| **RESEARCH ARTICLE**

The Impact of Reading Medium on the Comprehension and Judgment of Performance of Moroccan EFL Readers

Maryem Larhmaid
Faculty of Education, Department of Foreign Languages, Madinat Al Irfane, B.P. 6211 Mohammed V University in Rabat, Morocco.
Corresponding Author: Maryem Larhmaid, **E-mail**: mlarhmaid@yahoo.fr

| **ABSTRACT**

Technology use in Moroccan higher education classrooms is growing at an exponential rate. However, current knowledge about the pedagogical effectiveness of Information Communication Technology (ICT) usage for reading and self-efficacy beliefs of Moroccan EFL readers is inconclusive. The main purpose of the present study was to examine the impact of reading texts on paper versus on-screen on reading comprehension and judgment of performance, while controlling for relevant individual difference variables. In a between-subjects design, three groups of first-year university students (*N* = 83) read an expository text on a sheet of paper versus on a laptop. Before reading, topic knowledge was assessed. After reading, participants were asked to answer three open-ended questions (main idea, key points, and other relevant ideas) and one closed-ended question (true-false). Next, based on the medium used for reading, participants were asked to rate how confident they were that the answers they provided were correct. Results of the *t*-test showed that reading medium did not affect overall reading comprehension, but slight differences between groups emerged. Calculated means indicated that participants who read on paper scored somewhat better on the main idea and other-relevant ideas questions; whereas, participants who read on-screen scored a little bit better on the key points and true-false questions. Moreover, results suggested no influence of the reading medium on students' post-task judgments, indicating that participants who read on-screen were about as accurate in judging their comprehension performance as those who read on paper. These results suggest that reading short factual texts on the screen has no detrimental effects on the cognitive and metacognitive abilities of EFL readers.

1. Introduction

For centuries, reading was conducted merely via the medium of print (Ross et al., 2017; Pardede, 2019; Baron, 2021). Nonetheless, with the introduction of the Internet in the late 1990s and the widespread use of electronic devices at the beginning of the 2000s, the notion of reading has undergone a considerable shift. The shift involved a transition from reading on paper to reading on-screen. In today's learning contexts, reading digital-based materials has become increasingly prevalent among students of different educational levels and backgrounds. Numerous digital text formats, such as Microsoft Word documents and PDF files, have appeared to provide web users (or readers) with different options and preferences for reading. While these formats offer various opportunities for text-based learning, they may also bring some unforeseen challenges for readers who lack the fundamental skills to deal with the demands of cyberspace (Afflerbach & Cho, 2009; Eshet-Alkalai & Chajut, 2010).

Perhaps one of the leading countries in the digitalization of content materials is the United States, as evident from the extensive use of electronic textbooks in elementary, secondary, and higher education classrooms (Wells, 2012; Baron, 2021). In the same vein, recent statistics about the use of Information Communication Technology (ICT henceforth) rank Morocco among the top North African countries in the adoption of digital technologies. According to a recent report by digital Morocco, the vast majority

of Moroccans (nearly 89%) own a digital device (e.g., smartphones, laptops, desktops computers, tablets), and around 74.4% of the overall population have access to the Internet and spend around 3h56m[1] using mobile Internet daily (Kemp, 2022; Hafa & Moubtassime, 2021).

In academia, the Moroccan Ministry of Education has been engaged in promoting ICT-based instruction by launching several programs and initiatives that aim to connect all students, staff, and classrooms with Internet access, digital devices, and educational content. Some of these programs are INJAZ, Lawhati, and Morocco Digital University. Firstly, INJAZ (INJAZ Al-Maghreb) was a program that gave university students access to computers and handheld devices at preferential prices. The program was implemented over five academic years from 2009 to 2014. Secondly, Lawhati (my tablet) was launched in 2015 and aimed to provide university staff and students with a '2 in 1 tablet', equipped with integrated educational content at profitable rates. Thirdly, Morocco Digital University (MUN) was launched in 2019 and aimed to solve issues related to overcrowding in Moroccan universities (Ennaji, 2019).

This move toward ICT-based instruction in higher education is, however, faced with relatively little research about the educational effectiveness of digital reading, especially in one-to-one comparison with print reading. Over the past years, much of the research in the area of paper vs. screen reading has included students from postindustrial countries with widely different socioeconomic developments and educational systems (e.g. US, Norway, Sweden; Singer & Alexander, 2017; Mangen et al., 2013; Rasmusson, 2015); while, research studies involving students from developing countries are scarce. This calls for a comprehensive and up-to-date investigation about the impact of new technologies not only on subjective measures such as how students perceive their reading and learning across digital devices, but also on objective measures such as what effects these devices have on students' reading comprehension and overall performance. This research is particularly needed because of emerging concerns about the potential negative effects of digital reading when compared with print reading (Clinton, 2019; Delgado et al., 2018; Baron, 2021). To guide this research, two major questions are addressed:

- RQ1. Does the medium of reading (paper vs. screen) affect the reading comprehension of Moroccan EFL readers?

- RQ2. Does the medium of reading (paper vs. screen) influence the judgment of performance of Moroccan EFL readers?

2. Literature Review
This section (1) defines key concepts relevant to understanding the topic, (2) provides the theoretical basis for the study, and (3) reviews the relevant literature.

2.1. Terminology
This study defines and approaches reading comprehension and judgment of performance as follows.

The term *reading comprehension* is perceived as the ability to understand and interpret the meaning of a text across print and digital media. For this matter, students need to be (a) able to comprehend the main idea of the text accurately, (b) connect what they read to what they already know, (c) recall the major points of the text, and (d) consider what they read in-depth (Snow, 2002; RAND Reading Study Group, 2002).

The term *judgment of performance* is used to refer to how well students evaluate and assess their performance on a comprehension test (Dunlosky & Lipko, 2007; Wiley et al., 2016; Halamish & Elbaz, 2020). Simply put, judgment of performance is the reader's ability to determine the extent to which they comprehended text materials.

