaborative reading on screen and reading on paper, and they observed that the students in the group of reading on screen were generally interacting with animation on the e-book reader while students who read books had verbal discussions and practice using language. Moreover, they inferred that reading on paper supported literacy development better. Holzinger et al. (2011) observed no significant performance difference between reading diagnosis reports on screen or paper in terms of speed, accuracy, and comprehension. Moreover, they claimed that medical professionals preferred to read diagnosis reports on paper.

In another study carried out by Fortunati & Vincent (2014), graduate Master degree students reported that the emotional and sensorial experience while reading on paper was greater than reading or writing on screen and the Master degree students found the experience of reading on screen difficult and tiring. Macedo-Rouet et al. (2009) observed that students who read on paper outperformed those who read on screen in terms of quiz performance and the undergraduate students reported that reading on screen was tiring and they would prefer to read the lecture notes on paper when preparing for quizzes.

6.4. Studies examining the factors and affordances in reading on screen

In total, 9 studies explored the factors and affordances which affected reading performance while reading on screen (Gil-Flores et al. 2012; Park & Kim 2017; Bowman et al. 2010; Lin et al. 2013; Lee et al. 2011; Khezrlou et al. 2017; Huang et al. 2009; Stone & Baker-Eveleth 2013; Li et al. 2013).

Gil-Flores et al. (2012) discovered that information-seeking activities in online reading had a greater impact on 15-year-old student reading performance than social activities such as texting or sending e-mail; yet, they also observed that these information-seeking activities had a lower significance on the participants' reading experiences. In another study conducted by Park & Kim (2017) investigated the strategies used by 4th and 5th grade English language learners and factors affecting the process while reading on screen and reported that the students used nine strategies, namely, "accessing a web page",

"adjusting the reading pattern", "dialoguing", "inferring from the text", "making a connection", "monitoring comprehension", "previewing and setting up the purpose", "using computer skills and devices", "using references" and "sharing an information source". Moreover, they stated that "electronic literacy knowledge", "their parents' and teachers' guidance for online reading", and "the language of online texts" affected their selection of texts. Bowman et al. (2010) discovered that students who sent instant messages while reading academic passages on screen took significantly longer to finish; however, there was no difference in performance in terms of comprehension. Lin et al. (2013) found out that text direction, screen size, and character size are important factors affecting the legibility of the text and time spent in searching for target words. More specifically, they found out that horizontal texts, bigger screens, and fonts positively affected the search time and the size of the font affected accuracy and visual fatigue of the participants. In a similar vein, Lee et al. (2011) found out that the light source of digital devices was not the only factor affecting visual performance and visual fatigue. Additionally, they concluded display type, character size, interline spacing affected the search time and accuracy of the participants and better visual performance was observed for e-ink displays.

Khezrlou et al. (2017) found out that explicit instruction about the target lexical items before computerized reading and instructing them to check multimedia glosses while reading showed greater vocabulary performance than the control group which did not receive any such instruction. Moreover, the group that had intentional instruction performed better in terms of reading comprehension. Another study conducted by Huang et al. (2009) reported that significant differences were found in reading performance and preference of the participants with regard to the size of the fonts and resolution of the displays of the devices. Moreover, they concluded that between 3.8 mm font size on 125 dpi and 2.2 mm font size on 250 dpi, the readability of the displays was suitable for Chinese characters. Stone & Baker-Eveleth (2013) stated that university student' satisfaction with e-texts and their perceived usefulness directly affect their e-reading continuance intentions. In other words, students who were more experienced with e-texts tended to continue reading them when they were more satisfied with the e-texts. Li et al. (2013) developed an e-book reader platform which enables the reader to create a cognitive map with visual cues that integrates user-made contextual cues, underlined sections, summaries, and comments within the page. The platform included a content section and an overview section for each page and a systematical approach to promote skimming the readings and underlining some sections. They tested the reading, reviewing and navigational performance of the platform with the participation of 60 undergraduate students in Taiwan and their experiment revealed that participants who used their platform showed greater comprehension performance after the reviewing phase and spent less time to complete the tasks whereas the participants in the other two groups who used Acrobat Reader software either with or without guidance. The participants in the experimental group who used the platform completed a satisfaction questionnaire and most of the participants showed a positive attitude. Even though the authors observed some improvements in task completion time and comprehension after reviewing, the restrictions in the experimental design of the study pose a threat to the reliability of the results in the study.

