# Unveiling the Depths of Comprehension in E-Reading and Paper Reading: A Systematic Literature Review

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## Article Info

## ABSTRACT

It is deemed that human brain is highly flexible which provides the ground for learning so many new things, while it is also the case that when it comes to reading from different mediums, that flexibility can be a problem. That is, the brain mechanism during paper reading and e-reading is significantly different. There are numerous studies from cognitive sciences, neuroscience, education, etc. which have studied the topic from various perspectives, while there is a lack of literature which systematically reviewed the primary studies to gain insight into comprehension change across media platforms, a comparison between e-reading and paper reading in terms of comprehension and whether e-reading substitutes paper reading. In the present paper, the main objective is the comparison between e-reading and paper reading in terms of comprehension. For this purpose, systematic literature review method was adopted and three major indexes, namely, Scopus, WoS and IEEE Xplore were selected as the source of corpus. Totally, 27 papers were found, after applying inclusion and exclusion criteria the number of the papers was decreased. The results showed that there are several factors effective on reading comprehension, such as Story elements, Characters analysis, Main idea and details, Problems and solution Eyestrain, Headaches, Distraction, Mentally mapping, Availability, Portability, Eco-friendly, Font size, Tools, Reading program, Convenience, Compatibility, Media richness, Licensing issues, Graphic display capabilities, Reading task and Reading techniques Eye strain, Time constraint Gender, Age, Pleasure, Motivation, Challenge, Involvement, Curiosity, Competition, Recognition, Social aspects, Compliance, Grades, Personal relationship, Readership, Reading experience, Context area of school, Context constraints, Reader comfort and Mental values. Moreover, while some studies point out that there is no significant difference between comprehension of reading across media, other studies showed that there are differences among study subjects in terms of comprehension, if age, gender, experience, etc. are taken into account.

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## 1. INTRODUCTION

In this era of digital transformation, when technology is constantly reshaping how we engage with information, the dispute between e-reading and conventional paper reading has become a hot topic. The transition from flipping physical pages to swiping digital screens raises issues regarding how these various reading modes affect our comprehension of textual material. This article does a systematic literature review,

attempting to uncover the intricacies that characterize understanding in the domains of e-reading and paper reading.

Now since everything is being linked to technology, reading is no different, especially considering how much e-books can be catered towards the readers and offer tools and interactions that paper simply cannot offer. Personalized e-books and gamified e-books are not only an alternative to printed book reading, but they also function as unique resources that are significantly more effective than printed books [1].

At least 21% of Americans have read an eBook [2]. The rising availability of e-content is encouraging some people to read more than before and to prefer buying books over renting them. Wider availability could result in consumers being more acceptive of this type of media and affect their preference on how to read books.

The possibilities of e-books in schools are also exhilarating and endless [3]. Although e-books have been accessible for over a decade, academics have only lately begun to examine the quality, advantages, and prospects of this type of reading [4]. One study reveals that there is a considerable "book effect" on quiz results; when compared to e-books, printed books appear to improve reading comprehension. Students reported much more eye fatigue after reading e-books than after reading traditional books. Students were pleased with the e-book, but preferred printed ones [4].

The Millennials are the most computer-literate generation to join the workforce. People born between 1981 and 2001, sometimes known as the Net Generation, grew up in an era of immediate access [5]. Moreover, their learning and communication strategy is multi-media. Text messaging, instant messaging, and cell phones are the most frequent forms of communication. Learning has also spread to web-based resources like online courses, online blogs, and iPod downloads. The diverse surroundings of this digitally advanced generation will be vital to comprehend for their learning at school and at work. With all that being said, being the most exposed to technology, they might be more acceptive of e-reading than their older counterparts.

Findings in one study suggests that e-reading may accelerate students' reading rates, maybe due to the use of reading application features that encourage students to read at quicker rates. When reading from an e-resource, students reported poorer comprehension levels. On the other hand, students' opinions regarding e-reading are less positive when compared to traditional book reading, owing to a variety of external influences that were not inherent in the e-reading activity [6]. While another research found no significant difference between the two mediums [7].