Based on the above, it is noteworthy that this research focuses on academic reading that comes from reading school-related academic materials in an EFL context[2], and not on reading that comes from scanning and skimming data from newspapers, magazine headlines, or social media writing snippets. In this respect, this research uses the term 'print reading' or 'reading' to refer to the process of constructing meaning using print texts (i.e., paper); whereas, the terms 'digital reading', 'screen reading', or 'electronic reading' are used interchangeably to refer to the ability to read and construct meaning from texts displayed on digital screens, including desktop computers/laptops, Kindles, smartphones, iPads, and tablets. Such conceptions of reading underpin the inquiry into how the medium used for reading may affect the reading comprehension and judgment of performance of Moroccan EFL university students.

---

[1] This includes using the Internet for leisure reading and entertainment (e.g., social media, a casual reading of news headlines, blogging, video viewing, chatting, etc.).
[2] An EFL context is defined as one where English is not the primary language of the society in which the language is being studied.

2.2. Theoretical framework

The theoretical basis for this study on reading comprehension is found within schema theory. Schema theory views the reader's prior knowledge as of paramount importance to the construction of meaning (Rumelhart, 1980). According to schema theory, efficient reading comprehension requires the ability to match the information found in the text with knowledge stored in the reader's long-term memory (Duffy & Israel, 2009; Goldman, 2015). Put differently, the reader constructs the meaning of a text based on both the knowledge they bring to the act of reading and text characteristics.

In traditional print reading, the reader often interacts with a text that lacks the needed tools to recognize the meaning of unknown words and concepts. Such a lack of tools in the print environment may challenge the reader's ability to construct meaning, which may present an obstacle to reading comprehension. In digital reading, however, the reader can determine the meaning of unfamiliar vocabulary terms using linked dictionaries or thesauruses. This means that digital devices with an Internet connection offer the reader the opportunity to search for key concepts or terms, improving pre-existing knowledge and topic familiarity; and as such, expanding schemata.

What is more interesting is that traditional models of reading comprehension (RAND Reading Study Group, 2002; Snow, 2002) have mainly focused on how characteristics of the reader, the text, and the task may influence reading comprehension, while characteristics of the text display, such as font type, size, line spacing, and screen resolution, have been neglected. Thus, it is critical to examine if the medium used for reading (paper vs. screen) has any effect on reading comprehension.

Another related issue is whether the medium used for reading affects metacognition. Metacognition is usually defined as "thinking about thinking" (Flavell, 1979; Brown, 1987). It is the knowledge of the reader's cognition and self-monitoring strategies they exercise when reading a text. Within the framework of metacognition, this study uses calibration of performance as a paradigm of metacognitive regulation to explain students' self-assessment judgments regarding their comprehension across print and digital texts.

In reading research, calibration of performance refers to the correlation between test postdiction (i.e., understanding level) and test performance (Thomas & McDaniel, 2007; Wiley, Griffin, & Thiede, 2005). In this paradigm, students are often required to read a text, answer questions related to the text, and then judge how sure they are about the accuracy of their answers. Therefore, given the fundamental role of metacognition in reading comprehension, it is necessary to examine if it is affected by the reading medium.

2.3. Background research

In recent years, research about the effects of screen technologies vs. traditional print on cognitive and metacognitive aspects of reading has reported mixed results (Ronconi et al., 2022; Ben-Yehudah & Eshet-Alkalai, 2018; Kong et al., 2018). Some studies have pointed to the advantages of print reading over digital reading, for both comprehension assessment and metacognition (Singer & Alexander, 2017; Mangen et al., 2013; Rasmusson, 2015; Halamish & Elbaz, 2020).

In a prominent study, Singer and Alexander (2017) investigated university students' reading performance and calibration across print and digital texts. The results showed that reading comprehension performance was significantly higher in print texts. However, the prediction of performance (i.e., calibration) was consistently better in the digital text. Likewise, Chen et al. (2014) examined differences between shallow (i.e., multiple-choice questions) and deep (i.e., summarization questions) comprehension among 90 university students who read from computer displays and paper. The results showed that the paper-based group outperformed the computer-based group, but only on the shallow comprehension questions. In another study, Ackerman & Lauterman (2012) compared paper versus screen reading among undergraduate students and found that print reading was more efficient for learning and self-assessment of knowledge.

Several other studies, though, have demonstrated no effects of digital media on performance or a benefit of screen reading over print reading (Sackstein et al., 2015; Dennis et al., 2016; Chen & Catrambone, 2015). Sackstein et al. (2015), for instance, conducted a quasi-experimental study with 68 students from diverse South African high schools and universities to analyze the influence of paper and tablet use on reading comprehension. Sackstein et al. (2015) found that, while reading comprehension test scores did not differ significantly between paper and tablets, the majority of students read faster on-screen than on paper. Based on these findings, Sackstein and colleagues concluded that reading on-screen was "suitable" for academic reading and learning.

Overall, in most studies, reading on paper was found to be more efficient than reading on-screen, and readers tended to be more biased, i.e., overestimate their performance, when reading digitally than when reading in print (Singer & Alexander, 2017; Baron, 2015; Halamish & Elbaz, 2020).

Having examined the literature around the topic of this study, it seems that the effectiveness of print versus digital technologies as tools for reading and learning is still an ongoing subject of study that necessitates further research. For this matter, the following two research hypotheses were derived:

- H_{01}. Students who read on paper versus those who read on-screen will display statistically significant differences in reading comprehension.

- H_{02}. Students' reading medium (paper vs. screen) will correlate with their judgment of performance.

3. Methodology

This section outlines and describes the various procedures and statistical tests used to collect and analyze data. This includes a detailed description of the research design, setting, sample, and participants.

3.1. Research design

This study opted for a field quasi-experimental design to gather data. This design was followed as students were tested in their natural school setting and not in a laboratory environment. Although quasi-experimental research has several shortcomings such as threats to internal validity[3] due to the lack of subjects' randomization to control and experimental groups, it does allow researchers to reach insightful conclusions. To increase the internal validity of the study, a between-subjects design was adopted as it minimizes the learning effect between groups. The central aim of this approach was to measure the effect of the independent treatment variable (reading medium) on two outcome measures (reading comprehension and judgment of performance). To that end, it was ensured that each group of participants (control and experimental) was experiencing reading the text in only one condition (reading on paper or on-screen).