7. Conclusions and implications

The articles published between 2009 and 2017 were reviewed, and 3 articles were included in the analysis. Empirical investigations of the studies have suggested four possible trends or outcomes considering reading on paper and on screen: (1) Reading on screen is more effective or preferred, (2) Both types of reading are the same; there is no difference, (3) Reading on paper is more effective or preferred, and (4) the factors and affordances in reading on screen affect results. The number of the studies that reveal either reading on screen or reading on paper is more effective is almost the same and it must be stated that definitive conclusions cannot be drawn. Several reasons can be accounted for this, among which are the varieties of methodologies, instruments, and materials employed and the procedures followed. Based on the findings, it almost seems certain that reading speed and accuracy are affected negatively when learners are required for cognitively demanding tasks during reading on screen. The results indicate that reading on screen might be slower compared to reading on paper, especially when the screen and font size are not suitable and cause visual fatigue. Therefore, these results suggest that designers of online materials should consider these factors and that reading on screen is slower than on paper and is affected by a variety of factors, and take necessary precautions such as using suitable font size and background color. Moreover, one might also state that how comprehension and retention are affected by the presentation medium is more important than the speed of reading. The current review also indicates that the issue of comprehension and retention cannot be seen as fully researched, for as indicated by several findings it is not possible to devise and implement a suitable means of measurement of comprehension and retention.

Text length and readers' age and their familiarity with reading on screen are the other two factors that receive attention in the studies reviewed in this paper. Text length appears to be a factor while reading on screen, and it is agreed that the longer a text is, the more discomfort that reading on screen causes readers. However, reading lengthy texts on paper appears to have an advantage in terms of comprehension and comfort. Regarding age, it must be noted that age might affect the findings of the results, for when the participants grow up reading printed materials and spend less time on reading on screen (Salter 2016), this might lead to a preference over reading on screen and might affect the results. Moreover, it might not be easy to aid the strategies or actions that people perform while reading on text such as taking notes or underlining during reading on screen, though new electronic devices allow readers to perform these actions.

Considering the inconclusive but illuminating results of the studies reviewed here, it might be suggested that practitioners and teachers consider exposing learners to develop and improve their reading skills in both environments: on text and on screen. Learners need to practice reading texts, improve their comprehension and retention; however, at the same time, they also need to build confidence in reading on screen and benefit from several advantages of technological devices such as the ability to find information quickly and with ease of navigational opportunity. Practitioners and teachers, then, can combine these two into several tasks in which learners practice both reading on screen and on paper. There is however still further research needed to establish the factors affecting

reading and comprehension while reading on screen and on paper. Further studies can study in detail whether reading online lead learners to obtain the information quickly and to forget it after using it without trying to keep in memory so that they can use it later. In addition, further research can investigate whether reading on screen prevents learners from practicing 'deep reading' (Kılıçkaya 2016). Moreover, more studies can be conducted on how the brain works while reading on screen and paper through new technological improvements such as brain imaging techniques. But, the ultimate aim should be to benefit from opportunities to improve reading in any context, be it on screen or on paper. Therefore, the further research can also combine these different contexts and look for how reading can be improved, rather than trying to find a difference or to show the superiority of one over the other.

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References

Ackerman, Rakefet, & Lauterman, Tirza. 2012. Taking reading comprehension exams on screen or on paper? A metacognitive analysis of learning texts under time pressure. *Computers in human behavior* 28. 1816-1828.

Berg, Selinda A. & Hoffmann, Kristin & Dawson, Diane. 2010. Not on the same page: Undergraduates' information retrieval in electronic and print books. *The Journal of Academic Librarianship* 36(6). 518-525.

Bowman, Laura L. & Levine, Laura E. & Waite, Bradley M. & Gendron, Michael. 2010. Can students really multitask? An experimental study of instant messaging while reading. *Computers & Education* 54. 927-931.

Chen, Chih-Ming & Chen, Fang-Ya. 2014. Enhancing digital reading performance with a collaborative reading annotation system. *Computers & Education* 77. 67-81.