Reading necessitates two essential processes: the conscious process, in which the reader focuses on textual information in a top-down mode, and the unconscious process, in which the user focuses on his previous knowledge about the topic, as well as whatever background he has on the subject at hand, which is organized in the reader's brain in categories [8].

There is a controversy that the usage of e-books is not favorable for comprehension, but it may bring other significant benefits, but the comprehension aspect may not be as outstanding as suggested by some earlier studies [9]. All in all, the correlation between e-books and understanding is not straightforward [10]. Different studies show different results, it could still depend on the scenario and the factors that impact reading preference, this may not let e-reading take the place of paper reading just yet, but it is perhaps still a viable option. There are several factors that affect a person's preference towards opting for e-reading or paper reading, comprehension is crucial thing, since the literature debates on which type of reading is best for comprehension, and also depends on the reading purpose as well as other criteria.

Within this work we will be reviewing several articles that discuss reading comprehension under these terms and look forward to finding an answer to our questions based on available recent literature. This study aims to bridge the gap between the tactile and the digital by utilizing cognitive psychology, educational research, and human-computer interaction investigations. By reviewing the available evidence, we want to identify trends, discrepancies, and possible synergies in comprehension results across e-reading and paper reading. This comparative investigation, using an unbiased lens, attempts to provide nuanced insights to the current debate over the influence of technology improvements on human cognitive processes and learning experiences.

## 2. RELATED WORK

Çetin and Ferit Kılıçkaya [11] conducted a systematic review research on reading on the basis of screen and paper. They believe that by the emergence of digital devices, especially mobile ones, the way that learners read and do research has altered, and such trend has gained interest among the scholars to study the difference between e-reading and text-based reading and comprehension. The main objective was to identify the findings and current trends in reading research by comparing reading on screen and on the paper. They adopted systematic review as the research methodology, as well as the articles were selected and screening process was applied. Their corpus consisted of the published 37 articles between 2009 and 2017. According

to the observations, the majority of the research on screen and paper-based reading has focus on comparing the learners' performance in comprehension. Moreover, they observed that scholars are interested in scrutinizing the factors and affordance in reading on screen, implying the need for further research to define the factors effective on the reading and comprehension for both mediums, namely, paper-based reading and digital-based reading. Generally, four possible trends were observed in the empirically investigation of the studies between 2009 and 2017:

1) Reading on the screen is more effective.
2) Both types of reading are the same and there is no difference.
3) Reading on paper is more effective or preferred.
4) The factors and affordance in reading on screen affect the results.

They also believe that the comprehension and retention factors are not fully surveyed and studied, that is, it is not liable to come up with a suitable means of measurement for comprehension and retention. They also showed that text length and readers' age and their familiarity with reading on screen are the other two factors that gained attention in the studies reviewed.

Fontaine, Lapierre and Lordkipanidz [12] conducted a meta-analysis in order to study the effect of paper versus e-reading on reading comprehension in the sphere of health professional education. They believe that although there is a surge in the usage of digital education in health professional education, so-called HPE, but there is a research gap on juxtaposing the paper-based reading and e-reading, and the associated effect on the reading comprehension. In this regard, they aimed at identifying, assessing and synthesizing the evidence regarding the impact of reading medium on the comprehension in the context of HPE. To this end, the observational, quasi-experimental, and experimental studies which are published before April 16, 2021 in which the effectiveness of paper-based and digital-based reading on reading comprehension were compared. According to the obtained results, they observed that there is no significant advantage for the students who have read paper-based HPE text, compared with digital text. Considering the subgroup analyses, it was observed that students reading paper-based HPE texts exhibits better reading comprehension than the students who read digital-based HPE text. It was construed that there is little to no difference among the student's comprehension reading HPE texts on hardcopies vs. digitally. Meanwhile, it was observed that students paper-based reading when the topic is related to their professional discipline.