Furthermore, to ensure that they belonged to similar groups, participants from the same university (liberal arts university), same class (Arabic language and literature class), and same educational level (freshmen) were selected. This means that participants were of similar age (17 to 20 years old), and had similar teaching and learning styles (student-centered learning approach). These procedures were carried out to hopefully eliminate any potential effects that may have been caused by a confounding variable[4].

3.2. Setting and participants of the study

The present study was conducted in a typical classroom setting in the fall semester of the 2020/2021 academic year. Participants were 90 undergraduate students (freshmen) who were taking an Arabic language and literature class to fulfill course credits. However, the data of seven (7) participants were discarded because their answer sheets had missing data. This means that data from 83 students were finally retained for analysis. The sample size included an experimental group of 44 participants and a control group of 39 participants. The age range of all participants was between 17 and 20 years old. Statistically speaking, the sample was 56.6% female with a mean age of 17.88 (standard deviation = 0.688) years.

Participants represented a wide range of majors, primarily in Business Administration (56.7%) and Computer Science (15.7%). Additional majors included Engineering and Management Science (8.4%), General Engineering (7.2%), International Relations (6%), Big Data Analytics (2.4%), Communication Studies (2.4%), and Environmental Science (1.2%). All of the 83 participants had normal or corrected to normal vision, were native speakers of Moroccan Arabic, and possessed varying levels of English proficiency—ranged from intermediate to upper-intermediate levels as reported by the university's English class placement test scores, i.e., TOEFL iBT® scores—reading ability, and technology exposure. A summary of the demographic characteristics of the sample is presented in Table 1.

---

[3] Internal validity is the extent to which a study establishes a cause-and-effect relationship between a treatment and an outcome.

[4] A confounding variable is an unmeasured third variable that may influence both the independent variable and the dependent variable.

Table 1. Sample characteristics

Participants	N (83)	% (100)
Field of study		
▪ Business Administration	47	56.7
▪ Computer Science	13	15.7
▪ Engineering and Management Science	7	8.4
▪ General Engineering	6	7.2
▪ International Relations	5	6.0
▪ Big Data Analytics	2	2.4
▪ Communication Studies	2	2.4
▪ Environmental Science	1	1.2
Age range		
▪ 17-18	72	86.7
▪ 19-20	11	13.3
Gender		
▪ Male	36	43.4
▪ Female	47	56.6
Group assignment		
▪ Control group	39	47
▪ Experimental group	44	53

The decision to focus on undergraduate students was based on two primary factors related to the existing literature and accessibility. The first factor is that today's university students comprise one of the largest groups who often spend a considerable amount of time reading for academic purposes—making understanding their varied reading experiences particularly important and relevant to policy (Lai & Chang, 2011; Goodwin et al., 2020). What is more, this category of students generally embraces technology and, therefore, possesses a set of skills that enable them to cope with reading in the digital environment as well as in the print environment.

The second factor was the fact that this research was conducted during a health crisis (COVID-19), a period where the majority of the Moroccan educational institutions transitioned to distance learning to limit the spread of the virus. Based on this and given the circumstances of COVID-19 (social distancing), conducting a test that included more than 15 students in each class was very challenging. However, with the coordination and support of a professor from the target university, the researcher was granted access to the research site and managed to conduct the test.

3.3. Testing materials

The text. Reading comprehension was assessed using an expository text. The topic of the text was *Coronaviruses* and particularly *Coronavirus 2019* (COVID-19). This topic area was chosen because it was a hot topic in 2020 that had a tremendous impact on the lives of students and their learning environment, as evident from the transition to distance learning instead of in-person learning. For this reason, the researcher thought that the topic would presumably be of interest to the sample and, therefore, they would have a fair knowledge of it.

The reading text was sourced from a reliable and credible source called "my English pages website"[5], which creates practice reading materials and resources for ESL and EFL students. To determine the appropriate readability of the text, the Flesh-Kincaid tests[6] (the Flesh Reading Ease test indicates the level of difficulty of a reading text, and the Flesh-Kincaid Grade Level Test measures the grade level at which the text would be understandable) were used (Burke & Greenberg, 2010).

Display characteristics. The reading passage was presented to the participants with a different mode of delivery. One group read from a sheet of paper and the other group read from the laptop. For the paper condition, the passage was printed on A4 paper (210 x 297 mm). For the laptop condition, the same passage was presented as a PDF file with Adobe Reader for Windows. The laptop display for the majority of the participants was a 15 ''LCD monitor at a resolution of 1280 x 1024 pixels. To eliminate further confounding variables, both the screen and paper-based texts were presented in identical ways, with the same page layout (A4)

---

[5] https://www.myenglishpages.com/site_php_files/reading-coronavirus.php
[6] Please note that the Flesh Kincaid Reading Ease and Flesh-Kincaid Grade Level scores were calculated using an online calculator that is accessed via the following link. https://goodcalculators.com/flesch-kincaid-calculator/

including font type (Times New Roman), size (12), and line spacing (1.5 pt.). It was also ensured that the text in the two formats was of similar length (approximately 583 words) and readability (approximately college level, with a reading ease score of 49.5).

3.4. Procedures of data collection

The procedure of data collection was completed through two sessions. Each session took approximately 30 minutes (60 minutes in total). In the first session, all participants were asked to complete a questionnaire that included two sections: (a) demographic information, and (b) an assessment of prior knowledge. In the demographic section, participants had to report their age, gender, level of study, and field of study. In the prior knowledge section, participants had to assess their background knowledge on the topic of Coronavirus-19.

In the second session, the sample was randomly divided into an experimental group and a control group by seating arrangements. The experimental group was tested using digital media (laptop) and the control group was tested using print media (paper sheet). All participants were asked to read the text carefully as they were not allowed to use the text when answering the comprehension questions. After both groups (experimental and control) indicated that they have finished reading the passage, participants in the paper group were asked to hand over the text, and similarly, participants in the digital group were asked to shut down their laptops.