Chen, Nian-Shing & Teng, Daniel. C. & Lee, Cheng-Han. 2011. Augmenting paper-based reading activity with direct access to digital materials and scaffolded questioning. *Computers & Education* 57. 1705-1715.

Daniel, David B. & Woody, William D. 2013. E-textbooks at what cost? Performance and use of electronic v. print texts. *Computers & Education* 62. 18-23.

Farinosi, Manuela & Lim, Christopher & Roll, Julia. 2016. Book or screen, pen or keyboard? A cross-cultural sociological analysis of writing and reading habits basing on Germany, Italy and the UK. *Telematics and Informatics* 33. 410-421.

Fesel, Sabine S. & Segers, Elaine & Clariana, Roy B. & Verhoeven, Ludo. 2015. Quality of children's knowledge representations in digital text comprehension: Evidence from pathfinder networks. *Computers in Human Behavior* 48. 135-146.

Fortunati, Leopoldina & Vincent, Jane. 2014. Sociological insights on the comparison of writing/reading on paper with writing/reading digitally. *Telematics and Informatics* 31. 39-51.

Gil-Flores, Javier & Torres-Gordillo, Juan-Jesus & Perera-Rodríguez, Victor-Hugo. 2012. The role of online reader experience in explaining students' performance in digital reading. *Computers & Education* 59. 653-660.

Holzinger, Andreas & Baernthaler, Markus & Pammer, Walter & Katz, Herman & Bjelic-Radisic, Vesna & Ziefle, Martina. 2011. Investigating paper vs. screen in real-life hospital workflows: Performance contradicts perceived superiority of paper in the user experience. *International Journal of Human-Computer Studies* 69. 563-570.

Hou, Jinghui & Rashid, Justin & Lee, Kwan M. 2017. Cognitive map or medium materiality? Reading on paper and screen. *Computers in Human Behavior* 67. 84-94.

Huang, Ding-Long & Rau, Pei-Luen P. & Liu, Ying. 2009. Effects of font size, display resolution and task type on reading Chinese fonts from mobile devices. *International Journal of Industrial Ergonomics* 39. 81-89.

Huang, H. C., Chern, C. L., & Lin, C. C. 2009. EFL learners' use of online reading strategies and comprehension of texts: An exploratory study. *Computers & Education* 52. 13-26.

Jan, Jiun-Chi & Chen, Chih-Ming & Huang, Po-Han. 2016. Enhancement of digital reading performance by using a novel web-based collaborative reading annotation system with two quality annotation filtering mechanisms. *International Journal of Human-Computer Studies* 86. 81-93.

Ji, Sung W. & Michaels, Sherri & Waterman, David. 2014. Print vs. electronic readings in college courses: Cost-efficiency and perceived learning. *The Internet and Higher Education* 21. 17-24.

Kang, Yen-Yu & Wang, Mao-Jiun J. & Lin, Rungtai. 2009. Usability evaluation of E-books. *Displays* 30. 49-52.

Kao, Gloria Y. & Tsai, Chin-Chung & Liu, Chia-Yu & Yang, Cheng-Han. 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.

Khezrlou, Sima & Ellis, Rod & Sadeghi, Karim. 2017. Effects of computer-assisted glosses on EFL learners' vocabulary acquisition and reading comprehension in three learning conditions. *System* 65. 104-116.

Kılıçkaya, Ferit. 2016. Video killed the radio star: Language students' use of electronic resources-Reading or viewing? In Arıkan, Arda & Saraç, Hatice Sezgi & Leal, Elana Seoane & Zorba, Hatice Akın (eds.), *Proceedings from 2nd International Language, Culture and Literature Workshops*, 89-92. Antalya, Turkey: Damla Kırtasiye. https://files.eric.ed.gov/fulltext/ED570284.pdf. (Accessed 2018-09-12.)

Korat, Ofra. 2010. Reading electronic books as a support for vocabulary, story comprehension and word reading in kindergarten and first grade. *Computers & Education* 55. 24-31.

Lee, Der-Song & Ko, Ya-Hsien & Shen, I-Hsuan & Chao, Chih-Yu. 2011. Effect of light source, ambient illumination, character size and interline spacing on visual performance and visual fatigue with electronic paper displays. *Displays* 32. 1-7.