Kucirkova [13] focused on reviewing and integrating the available literature related to studies on the children's reading on screen using quantitative and qualitative methods, which are published between 2016 – 2017. In that study, the main focus on the scholar was concentrated on the researchers' epistemological perspectives on knowledge and learning. To this end, Johri's (2011) [14] framework of socio-material assemblages was used for synthesizing the epistemological dualities and examining the ways in which scholars conceptualize children's learning with digital books. According to the obtained results, it was observed that the extant empirical studies map directly onto the social part of Johri's framework and onto the material aspects of children's digital books. He claims that only theatrical studies pay equal attention to the social and material aspects in the conceptualization of children's reading on screen. According to the reviewed corpus, it was observed that there were no in-depth empirical examples of how the social and material aspects are inseparable from children's reading of digital books. He claimed that the empirical studies highlighted either their social or material aspects. Socio-materialism, however, challenges that the social and material are inseparable. The findings show that the empirical studies constitute a model of predictors and mediators that significantly contribute to the advancement of knowledge of children's reading on screen. Studies conducted in the Material strand of literature either conduct comparative experiments with digital books and other reading formats, such as print books versus flat e-books, or they focus on both the content and format of digital books to develop evaluation frameworks and criteria. Studies in the Social strand, on the other hand, foreground parents' influence on children's reading of digital books, which includes parents' attitudes and preferences for children's reading materials as well as parent–child physical proximity during book reading.

Kang, Lu and Xu [15] focused on the environmental impacts of formats of reading. For Kang, Lu and Xu [15], using the systematic literature review methodology the scholars are able to synthesize and integrate the findings of the preceding comparative studies on print reading and on-screen reading. According

to the obtained results, the environmental impacts of printed and digital media is related to the usage rates and number of readers of both types of media, as well as user behaviors and other parameters. It is worth noting that digital reading also possesses its own negative environmental impacts. The main objective of that study was to clear the misconception and alter the popular stereotype that "e-reading is environmentally more sustainable than conventional reading," and to provide stakeholders with more valuable information that is necessary to make environmentally informed decisions.

## 3.    METHOD

The study method that we used for this systematic review evaluation is presented in this part. We chose to conduct our research around E-reading comprehension, and if it differs from paper reading, whether in a better or a worse way. We chose multiple indexes and searched them for related articles, eventually ending up with 14 articles that fell within our inclusion criteria which will be explained further on. Since the number of obtained articles was not large, we opted for the Systematic Literature Review method over the Systematic Mapping method. The articles were later analyzed thoroughly in order to answer the following questions:

1. Does reading comprehension change across media platforms?
2. Does reading from paper allow better comprehension when compared to e-reading?
3. Can e-reading substitute paper reading?
4. Which factors affect reading comprehension?

Our research questions try to uncover the truth in a not so consistent literature. E-reading has been developing quite rapidly over the years, as we previously covered in our Introduction section, thus things to be changing quickly and opinions seem to shift from time to time and based on different studies and approaches. We believe there is a difference when reading from different devices for E-reading, each offering different capabilities, advantages, and disadvantages, and thus comprehension levels may change along with it, and there is the standard idea that paper reading will always be superior and more preferred by the public than E-reading and which factors affect all this. The Idea of E-reading replacing standard paper reading has also crossed some people's minds, therefore we tried to see if we can find an answer to that hypothesis within the available research.

### 3.1. Article Selection

The papers reviewed in this study are extracted using three main indexes, namely, Scopus, IEEE Xplore and WoS. As a search string the keywords were e-reading and comprehension, which were combined using AND and OR operators. The search string was as below:

("e-reading *") AND ("paper*") AND ("reading*") AND ("comprehension*")

As it is known, in any Systematic Literature Review (SLR) study, it is an obligation to follow a systematic approach in finding, screening, eliminating, reading, and synthesizing the papers. Considering the fact that in any SLR research it is needed to screen and exclude or include relevant and irrelevant papers, in the present study following strategy on the basis of inclusion and exclusion was followed (See Figure 1).
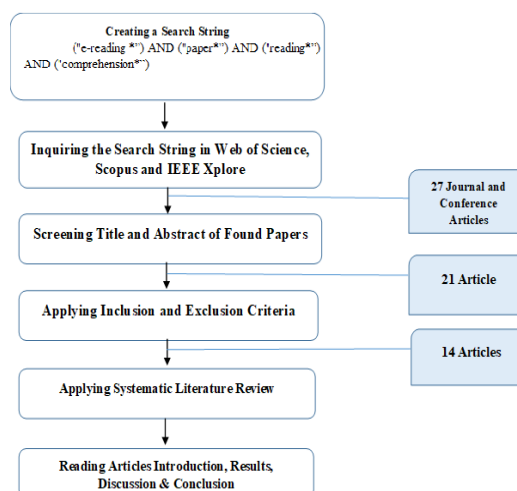