Next, the reading task was handed to the participants in print format, and they were instructed to finish the task with pen/pencil and paper. The reading task had participants respond to three open-ended questions (main idea, key points, and other-relevant ideas) and one closed-ended question (true-false). In the end, participants were asked to judge their comprehension performance based on the medium they used to read the text. The choice of using short-construction and true-false questions in the assessment of reading comprehension was made because of their practicality (i.e., they are easy to grade) and ability to generate a larger sampling of content.

This study has catered to several ethical considerations. Three weeks before the day of the test, an informed consent form was sent (via email) to the participants. The informed consent form described and explained the nature of the test as well as its procedures. This means that participants were informed that participation in the study was voluntary and that all information gathered from the test would be used only for academic purposes. Once the researcher was onsite, all participants were briefed on what they would be doing and provided the opportunity to ask questions, as well as the possibility to withdraw from participating in the study at any time and without consequences. Moreover, to ensure the anonymity and privacy of the participants, no personally identifiable data were gathered or maintained, and all individual responses were treated and coded as group data to make identifying participants impossible.

3.5. Measures

Prior knowledge. Topic knowledge was assessed based on three response items: (a) no knowledge, (b) fair knowledge, and (c) expert. Level of topic familiarity was determined by calculating the frequency at which participants selected each item.

Reading comprehension: Questions and scoring[7]. Reading comprehension was rated on an overall score of 20 points. Scoring measures for each of the comprehension questions were as follows. The main idea question was scored on a 4-point scale. A score of 0 was given if the student wrote nothing or had a main idea that was different from the one expressed by the text. A score of 1 point was given if the student provided an uncomprehensive answer or if the answer given was simply "Coronaviruses" or "COVID-19". A score of 2 points was given if the student mentioned an idea that is relevant but not fully expressed such as "the text is about coronavirus and its symptoms". To earn 4 points, participants had to provide a clear, accurate, and comprehensive response.

Questions about key points and relevant ideas were scored on a 6-point scale. This scale allowed participants in both groups to earn one point for each key point listed and to earn one point for each relevant idea listed. All responses had to be text-related and comprehensive. The true-false question was scored on a 4-point scale. This question had four statements and each statement was scored 0–1 point. A score of 0 was given if the student answered the statement incorrectly, and a score of 1 point was awarded if the student answered the statement correctly. This means that participants could earn up to 4 points for the true-false question if they answered all the statements correctly. For the sake of concreteness, Table 2 provides the scoring rubric that was used to grade participants' responses.

---

[7] It should be noted that the scoring scale for the reading comprehension test was constructed using the researcher's own scoring rubric and student responses. The scoring rubric indicates what knowledge and skills students must demonstrate in order to earn each score point.

Table 2. The scoring rubric

Question type	Score
Main idea	
▪ Does not answer the question	0
▪ Provides an uncomprehensive answer	1
▪ Mentions an idea that is relevant but not fully expressed	2
▪ Provides a clear, accurate, and comprehensive response	4
Key points	
▪ Mentions one key point	1
▪ Mentions two key points	2
▪ Mentions three key points	3
▪ Mentions four key points	4
▪ Mentions five key points	5
▪ Mentions six key points	6
Other relevant ideas	
▪ Mentions one relevant idea	1
▪ Mentions two relevant ideas	2
▪ Mentions three relevant ideas	3
▪ Mentions four relevant ideas	4
▪ Mentions five relevant ideas	5
▪ Mentions six relevant ideas	6
True-false	
▪ Each statement was answered incorrectly	0
▪ Each statement was answered correctly	1
▪ All statements were answered correctly	4
Overall reading comprehension	20

Judgment of performance. After they read and answered the comprehension questions, participants were asked to judge their comprehension performance depending on the medium they used to read the text. More specifically, students were asked *"Do you believe you performed well in the reading comprehension test using the digital (or print) text?"* To answer this question, two options were provided, (a) *Yes, I believe so*, and (b) *No, I do not believe so*. Level of judgment of performance was assessed for both groups (experimental and control) by calculating the frequency at which they selected each item.

3.6. Data analysis

To determine whether students' reading comprehension differed due to the reading medium, descriptive (i.e., mean, standard deviation) and inferential statistics (i.e., an independent samples *t*-test) were performed. The independent samples *t*-test was used to evaluate the following alternative hypothesis: *students who read on paper versus those who read on-screen will display statistically significant differences in reading comprehension*. This statistical test was chosen because this research was testing a hypothesis of differences with one independent variable (reading medium) and one dependent variable (reading comprehension) with no covariates (Ary et al., 2010). The effect size was calculated using the results from the *t*-test and interpreted using Cohen's *d* (1988). A value of *d* = 0.20 is considered to be a small effect, *d* = 0.50 a medium effect, and *d* = 0.80 a larger effect.

To establish whether there was a possible correlation between reading medium and judgment of performance, the chi-square test of independence was used. The goal was to assess the following alternative hypothesis: *students' reading medium (paper vs. screen) will correlate with their judgment of performance*. The Effect size for the chi-square test of independence is reported using the phi-coefficient test. A value of ϕ = 0 indicates no relationship, ϕ = 1 a perfect positive relationship, and ϕ = -1 a positive-negative relationship. A p < .05 level of significance was used for all analyses in this study to determine if the alternative hypotheses could be supported. The IBM Statistical Package for the Social Sciences (SPSS, version 20.0) was used to analyze the data.

4. Results

This section presents the major findings and results from the quasi-experimental test. The results are reported following the research questions listed earlier in the introduction.

