

Screen Reading vs Paper Reading: An Experimental Study on the Impact of Different Reading Materials on Recall and Comprehension Among Students

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Abstract

This study was conducted to determine the effects of different reading materials on recall accuracy and comprehension among students of Melaka Manipal Medical College and to determine which type of reading material is preferred among students. 80 participants were randomly assigned into two groups, 40 paper readers and 40 screen readers. After going through the reading materials provided on either paper or screen, the participants were administered a series of three tests, two assessing memory and one assessing comprehension. Test scores of the two groups was then converted to percentages and analysed using Epi Info™. The 80 participants in this study were divided into two groups, screen readers and paper readers which consist of 40 individuals in each group. After reading the material given, all participants were required to do three tests. For memory test one, screen readers have a mean percentage score of 52.26% which is higher than the 51.90% of paper readers. The paper readers performed better on memory test two with mean percentage score of 87.50% compared to 83.21% of screen readers. Screen readers also performed better for the comprehension test with mean percentage score of 95% compared to 94% of paper readers. Based on the feedback received, more participants still prefer reading from a paper text compared to text on a screen although they own electronic devices and have access to e-books. Screen readers performed slightly better than paper readers, but students still prefer to read lengthy academic material in print.

Keywords

Experimental Study, Reading Materials, Recall, Comprehension, Students

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1. Introduction

Today's students, known as digital natives or net-generation, are different from those of the past. Born into an era of instant connectivity and networking they explore the world in an entirely new way. As a result, digital natives have different expectations for education that centres on their relationship with technology. For higher education institutions the digital demand is real. In order to stay

relevant, colleges and universities must adapt their systems to meet the unique and evolving needs of this new breed of learners. [1] As digital texts and technologies become more prevalent, we gain new and more mobile ways of reading, but are we still reading as attentively and thoroughly? [2] Globally the number of E book users is expected to amount to 621.8 million by the year 2022, and in Malaysia the number is expected to reach 2.7 million by the same year. [3]

Screen reading is the act of reading a text on a computer

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screen, smartphone, or e-book reader. It is often contrasted with the act of reading a text on paper. [4] Recall is as defined the ability to bring the memory of a past event into your mind, and often to give a description of what you remember, while comprehension is the ability to understand completely and be familiar with a situation or facts. [5] Recall and comprehension includes cognitive operations therefore, this study draws upon concepts, principles, and assumptions associated with cognitive information-processing. [6]

The usage of tablet or computer in medical education is an area of interest. According to a study done among medical students and residents, majority of medical trainees felt that tablet or computers added value to the curriculum. There is a higher prevalence and frequency of tablet or computer use among physicians. Most residents and students prefer tablet or computers to access medical references, e books, to study for board exams and even to complete clinical tasks. [7]

New inventions do make our lives easier in many ways, but they can also cause worries and troubles. Paper-based learning may seem outdated. However, numerous scientific studies prove its benefits. Taking notes by hand may be the secret for retaining information. According to one of the study conducted, they found that students with handwritten notes understand and apply the concepts better than those students who use laptops and tablets. When students physically write out notes, they use different cognitive processes. The processes used when writing by hand help them understand and retain the information better than when they type the notes. [8]

A reader can focus on a page in a book without losing sight of the whole text, because books have more obvious topography than text onscreen. Text in a paper book is easily navigable, and forming a coherent mental map of the information is easier. Surveys and consumer reports also suggest that the sensory experiences associated with reading, especially tactile experiences matter to people more than one might assume. Researchers have suggested that comprehension is less with screen reading because it is more physically and mentally demanding. [9]

Another study suggested that computer screens, smartphones and tablets shine light directly into people's faces which can tire the eyes. An emerging collection of studies also emphasizes that people do not approach reading on screens with as much mental effort as compared to reading on paper as it is considered a less serious affair. [10]

In previous studies statistical analysis indicated that prior knowledge prepared readers for better comprehension of the familiar information in the passage. [11] Studies have been conducted among school going children and college students

however none specifically targeted medical students. In this study, we will test the medical students recall and comprehension based on reading material from general topics not relating to the medical curriculum. This is to ensure there is no prior background knowledge which could invariably affect the result of the study.

This study aims to contribute to the body of literature by providing an improved understanding of how screen reading and paper reading impact the recall and comprehension ability of medical students. Objectives of this research include, determining the effects of different reading materials on recall accuracy and comprehension. Determining which type of reading material is preferred among students and to understand the student's perception on the usefulness of screen reading and paper reading in terms of learning. [12]. In this research we hypothesize that students who read a paper article or perform a memory test on paper will have a difference in recall and reading comprehension as shown by higher test scores compared to those who perform the same tasks on a screen. [13]

2. Methodology

2.1. Study Design

We conducted a randomized controlled trial study to investigate the impact of screen reading and paper reading on recall and comprehension among medical students of MMMC, Muar Campus, Malaysia.