Figure 1. Systematic literature review steps used in this study

### 3.2. Inclusion Criteria

1. The papers published in year range between 2012-2022 were considered
2. Papers which clearly stated their objectives and methodology
3. Papers focusing on comprehension aspect
4. Papers of journals, proceedings were considered

### 3.3. Exclusion criteria

1. Non-English papers were eliminated
2. Duplicates were eliminated
3. Irrelevant papers considering their abstracts were eliminated
4. Papers which only their abstract was obtained

We choose the academic databases we wanted to look in after establishing our search string. Although we are aware that there may be additional databases containing comparable research that are not included in our selection, we only selected those databases that are focused on software engineering. However, it is difficult to avoid this, which is why we added three libraries:

IEEE Xplore (https://ieeexplore.ieee.org/)

Scopus (www.scopus.com)

Web of Science (www.webofscience.com)

In the initial search, 27 publications were found, however after applying the exclusion criteria mentioned above, the number was cut down to 14 articles, conference, or proceedings papers. Those were the ones that have been analyzed for our research.

## 4.    RESULTS AND DISCUSSION

In the present article, systematic literature review methodology was applied on 14 studies with main focus on comparing e-reading and paper reading in order to answer four main research questions encoded with RQ1, RQ2, RQ3 and RQ4, where RQ stands for Research Question. In what follows, it was endeavored to answer these questions after analyzing and synthesizing the results and conclusions sections of studies. Figure 2 present the yearly distribution and trendline of the  primary studies on e-reading and paper reading between the years 2012 throiugh 2022.
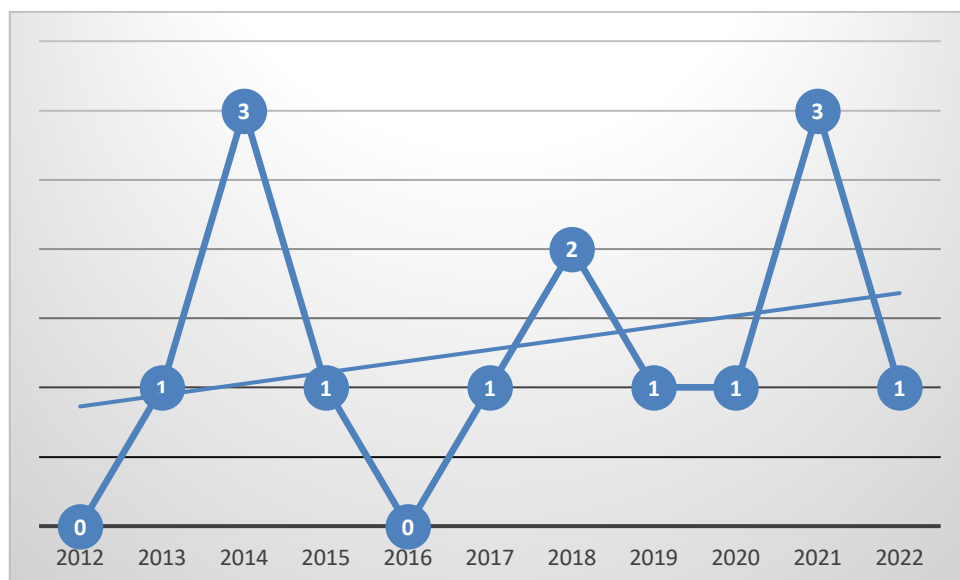