4.1. Assessment of topic knowledge

The first step in answering the research questions was to assess prior knowledge (or topic familiarity). Preliminary data analysis showed that the majority of participants had a "fair knowledge" of the topic of Coronaviruses (COVID-19); whereas, 7.2% of the participants had "no knowledge". The remaining 3.6% reported that they had "expert knowledge". These results suggested that participants of this study were quite knowledgeable about the topic of the passage. For a better illustration, please see Figure 1.
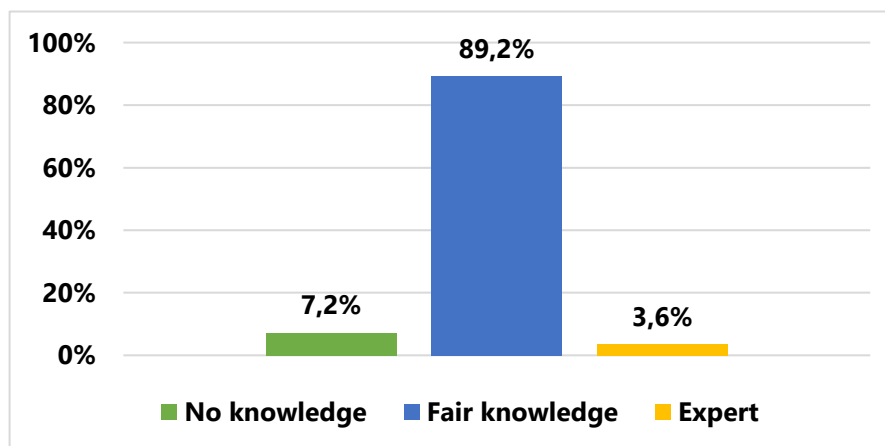

Figure 1. Level of topic familiarity

4.2. Effect of reading medium on the comprehension of EFL readers (RQ1)

To investigate whether there was a statistically significant difference in reading comprehension between the experimental and control groups as measured using raw scores from the comprehension test, descriptive (mean, standard deviation) and inferential (t-test) statistics were used. The main objective is to answer the following research question: *Does the medium of reading (*paper vs. screen*) affect the reading comprehension of Moroccan EFL readers?*

Table 3. Statistics of comprehension test scores by reading medium (*N* = 83)

Comprehension	Reading Medium	N	M	SD	t	Sig. (2-tailed)	Cohen's d
Overall	Screen	44	10.40	3.68	0.26	0.79	-0.05
	Paper	39	10.61	3.52			
Main idea	Screen	44	2.14	1.23	0.98	0.32	-0.21
	Paper	39	2.38	1.04			
Key points	Screen	44	2.77	1.59	0.40	0.68	0.09
	Paper	39	2.64	1.30			
Other relevant ideas	Screen	44	2.05	1.68	0.65	0.51	-0.14
	Paper	39	2.28	1.60			
True-false	Screen	44	3.45	0.62	0.91	0.36	0.19
	Paper	39	3.31	0.83			

As shown in Table 3, the mean scores for the experimental group (screen) and the control group (paper) on the assessment of overall reading comprehension are 10.40 and 10.61 respectively. These statistics suggest that participants who read on paper performed slightly better than their counterparts who read on-screen. However, the results of the t-test indicate that there are no statistically significant differences in the overall reading comprehension between the experimental group and the control group, $t(81) = .26$, $p = .79 > .05$. Further, Cohen's effect size value ($d = -0.05$) suggest low practical significance.

To determine whether there is a possible statistically significant difference in comprehension by question type and reading medium, an independent samples t-test was run. The results of data analysis show that the average score of the experimental group on the main idea question is 2.14 ($SD = 1.23$), compared to the control group whose average score is 2.38 ($SD = 1.04$). Calculated means for both groups indicate that there is a slight difference between the experimental and control groups on the main idea, but is it statistically significant? The t-test for equality of means outcome indicates that the significance value is 0.32.

According to these results, there is no main effect of the reading medium (i.e., paper or screen) on the main idea question, $t(81)$ = .98, p = .32 > .05, d = -0.21.

By the same token, the results show that while calculated means for the experimental group (M = 2.77, SD = 1.59) scored a little bit better than the control group (M = 2.64, SD = 1.30) on the key-points question, the t-test outcome indicates that there is no main effect of reading medium on the key-points question, $t(81)$ = -.40, p = .68 > .05, d = 0.09.

For the impact of the reading medium on the other-relevant ideas question, results of the *t*-test show that there is no statistically significant difference between the experimental group (M = 2.05, SD = 1.68) and the control group *(M = 2.28, SD =1.60)*, $t(81)$ = .65, p = .51 > .05, d = -0.14.

Finally, for the impact of reading medium on the true-false question, the *t*-test was run, revealing no statistically significant difference between the experimental group *(M = 3.45, SD = 0.62)* and control group *(M = 3.31, SD = 0.83)*, $t(81)$ = -.91, p = .36 > .05, d = 0.19. These statistics suggest, therefore, that the alternative hypothesis is not supported.

4.3. Effect of reading medium on the judgment of performance of EFL readers (RQ2)

To examine if reading medium influences students' ability to judge their comprehension performance, frequency statistics and the chi-square test of independence were used. Frequency statistics were used to describe the extent to which students in the experimental group and control group believed that they performed well in the reading comprehension test. The chi-square test of independence was used to investigate whether there is a statistically significant relationship between the use of digital or print texts and students' judgment of performance. The prime goal is to answer the following research question: *Does the medium of reading (*paper vs. screen*) influence the judgment of performance of Moroccan EFL readers?*

Table 4. Frequencies of the judgment of performance by reading medium (N = 83)

Reading Medium	Judgment of Performance	
	Yes, I believe so	No, I do not believe so
Screen	37 (84.1%)	7 (15.9%)
Paper	34 (87.2%)	5 (12.8%)
Total	71 (85.5%)	12 (14.5%)

According to the frequency statistics shown in Table 4, the majority of the participants in the experimental group (84.1%) and control group (87.2%) believed that they did well in the comprehension test to a greater extent, compared to a few participants in the experimental group (15.9%) and control group (12.8%) who did not believe so.

Table 5. Results of the chi-Square test of independence

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,159[a]	1	,690		
Continuity Correction[b]	,008	1	,931		
Likelihood Ratio	,160	1	,689		
Fisher's Exact Test				,762	,468
Linear-by-Linear Association	,158	1	,691		
N of Valid Cases	83				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 5,64.
b. Computed only for a 2x2 table

To see if there is a significant relationship between reading medium and judgment of performance, the chi-square test of independence was used. According to the chi-square test output (see Table 5), there is no correlation between reading medium and judgment of performance X^2 (1, N = 83) = .15, p = .69 > .05, ϕ = -0.04. In other words, the results of the correlation analysis indicate that participants who used the digital text in their reading were about as accurate in judging their comprehension performance as those who used the print text. The alternative hypothesis is, then, unsupported.