2.1.1. Study Setting and Study Population

This study was set in a private medical college in Muar, Johor, Malaysia, where the student population is around 300, comprising of 2 batches of 4th year MBBS students only. The study was held between the months of June and August 2018. Our inclusion criteria comprised of MBBS students aged 19 to 26 from both batches 36 and 37 irrespective of gender, race or posting. Exclusion criteria were those students who were unwilling to provide a written consent, students who had less than 6 hours of sleep or caffeinated drinks before taking the test. Students who are on any medication that leads to drowsiness will also not be considered for this study

2.1.2. Sample Size and Sampling

Our sample size was generated from the values of a previous research entitled, "The Effects of Tablets on Learning: Does Studying from a Tablet Computer Affect Student Learning Differently across Educational Levels" (2015) by Devin M. Nishizaki at Claremont McKenna College. [14]

The effects of tablet on learning

Comparison of Reading Comprehension Scores

College Students

Table 1. Mean and standard deviation from previous study.

Test type	M	SD	n
Paper Test	6.75	0.72	20
Tablet Test	6.20	0.89	20

Mean in group 1 (μ_1) = 6.20

Mean in group 2 (μ_2) = 6.75

SD. in group 1 (σ_1) = 0.89

SD. In group 2 (σ_2) = 0.72

Ratio (r) = 1

Alpha = 0.05

Beta = 0.2

Results obtained were 35 participants required for each group.

However, by calculating the 10% attrition, our research needed 39 participants for each group, which we rounded off to 40. Hence our total sample size is 80 participants, 40 in control and 40 in experimental group.

2.2. Randomization

We used the non-probability sampling method, where we asked for 80 volunteers from 145 students of Batch 37. The 80 participants were then further divided into two groups. Firstly, a group of participants who used screen based reading (experimental group) and another group of participants who used paper based reading (control group). Method of randomization used was block randomization. Each group having 40 participants were selected by using the software Research Randomizer. (<http://www.randomizer.org>)

2.3. Procedure and Intervention

Two randomly assigned groups (paper readers and screen readers) were administered two tests that are the recall test and comprehension test. The study group was given laptops, whereas the control group was given papers to answer the test. To ensure a non-biased result, our intervention was been conducted in a conducive study environment and equal time was given to all the participants to read the prepared material. The screens used was standardized and reading material given was concise and interesting enough to attract attention while maintaining focus.

2.4. Data Collection and Data Processing

After going through the reading materials provided on either paper or screen, the participants were required to sit for a series of tests. There were three tests that tested the participants' memory and comprehension. The first and

second tests were memory tests. In the first memory test, the participants were given fifty seconds to read and memorize a list of twenty one words. After the time allotted ended, participants were given one minute to write down as many words as they can remember on a sheet of paper given. Meanwhile in the second memory test, participants were required to look at seven pictures and try to remember as many details as possible. They were given one second for each picture with total duration of seven seconds for seven pictures. After that, they were required to answer 1 MCQ question for each picture within 5 minutes. The third test was a comprehension test. Participants read a text titled 'The Magical Paintbrush' for ten minutes. They were then required to answer 15 MCQ questions within another ten minutes which tested their comprehension on the text they read earlier. In all the three tests carried out, participants were given one mark for each correct answer. The highest total possible marks that could be obtained was 43 marks for all three tests. We measured the participants' performance in the tests by calculating the marks obtained by each of them and converting the marks into percentage. This data was tabulated using Microsoft Excel.

2.5. Data Analysis

Data was entered and summarized using Microsoft Excel. Data was analysed using Epi Info™ version 7 from Centres for disease control and prevention website (CDC).

For categorical variables, proportions and frequency counts were calculated. For continuous variables, mean and standard deviation were computed. In addition, range, minimum, and maximum values will be reported for both types of variables. Missing, extreme, and variable distributions were explored. Group comparisons of categorical variables were made using Pearson's chi-square (χ^2) tests and continuous variables using t-tests.

Results will be depicted using bar graphs and box plots. Measure of association calculated is relative risk. Estimation of parameters using confidence interval (95% CI) and level of significance (5%)

2.6. Ethical Consideration

An Informed consent form with all the important and relevant details of the study was given to the participants, and the participants were not forced, but given the option of whether they wanted to participate or not in the study. Participants were notified that all data and information gained through the study would be kept confidential. The form also had a concise explanation about the study and its requirements, and the participants were told that they could choose to withdraw from the study whenever they needed.