Figure 2. Year Distribution of Studies on E-learning and Paper Reading

### RQ1. Does reading comprehension change across media platforms?

In a study conducted by Kaban and Karadeniz [S2], it was observed that there is no significant difference between comprehension of reading  across media platforms, which is in line with findings of Liu, Xie and Johnson [S3] and Veras, Paluka, Chang, Tsang, Shein and Collins [S6]. For Miller and Warschauer, [S8], e-books that have narration and dictionary capabilities can lead to an increase in children's reading

comprehension. According to the findings, it can be suggested that online reading can provide multisensory reading experience, supporting comprehension and critical reading. The studies, including [S1], [S4], [S5], [S7], [S9], [S10], [S11], [S12], [S13] and [S14] have not provided any explicit justification for Research Question (Q1).

### RQ2. Does reading from paper allow better comprehension when compared to e-reading?

Regarding the question (Q2) "whether reading from paper allow better comprehension, compared to e-reading", the explicit answers are provided by studies, including [S2], [S3], [S5], [S7], [S8] and [S9]. In [S2], Kaban and Karadeniz showed that the students' scores were not higher on the assessments whether they read printed text or when they read digital text. Liue, Xie and Johnson [S3], construed that paper books were favored over e-books for the educational purposes. The participants indicated that in the tests on the basis of the e-reader, it was harder to recall the information they had obtained from that reading. In the case of reading for pleasure, e-books were okay, but in small amounts of reading. In [S5], the students reported lower levels when they read from an e-resource, due to a number of extraneous factors that were not part of the inherent nature of the e-reading activity. According to [S7], the students' reading rate, vocabulary and comprehension that were taught using Pamanpintermu e-reading had gained higher scores than those students who were taught using traditional reading. In [S8], there was no statistical and meaningful difference regarding comprehension scores between conditions; however, it took longer for children to read the e-books than the printed ones. Moreover, the results showed that the narration feature in the e-book significantly enhanced children's comprehension, and learning, media and teaching. The use of electronic dictionary was significantly higher than the printed one. Nikolakopoulos and Paraskeva [S9] obtained data providing significant evidence which showed that reading with a dedicated e-reader evoke new comprehension strategies clustered into the application of printed text comprehension strategies, encompassing a) selective reading b) self-regulating comprehension process. Regarding research question Q2, the studies including [S1], [S4], [S6], [S10], [S11], [S12], [S13] and [S14] has provided no explicit information.

### RQ 3. Can e-reading substitute paper reading?

The available literature between 2012-2022 years have not provided any explicit or implicit answer to a question that does e-reading possesses required features and properties to consider it as an substitution of paper reading? Therefore, maybe by expanding the query year, indexes and enhancing the search string, we can reach to the answer of this question.

### RQ 4. Which factors affect reading comprehension?

In answering the research question Q4 "what are the factors effective on reading comprehension", articles [S2], [S3], [S7], [S10] and [S11] have presented several factors. For instance, Kaban and Karadeniz point out that factors, such as story elements, characters analysis, main idea and details, problems and solution are effective on the comprehension of the study subjects [S2]. Liu, Xie and Johnson [S3] proclaimed that factors like eyestrain, headaches, distract, mentally mapping, Available or portable, Eco-friendly, Font size, Tool media, reading program, convenience, compatibility, Media richness, Licensing issues, Graphic display capabilities, Reading task and Reading techniques are also among the factors affecting reading comprehension. In [S7], Arifani showed that eye strain and time constraint can have an impact on reading comprehension. Wang and Gan [S10] found that gender, Age, Pleasure, Motivation, challenge, involvement, curiosity, competition, recognition, social aspects, compliance, and grades are among the facts effective on comprehension. Vichedcova [S11] concluded that personal relationship to books, the area of readership, reading experience, context of the school, and their influence on the level of pupils' reading strategies, the area of school context constraints, reader comfort and mental values have an impact on the comprehension of the readers (See Table 1).