5. Discussion

The results of the present study suggest that reading short informational texts on the screen does not impair reading comprehension and judgment of performance of EFL students. These results are consistent with previous research studies, which

have demonstrated that differences in reading comprehension between print and digital texts are diminishing. For instance, in a study by Margolin et al. (2013), EFL undergraduate students were assigned to one of three reading conditions; i.e., paper, laptop, and e-reader. The results yielded that different presentation modes did not affect reading comprehension. Similarly, Goodwin et al. (2020) explored digital and paper reading processes and outcomes for 371 fifth to eighth-graders completing a reading task similar to standardized testing. The findings indicated that while participants highlighted and annotated more when reading in the paper text, their reading comprehension level was quite similar across print and digital texts.

Three possible reasons may explain why participants had equivalent reading comprehension levels across print and digital texts. The first reason is familiarity with the topic of the text. Topic familiarity is a key factor of success in reading comprehension tests (Nassaji, 2002; Pulido, 2007). In simple terms, students who have relevant background knowledge about the topic of the text are more likely to succeed in reading comprehension assessments than those who have insufficient background knowledge. To account for this, prior knowledge was assessed before administering the reading comprehension task. The results showed that the majority of the participants had sufficient knowledge about the topic of the text. Unsurprisingly, participants were expected to have adequate knowledge about the topic (COVID-19) since it was a topic of interest to most people around the world, including Morocco, in 2020.

The second reason is exposure to technology. It is plausible that participants were experienced in using electronic devices for reading purposes. Such an experience helped them to read and answer the questions correctly and efficiently. Prior studies have also postulated that students who are surrounded by digital technologies earlier in life are expected to achieve equivalent, or perhaps even better, comprehension performance in digital-based reading compared to paper-based reading (ASHA, 2015; Childwise, 2017; Delgado et al., 2018).

The third reason is developments in screen technology. It is conceivable that recent display technologies have addressed the issues of eyestrain and discomfort with online reading by improving the resolution of screen devices. Numerous display devices, such as the iPad Pro, Mac Pro, and Samsung's new tablets (e.g., Galaxy Tab A8) to name just a few, have seen modifications and improvements in terms of screen resolutions (e.g., Retina displays). These improvements were introduced so that the display of digital content would not be hurtful to the eye (Nielson, 2012; Rosenfield, 2016; Lynch, 2018). The main goal was to provide the reader with an enjoyable, satisfactory, and user-friendly reading experience. All things considered, it appears that recent advancements in screen technologies, topic familiarity, and prior experience with electronic devices have minimized the differences between print and digital reading.

Beyond the assessment of reading comprehension, it was hypothesized that students who read on paper versus those who read on-screen would display statistically significant differences in judgment of performance. Data analysis, however, did not support such a hypothesis as students who used the digital text were about as accurate in judging their comprehension performance as those who used the print text. For this research, judgment of performance was assessed as students' post-task predictions regarding their performance on a comprehension test on paper versus on-screen and then compared those post-task predictions with their actual comprehension performance (Thomas & McDaniel, 2007).

The results are inconsistent with previous studies in which undergraduate students were found to be not particularly accurate in judging their comprehension performance under print and digital media (Singer & Alexander, 2017; Halamish & Elbaz, 2020). A variety of factors could explain these results, such as students' reading ability, text difficulty, and task requirements. Recall that participants of this study were undergraduate students from a liberal arts university that uses English as the main language of instruction. This implies that students who study at such a university are presupposed to have a good level of English language and sufficient English reading ability.

Interestingly, judgment of performance was assessed using a text that falls within the same grade level as the participants. The text was sourced from an EFL/ESL[8] website (my English pages) with a reading ease score of 49.5, which indicates that the text was somewhat easy to read. An alternate explanation for participants' judgments accuracy is that they have generated additional self-feedback from taking the test. Prior research has documented the positive effects of feedback on students' judgment accuracy (Hattie & Timperley, 2007; Snow, 2002, Singer & Alexander, 2017).

---

[8] English as a Second Language. An ESL context is defined as one in which English is used in the society in which the language is being studied (Anderson, 2003).

6. Conclusions and implications

The current study was guided by the surge in the use of ICT tools in education. With the 21st century ever-changing technologies inside and out of the classroom, there has been a need to investigate the effects of the medium used for reading (paper vs. screen) on reading comprehension and judgment of performance of Moroccan EFL university students. The results revealed that students' reading comprehension was indifferent to the effect of the medium, and their judgments of performance further suggested that they were insensitive to the medium used for reading.

These results have important implications for theory and pedagogy. For one, the results confirm that schema theory is still a valid theory in the 21st century, where technology has resulted in alternative forms of reading (e.g., multimodal reading). This suggests that traditional theories of print reading can be adapted and extended to digital reading environments.

Apart from this, the results of this study are particularly significant for educators who are still reluctant to make the full transition to digital reading in EFL contexts. This research provides evidence that reading short factual texts on the screen neither compromises students' comprehension abilities nor affects their self-efficacy beliefs[9]. The results are also significant for those who are engaged in educational contexts where the cost of academic materials and constant changes in textbooks are major challenges (Eicker-Nel & Matthee, 2014; Mizrachi et al. 2018).

In addition, the fact that judgment of performance was not affected by characteristics of text display suggests that students were metacognitively aware of their reading and comprehension skills. Such positive judgments seemed to align with students' learning from and engagement with digital and print texts, as reflected in their comprehension test scores. This implies that self-efficacy beliefs should be highlighted in both print and digital reading activities. For instance, EFL teachers may design reading activities in which they may ask students to judge their comprehension performance about the task, and then share the results with the rest of the class.

Some limitations of the study should be mentioned. First, the results of this investigation pertain only to digital natives, a group of students who usually develop expertise in the use of digital media as a result of exposure to technology at early stages in life. This limits the generalizability of the results to students from other age groups. Thus, further studies are required to survey larger groups, including not only undergraduate and graduate students but also adults (digital immigrants[10]).