3. Results

Table 2. Students Demographics.

Variables	Screen Reading (n=40) n (%)	Paper Reading (n=40) n (%)	Total n (%)
Age (years) ^a	22.08 (0.92)	22.48 (0.99)	22.28 (0.97)
Gender			
Male	22 (55)	12 (30)	34 (42.5)
Female	18 (45)	28 (70)	46 (57.5)
Ethnicity			
Malay	5 (12.5)	9 (22.5)	14 (17.5)
Indian	18 (45)	19 (47.5)	37 (46.25)
Chinese	9 (22.5)	8 (20)	17 (21.25)
Others	8 (20)	4 (10)	12 (15)
Duration of usage of computers			
1 to 3 years	1 (2.5)	1 (2.5)	2 (2.5)
3 to 5 years	6 (15)	8 (20)	14 (17.5)
6 years or more	33 (82.5)	31 (77.5)	64 (80)
Number of electronic devices			
1	5 (12.5)	3 (7.5)	8 (10)
2	15 (37.5)	18 (45)	33 (41.25)
3 or more	20 (50)	19 (47.5)	39 (48.75)
Mode of Study			
Textbooks	36 (90)	39 (97.5)	75 (93.75)
E books	4 (10)	1 (2.5)	5 (6.25)
Sleep Duration			
Less than 4 hours	2 (5)	4 (10)	6 (7.5)
5 hours	18 (45)	16 (40)	34 (42.5)
More than 6 hours	20 (50)	20 (50)	40 (50)
Caffeinated Drinks			
Yes	17 (42.5)	20 (50)	37 (46.25)
No	23 (57.5)	20 (50)	43 (53.75)
Medications			
Yes	5 (12.5)	5 (12.5)	10 (12.5)
No	35 (87.5)	35 (87.5)	70 (87.5)

^aMean (SD)

Interpretation:

There was a total of 80 participants who took part in this study. A group of 40 participants who used screen based reading (experimental group) and another group of 40 participants who used paper based reading (control group). The age of the participants was between 19 to 26 years of age. The mean age of the participants was 22.28. Among the 80 participants, there was a total of 34 (42.5%) males out of which 22 (55%) was in the experimental group and 12 (30%) were in the control group. There was 46 (57.5%) females participated, out of which 18 (45%) were in the experimental group and 28 (70%) were in the control group respectively. For ethnicity the highest number of participants was Indians which was 37 (46.25%) of them, out of which 18 (45%) was in the experimental group and 19 (47.5%) was in the control group, followed by 17 (21.25%) Chinese participants, out of which 9 (22.5%) was in the experimental group and 8 (20%) was in the control group. Among 14 (17.5%) Malays who participated in the study, 5 (12.5%) was in the experimental group and 9 (22.5%) was in the control group. There was a total of 12 (15%) participants who belong to other races out of which 8 (20%) was in the experimental group and 4 (10%) was in the control group. Duration of usage of computers

between 1 to 3 years had 2 (2.5%) participants, out of which 1 (2.5%) participant was in the experimental group and 1 (2.5%) participant in the control group. Duration of usage of computers between 3 to 5 years was 14 (17.5%) of them, out of which 6 (15%) was in the experimental group and 8 (20%) in the control group and participants who used computers for 6 years and more was 64 (80%) of them, of which 33 (82.5%) was in the experimental group and 31 (77.5%) in the control group. There was 8 (10%) participants who had 1 electronic device, out of which 5 (12.5%) was in the experimental group and 3 (7.5%) in the control group. Among 33 (41.25%) participants who had 2 electronic device, 15 (37.5%) was in the experimental group and 18 (45%) in the control group. Among 39 (48.75%) participants who had 3 or more electronic device, 20 (50%) was in the experimental group and 19 (47.5%) was in the control group. Among the 80 participants, 75 (93.5%) of them chose textbooks as their preferred mode of study, out of which 36 (90%) was them was in the experimental group and 39 (97.5%) of them was in the control group. There was 5 (6.25%) participants who chose e books as their preferred mode of study, out of which 4 (10%) was in the experimental group and 1 (2.5%) in the control group. There was a total of

6 (7.5%) participants who slept for less than 4 hours, out of which 4 (10%) was in the experimental group and 2 (5%) in the control group. Participants who slept for 5 hours was 34 (42.5%) of them out of which 18 (45%) was in the experimental group and 16 (40%) in the control group. Participants who slept for more than 6 hours was 40 (50%) of them, out of which 20 (50%) was in the experimental group and 20 (50%) in the control group. There was a total of 37 (46.25%) participants who consumed caffeinated drinks, out of which 17 (42.5%) was in the experimental group and 20

(50%) in the control group. A total of 43 (53.75%) participants did not consume caffeinated drinks, out of which 20 (50%) was in the experimental group and 23 (57.5%) was in the control group. There was 10 (12.5%) participants consumed some medications before participating in the study, out of which 5 (12.5%) was in the experimental group and 5 (12.5%) in the control group. There was 70 (87.5%) of them who did not consume any medications, out of which 35 (87.5%) was in the experimental group and 35 (87.5%) in the control group.