| Study | Factors |
|---|---|
| [S2] | Story elements, Characters analysis, Main idea and details, Problems and solution |
| [S3] | Eyestrain, Headaches, Distraction, Mentally mapping, Availability, Portability, Eco-friendly, Font size, Tools, Reading program, Convenience, Compatibility, Media richness, Licensing issues, Graphic display capabilities, Reading task and Reading techniques |
| [S7] | Eye strain, Time constraint |
| [S10] | Gender, Age, Pleasure, Motivation, Challenge, Involvement, Curiosity, Competition, Recognition, Social aspects, Compliance, Grades, |

| [S11] | Personal relationship, Readership, Reading experience, Context area of school, Context constraints, Reader comfort, Mental values |
|---|---|

Table 1: Factors effective on reading comprehension

In the present article, it was shown that there numerous factors effective on reading comprehension which is in line with those factors identified by Çetin and Ferit Kılıçkaya [11]. Indeed, they believe that comprehension and retention are not full addressed by the preceding studies, but they demonstrated that factors like text length and reader's familiarity with reading on screen are among the factors which have the most interest among scholars. Fontaine, Lapierre and Lordkipanidz [16] reviewed the available literature on the topic of e-reading and paper reading, but they aimed at identifying, assessing, and synthesizing the evidence regarding the impact of the reading medium on the comprehension in the context of HPE. They concluded that students reading paper-based HPE resources and texts showed better reading comprehension than the students who read digital-based HPE text. It was inferred that there is little to no difference among the student's comprehension reading HPE texts on hardcopies vs. digitally. Meanwhile, it was observed that student's paper-based reading was preferable when the topic is related to their professional discipline, which are in line with findings of the studies reviewed in the present research, including [S2], [S3] and [S6]. In another study conducted by Kucirkova [13], it was shown that studies conducted in the material strand of literature either conduct comparative experiments with digital books and other reading formats, such as print books versus flat e-books, or they focus on both the content and format of digital books to develop evaluation frameworks and criteria, while among the studies reviewed in these papers, there was no study with such considerations and results. Kang, Lu and Xu [15] scrutinized the environmental impacts of printed and digital media, and this factor was also identified by [S3] as an effective factors in reading comprehension.

## 5.   CONCLUSION

In this paper, it was sought to find evidence and concrete results from papers published between 2012-2022 in answering questions with focus on comprehension variation across reading mediums, better comprehension in e-reading or paper reading, e-reading as a substitution of paper reading and the factors effective on reading comprehension. In this regard, the factors like story elements, characters analysis, main idea and details, problems and solution, eyestrain, headaches, distract, mentally mapping, available or portable, eco-friendly, font size, tool media, reading program, convenience, compatibility, Media richness, Licensing issues, Graphic display capabilities, Reading task and reading techniques, eye strain, time constraint, gender, age, pleasure motivation, challenge, involvement, curiosity, competition, recognition, social aspects, compliance, grades, personal relationship, readership, reading experience, context area of school, context constraints, reader comfort and mental values are effective on reading comprehension and other interesting findings and observations could be summarized as below

1) There is no significant difference between comprehension of reading across media platforms.
2) e-books that have narration and dictionary capabilities can lead to an increase in children's reading comprehension.
3) Online reading can provide multisensory reading experience, supporting comprehension and critical reading.
4) If the subject studies, are students, their scores were not higher on the assessments whether they read printed text or when they read digital text.
5) In the tests on the basis of the e-reader, it was harder to recall the information.
6) In the case of reading for pleasure, e-books were okay, but merely in small amounts of reading.
7) the students' reading rate, vocabulary and comprehension that were taught using Pamanpintermu e-reading had gained higher scores.
8) There was no statistical and meaningful difference regarding comprehension scores between conditions.
9) The narration feature in the e-book significantly enhanced children's comprehension, and learning, media, and teaching.
10) The use of electronic dictionary was significantly higher than the printed one.
11) Reading with a dedicated e-reader evoke new comprehension strategies clustered into the application of printed text comprehension strategies.

In answering research question RQ3, it was observed neither implicit nor explicit answer was provided by the reviewed studies, which signals the necessity for further research. Moreover, prospective studies can be focused on exam results of university students who read e-books and paper resources.

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## APPENDEX A

List of Primary Studies which were included in the systematic literature review:

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