Second, while this research was conducted using a between-subjects design, one may question whether the results found in this research would remain consistent in a within-subjects design, in which each student would be exposed to both conditions of the treatment being tested (paper and screen). This research elected to employ a between-subjects design because of its convenience and feasibility. The test was carried out during classroom sessions, where each session was about 90 minutes long. This means that if the within-subjects design has been chosen, this could have led to longer classroom sessions that might have been difficult to implement, especially since the participant students had to take other classes immediately after the test.

Third, this research assessed students' judgment of performance (or calibration of performance) after they took the test, limiting the results to only post-diction tasks. That is to say, it remains unclear if students would show different levels of self-efficacy judgments if they were asked to predict their comprehension performance before taking the test. Hence, future studies should address the impact of reading medium on calibration of comprehension.

To conclude, the digital transformation has shaped how millennials read and interact with course content. Bolter (1991), as cited in Liu (2008), notes that "the shift from print to the computer does not mean the end of literacy itself, but the literacy of print, for electronic technology offers us a new kind of books and new ways to write and read" (p. 54). This study, accordingly, took an important step in examining how paper and screen reading are different (or similar) within a simpler context with fewer confounding variables; that is, a single traditional text content presented on a paper sheet compared with the same text content displayed on a laptop.

Even though this research has found no statistically significant differences between print and digital reading, it has informed our understanding of how EFL students read traditional paper versus digital texts in a basic reading environment (i.e., with no hyperlinks, images, or sounds). This information is particularly important to policymakers and practitioners who are actively engaged in designing instruction and standardized reading assessment via different modes of teaching and learning.

---

[9] The belief in oneself abilities and capabilities (or the lack thereof) to perform a task.
[10] The term 'digital immigrants' refers to people who were born and raised before the digital age (Prensky, 2001).

ORCID iD: Maryem Larhmaid 🆔 https://orcid.org/0000-0003-3264-7223

References

[1]   Ackerman, R., & Lauterman, T. (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. https://doi.org/10.1016/j.chb.2012.04.023

[2]   Afflerbach, P., & Cho, B.-Y. (2009). Identifying and describing constructively responsive comprehension strategies in new and traditional forms of reading. In S.E. Israel, & G. G. Duffy (Eds.), *Handbook of Research on Reading Comprehension*, 69–90. New York: Routledge.

[3]   American Speech Language Hearing Association (2015). Parent pooling: Better hearing and speech month. Retrieved from http://www.asha.org/uploadedFiles/BHSM-Parent-Poll.pdf

[4]   Anderson, N. J. (2003). Teaching reading. In D. Nunan (Ed.), *Practical English Language Teaching*, 7–86. New York: McGraw-Hill Publishers.

[5]   Ary, D., Jacobs, L. C., Sorensen, C., & Razavieh, A. (2010). *Introduction to Research in Education* (8th ed.). Canada: Thompson Wadsworth.

[6]   Baron, N. (2021). *How we read now: Strategic choices for print, screen, and audio*. New York: Oxford University Press.

[7]   Baron, N. S. (2015). *Words onscreen: The fate of reading in a digital world*. Oxford University Press.

[8]   Ben-Yehudah, G., & Eshet-Alkalai, Y. (2018). The contribution of text highlighting to comprehension: A comparison of print and digital reading. *Journal of Educational Multimedia and Hypermedia, 27*, 153–178.

[9]   Bolter, J. D. (1991). *Writing space: The computer, hypertext, and the history of writing. Lawrence* Erlbaum Associates, Inc.

[10] Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. E. Weinert & R. H. Kluwe, (Eds.) *Metacognition, Motivation, and Understanding,* 65–116. Hillsdale, NJ: Lawrence Erlbaum.

[11] Burke, V. & Greenberg, D. (2010). Determining readability: How to select and apply easy-to-use readability formulas to assess the difficulty of adult literacy materials. *Adult Basic Education and Literacy Journal*, *4*(1), 34–42.

[12] Chen, D. W., & Catrambone, R. (2015). Paper vs. screen effects on reading comprehension, metacognition, and reader behavior. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 59,* 332-336.

[13] Chen, G., Cheng, W., Chang, T., Zheng, X., & Huang, R. (2014). A comparison of reading comprehension across paper, laptop screens, and tablets: Does tablet familiarity matter? *Journal of Laptops in Education, 1*, 213–225. https://doi.org/10.1007/s40692-014-0012z

[14] Childwise (2017). The monitor trends report. Retrieved from https://childwise.co.uk/reports.html#trendsreport

[15] Clinton, V. (2019). Reading from paper compared to screens: A systematic review and meta-analysis. *Journal of Research in Reading, 42*, 288–325. https://doi.org/10.1111/1467-9817.12269

[16] Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

[17] Delgado, P., Vargas, C., Ackerman, R., & Salmerón, L. (2018). Don't throw away your printed books: A meta-analysis on the effects of reading media on comprehension. *Educational Research Review, 25*, 23–28. https://doi.org/10.1016/j.edurev.2018.09.003

[18] Dennis, A. R., Abaci, S., Morrone, A. S., Plaskoff, J., & Hilmer, K. M. (2016). Effects of e-textbook instructor annotations on learner performance. *Journal of Computing in Higher Education, 28*, 221–235.

[19] Duffy, G.G., & Israel, S.E. (Eds.). (2009). *Handbook of Research on Reading Comprehension* (1st ed.). Routledge.

[20] Dunlosky, J., & Lipko, A. R. (2007). Metacomprehension: A brief history and how to improve its accuracy. *Current Directions in Psychological Science, 16*(4), 228-232.

[21] Eicker-Nel, S., & Matthee, M. (2014). *The adoption of tablet-based e-textbooks in a South African private school*. In Proceedings of the e-skills for knowledge production and innovation conference 2014. Cape Town, South Africa.

[22] Ennaji, K. (2019, July 13). Minister of education launches national platform "Morocco Digital University." *Morocco World News*.

[23] Eshet-Alkalai, Y., & Chajut, E. (2010). You can teach old dogs new tricks: The factors that affect changes over time in digital literacy. *Journal of Information Technology Education, 9*, 173–181.