Table 3. Comparison of scores of Memory Test 1, Memory Test 2 and Comprehension Test between screen readers and paper readers.

Variables	Mean (SD)		Mean Difference (95%CI)	t-statistic (df)	P-value ^a
	Screen Readers n=40	Paper Readers n=40			
Scores of Memory Test 1	52.26 (16.01)	51.90 (14.66)	0.36 (-6.47,7.19)	0.10 (78)	0.917
Scores of Memory Test 2	83.21 (12.48)	87.50 (10.82)	-4.29 (-9.49,0.91)	1.64 (78)	0.105
Scores of Comprehension Test	95 (8.09)	94 (4.96)	1 (-1.99,3.99)	0.67 (78)	0.507

^aIndependent t test

Interpretation:

The mean difference between paper readers and screen readers for memory test 1 was 0.36 with 95% CI -6.47, 7.19. Since 0 falls within this range, the difference is not statistically significant. This correlates with the P-value which is 0.917 (> 0.05). The t-statistic value is 0.10 with degree of freedom 78, which falls within the range to accept null hypothesis.

The mean difference between paper readers and screen readers for memory test 2 was -4.29 with 95% CI -9.49, 0.91. Since 0 falls within this range, the difference is not statistically significant. This correlates with the P-value which is 0.105 (>

0.05). The t-statistic value is 1.64 with degree of freedom 78, which falls within the range to accept null hypothesis. Hence, there is no significant association between memory and type of reading material (screen or paper).

The mean difference between paper readers and screen readers for the comprehension test was 1 with 95% CI -1.99, 3.99. Since 0 falls within this range, the difference is not statistically significant. This correlates with the P-value which is 0.507 (> 0.05). The t-statistic value is 0.67 with degree of freedom 78, which falls within the range to accept null hypothesis. Hence there is no significant association between reading comprehension and type of reading material (screen or paper).

Table 4. Percentage of agreement and disagreement with the feedback items for screen reading.

Items	Yes (%)	No (%)
The font size and typeface on the screen were easy to read	39 (97.5)	1 (2.5)
The sequence of the pages on the screen was clear	40 (100)	0 (0)
It was convenient to scroll up/down with the screen	38 (95)	2 (5)
It was easy to turn the pages on the screen	37 (92.5)	3 (7.5)
It was easy to find important information on the screen	35 (87.5)	5 (12.5)
The pictures on screen was clear	40 (100)	0 (0)
The time given was adequate to answer the questions	37 (92.5)	3 (7.5)
I intend to increase my use of screen reading (laptops, tablets)	24 (60)	16 (40)
I intend to read e books to assist my learning	22 (55)	18 (45)
If given a choice between electronic or print version of a particular book, I would choose the electronic version	14 (35)	26 (65)

Interpretation:

According to the survey, there was 100% satisfaction from the total of 40 participants for the sequence of the pages on the screen being clear and for the clarity of the pictures on screen. 97.5% of participants found the font size and typeface on the screen easy to read. 95% found it convenient to scroll up/down with the screen. 92.5% found that it was easy to

turn pages on the screen and that the time given was adequate to answer the questions. 87.5% of the participants found it easy to find important information on the screen, 60% intend to increase their use of screen reading, and 55% intend to read e books to assist their learning. If given a choice between electronic or print version of a particular book, 35% of the participants would choose the electronic version.

Table 5. Percentage of agreement and disagreement with the feedback items for paper reading.