Li, Liang-Yi & Chen, Gwo-Dong & Yang, Sheng-Jie. 2013. Construction of cognitive maps to improve e-book reading and navigation. *Computers & Education* 60. 32-39.

Lin, Hsuan & Wu, Fong-Gong & Cheng, Yune-Yu. 2013. Legibility and visual fatigue affected by text direction, screen size and character size on color LCD e-reader. *Displays* 34. 49-58.

Lysenko, Larysa V. & Abrami, Philip C. 2014. Promoting reading comprehension with the use of technology. *Computers & Education* 75. 162-172.

Macedo-Rouet, Mônica & Ney, Muriel & Charles, Sandrine & Lallich-Boidin, Geneviève. 2009. Students' performance and satisfaction with Web vs. paper-based practice quizzes and lecture notes. *Computers & Education* 53. 375-384.

Mangen, Anne & Walgermo, Bente R. & Brønnick, Kolbjørn. 2013. Reading linear texts on paper versus computer screen: Effects on reading comprehension. *International Journal of Educational Research* 58. 61-68.

Martin-Beltrán, Melinda & Tigert, Johanna M. & Peercy, Megan M. & Silverman, Rebecca D. 2017. Using digital texts vs. paper texts to read together: Insights into engagement and mediation of literacy practices among linguistically diverse students. *International Journal of Educational Research* 82. 135-146.

Martinez, Vicente G. & López-Río, Joaquim. 2015. About the horrific peril of reading on digital devices. Procedia-*Social and Behavioral Sciences* 178. 105-109.

Marzban, Amir. 2011. Improvement of reading comprehension through computer-assisted language learning in Iranian intermediate EFL students. *Procedia Computer Science* 3. 3-10.

Park, Ho-Ryong & Kim, Deoksoon. 2017. English language learners' strategies for reading online texts: Influential factors and patterns of use at home and in school. *International Journal of Educational Research* 82. 63-74.

Pölönen, Monika & Järvenpää, Toni & Häkkinen, Jukka. 2012. Reading e-books on a near-to-eye display: Comparison between a small-sized multimedia display and a hard copy. *Displays* 33. 157-167.

Porion, Aalexandre & Aparicio, Xavier & Megalakaki, Olga & Robert, Alisson & Baccino, Thierry. 2016. The impact of paper-based versus computerized presentation on text comprehension and memorization. *Computers in Human Behavior* 54. 569-576.

Rockinson-Szapkiw, Amanda J. & Courduff, Jennifer & Carter, Kimberly C. & Bennett, David. 2013. Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *Computers & Education* 63. 259-266.

Rosenblatt, Louise M. 1988. *Writing and reading: the transactional theory*. Technical Report No. 416. New York University: Center for the Study of Reading. https://www.ideals.illinois.edu/bitstream/handle/2142/18044/ctrstreadtechrepv01988i00416_opt. pdf. (Accessed 2018-06-17.)

Salter, Purue. 2016. *Impact of reading from a screen versus from printed material*. https://www.radford.act.edu.au/storage/reading-on-screens-v-paper.pdf. (Accessed 2018-08-20.)

Siegenthaler, Eva & Wrutz, Pascal & Bergamin, Per & Groner, Rudolf. 2011. Comparing reading processes on e-ink displays and print. *Displays* 32. 268-273.

Stone, Robert W. & Baker-Eveleth, Lori. 2013. Students' expectation, confirmation, and continuance intention to use electronic textbooks. *Computers in Human Behavior* 29. 984-990.

Taipale, Sakari. 2014. The affordances of reading/writing on paper and digitally in Finland. *Telematics and Informatics* 31(4). 532-542.

Tracey, Diane H, & Morrow, Lesley Mandel. 2002. Preparing young learners for successful reading comprehension. In Collins Block, Cathy & Pressley, Michael (eds.), *Comprehension instruction: Research-based best practices*, 319-333. New York: Guilford.

Tveit, Ase K. & Mangen, Anne. 2014. A joker in the class: Teenage readers' attitudes and preferences to reading on different devices. *Library & Information Science Research* 36. 179-184.

Woody, William. D. & Daniel, David B. & Baker, Crystal A. 2010. E-books or textbooks: Students prefer textbooks. *Computers & Education* 55. 945-948.