[24] Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry. *American Psychologist, 34*, 906–911.

[25] Goldman, S. R. (2015). Reading and the web: broadening the need for complex comprehension. In R. J. Spiro, M. DeSchryver, P. Morsink, M. S. Hagerman, & P. Thompson (Eds.), *Reading at a Crossroads? Disjunctures and Continuities in Current Conceptions and Practices*. New York, NY: Routledge.

[26] Goodwin, A. P., Cho, S.-J., Reynolds, D., Brady, K., & Salas, J. (2020). Digital versus paper reading processes and links to comprehension for middle school students. *American Educational Research, 57*(4), 1837–1867.

[27] Hafa, H., & Moubtassime, M. (2021). The use of ICT in learning English: A study of students in Moroccan universities. *SAR Journal, 4*(1), 19–28.

[28] Halamish, V., & Elbaz, E. (2020). Children's reading comprehension and metacomprehension on screen versus on paper. *Computers & Education*, 145, 103737.

[29] Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81–112. https://doi.org/10.3102/003465430298487

[30]   Kemp, S. (2022). *Digital 2022 April global statshot report*. We Are Social & Hootsuite.
[31]   Kong, Y., Seo, Y. S., & Zhai, L. (2018). Comparison of reading performance on screen and on paper: A meta-analysis. *Computers & Education*, *123*, 138-149.
[32]   Lai, J., & Chang, C. (2011). User attitudes toward dedicated e-book readers for reading: the effect of convenience, compatibility, and media richness. *Online Inf. Rev., 35*, 558–580.
[33]   Lauterman, T. & Ackerman, R. (2014). Overcoming screen inferiority in learning and calibration. *Computers in Human Behavior*, 35, 455–463.
[34]   Liu, Z. (2008). *Paper to digital: Documents in the information age*. Libraries Unlimited: Westport, Connecticut.
[35]   Lynch, M. (2018, May). Do digital tools improve reading outcomes? The Tech Edvocate.
[36]   Mangen, A., Walgermo, B. R., & Brønnick, K. (2013). Reading linear texts on paper versus laptop screen: Effects on reading comprehension. *International Journal of Educational Research, 58*, 61–68.
[37]   Margolin, S.J., Driscoll, C., Toland, M.J. and Kegler, J.L. (2013), E-readers, laptop screens, or paper: Does reading comprehension change across media platforms? *Applied Cognitive Psychology*, 27, 512–519. https://doi.org/10.1002/acp.2930
[38]   Mizrachi, D., Salaz, A. M., Kurbanoglu, S., & Boustany, J. (2018). Academic reading format preferences and behaviors among university students worldwide: A comparative survey analysis. *PLoS ONE, Vol., 13*(5). https://doi.org/10.137/journal.pone.0197444
[39]   Nassaji, H. (2002). Schema theory and knowledge-based processes in second language reading comprehension: A need for alternative perspectives. *Language Learning*, *52*, 439–481.
[40]   Nielson, J. (2012, July 1). *Serif vs. sous-serif fonts for HD screens*. Nielson Norman Group.
[41]   Pardede, P. (2019). Print vs. digital reading comprehension in EFL. *Journal of English Teaching*, *5*(2), 77–90.
[42]   Pulido, D. (2007). The effects of topic familiarity and passage sight vocabulary on L2 lexical inferencing and retention through reading. *Applied Linguistics*, *28*(1), 66–86.
[43]   Prensky, M. (2001). Digital natives, digital immigrants. Part 1. *On the Horizon*, *9*(5), 1–6.
[44]   Rasmusson, M. (2015). Reading paper – reading screen. *Nordic Studies in Education, 35*, 3–19.
[45]   Ronkoni, A., Veronesi, V., Mason, L., Manzione, L., Florit, E., Anmakrud, ø., & Bråten, I. (2022). Effects of reading medium on the processing, comprehension, and calibration of adolescent readers. *Computers & Education*, 185, 104520.
[46]   Rosenfield, M. (2016). Computer vision syndrome (a.k.a. digital eye strain). *Optometry in Practice*, *17*(1), 1–10.
[47]   Ross, B., Pechenkina, E., Aeschliman, C., & Chase, A.-M. (2017). Print versus digital texts: Understanding the experimental research and challenging the dichotomies. *Research in Learning Technology*, *25*.
[48]   Rumelhart, D. E. (1980). Schemata: The building blocks of cognition. In: Spiro, R., Bruce, B., & Brewer, W., (Eds.), *Theoretical Issues in Reading Comprehension*. Erlbaum Associates, Mahway, 33–58.
[49]   Sackstein, S., Spark, L., & Jenkins, A. (2015). Are e-books effective tools for learning? Reading speed and comprehension: iPad vs. paper. *South African Journal of Education, 35*, 1–14.
[50]   Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460–475.
[51]   Singer, M. L., & Alexander, P. A. (2017). Reading across mediums: Effects of reading digital and print texts on comprehension and calibration. *Journal of Experimental Education*, *85*(1), 155–172.
[52]   Snow, C. E. (2002). *Reading for understanding: Toward a research and development programming reading comprehension.* Santa Monica, CA: Rand Corp.
[53]   Thomas, A. K., & Mcdaniel, M. A. (2007). Metacomprehension for educationally relevant materials: Dramatic effects of encoding-retrieval interactions. *Psychonomic Bulletin & Review*, *14*(2), 212- 218.
[54]   Wells, C. L. (2012). *Do students using electronic books display different reading comprehension and motivation levels than students using traditional print books?* (Unpublished doctoral dissertation). Liberty University, Lynchburg, VA.
[55]   Wiley, J., Griffin, T. D., & Thiede, K. W. (2005). Putting the comprehension in metacomprehension. *The Journal of General Psychology, 132*(4), 408-428.
[56]   Wiley, J., Griffin, T. D., Jaeger, A. J., Jarosz, A. F., Cushen, P. J., & Thiede, K. W. (2016). Improving metacomprehension accuracy in an undergraduate course context. *Journal of Experimental Psychology: Applied*, *22*(4), 393-405.