Items	Yes	No
The font size and typeface on the paper were easy to read	40 (100)	0 (0)
The sequence of the pages on the paper was clear	39 (97.5)	1 (2.5)
It was convenient to answer the question on the paper	40 (100)	0 (0)
It was easy to turn the pages on the paper	39 (97.5)	1 (2.5)
It was easy to find important information on the paper	37 (92.5)	3 (7.5)
The pictures on paper was clear	39 (97.5)	1 (2.5)
The time given was adequate to answer the questions	35 (87.5)	5 (12.5)
I intend to increase my use of paper reading (textbooks, printed notes)	35 (87.5)	5 (12.5)
I intend to read printed books to assist my learning	38 (95)	2 (5)
If given a choice between electronic or print version of a particular book, I would choose the print version	40 (100)	0 (0)

Interpretation:

According to the survey, there was 100% satisfaction from the total of 40 participants for the ease of reading the font size and typeface on paper, for convenience in answering questions on paper, and for choosing print version if given a choice between electronic or print version. 97.5% of participants were satisfied with the sequence of the pages on the paper being clear, with the ease of turning pages on the paper, and with the clarity of pictures on paper. 95% of participants intend to read printed books to assist their learning and 92.5% of participants found it easy to find important information on paper. 87.5% of participants found the time given was adequate to answer the questions and that they intend to increase their use of paper reading.

4. Discussion

In this modern era, there is an increase in the ownership of digital devices such as laptops, tablets and mobile phones among students. Due to this, there is an increasing demand for the availability of textbooks in the form of e-books as students find this easier and more portable to carry around. The purpose of this study was to examine the differences of recall and comprehension scores between screen and paper readers. [15] This study was unique in that students completed a customized test right after reading the article. The reading for this study was limited to just over two pages with a closed book assessment in order to limit cognitive load from digital reading due to scrolling. Another intentional design was a paper assessment for both the screen and paper reading groups. The aim was to reduce cognitive load for screen readers by reducing navigation actions and switching of windows for digital assessments, thereby restricting unnecessary variation between conditions. Moreover, completing the assessment immediately after the reading prevented memory decay or threats from interference of learning by other topics. [16]

While some prior research has proven that paper readers score significantly higher in comprehension tests compared

to screen readers [17], other studies published have produced inconsistent results, with many finding few significant comprehension differences between reading on a screen or on paper [18]. Our sample of 80 participants, consisted of 34 (42.5%) males and 46 (57.5%) females. There is no significant difference in group between screen and paper readers was evident in our study, there were differences in score frequencies for both recall and comprehension. Screen readers have mean percentage scores of 52.26% and 95% for memory test 1 and comprehension test which is higher than mean percentage scores of paper readers, which was 51.90% and 94% respectively. Meanwhile for the memory test 2, paper readers have a mean percentage score of 87.50% which was higher than the 83.21% obtained by screen readers. This shows that screen readers performed better than paper readers in 2 out of the 3 tests. However the difference in mean percentage scores is small and may prove inconclusive as other factors may have affected the performance of the participants. Individual score differences may also be an important consideration when used for ranking and selection purposes.

5. Conclusion

In conclusion, our study finds little recall and comprehension differences between print and screen reading, keeping in line with recent research conducted on this topic. However majority of the students still prefer to utilize printed text for in depth learning. Almost every student possess both forms of reading material, and whilst they agree that screen reading via electronics is convenient and encourages enthusiasm to learn with the help of visual and audio aids, reading off paper may aid contextual analysis and a deeper sense of knowing resulting in better academic performance. Moreover other variables such as participants' existing technology expertise, their age, prior knowledge of the subject tested and length of the test documents make it difficult to accurately determine which form of reading is more beneficial for students.

Implications and Recommendations

Based on responses from feedback, we found that more than 82.5% of participants still prefer to study off paper rather than the screen, and would choose a textbook over electronic text. As learning strengths and preferences contribute greatly to student success, [19] it is possible that students chose to use textbooks based on preference and study habits. Thus, learning preferences may be a moderating or mediating variable that needs to be considered in future research. [20] Ackerman and Goldsmith concluded that the difference is therefore not in the presentation of the material itself, but relates to a more intuitive or subconscious feeling that makes the brain more conducive to learning when reading from a more familiar source, such as print, and less ready to learn when reading from a more unfamiliar source such as a screen [21]. Whereas this study used a short reading passage and simple memory tests to measure our outcomes, future experiments may consider longer readings that create a slight increase in cognitive load for digital readers and a longer time interval between reading and assessing. Educational leaders need to engage and promote research involving digital devices to be better informed about the effects and implications on learning and assessments.[22] Although our study targeted college students, future studies with primary and secondary school students could further advance the understanding on the effects of different reading materials, especially in relationship to developmental concerns.

Limitations

Our study was carried out on 6th and 7th semester students of Melaka Manipal Medical College. Therefore, these results do not represent screen versus paper reading efficacy among all medical students of other years in our college. Also generalizations to other demographic populations is not possible. Another limitation included the fact that we as researchers could not control the amount of sleep our participants had the night before taking part in the experiment, or their caffeine or drug consumption, which may have affected the participants recall and comprehension ability. While students were aware that an assessment followed the reading, there was no incentive offered, therefore, there is a chance that this affected students' motivation.

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