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# Education in the 21st Century: Challenges and Perspectives

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# SCREEN VS. PAPER
# CAN TECHNOLOGY CHANGE THE WAY STUDENTS LEARN?

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**Abstract**

The use of information technology in educational institutions has increased significantly in the last decade, and the reason for this is the need for students to acquire skills that are necessary for their life and work. Application of ICT in education brings certain benefits to students. By using modern devices, they have much easier access to learning materials, discussion forums, and educational software. Students more often attend lectures over the Internet, read e-books, communicate with colleagues online, or watch video presentations related to their studies. When it comes to the learning process, there is often a dilemma: is it better to read from a printed paper or an electronic medium? We read for many reasons. Sometimes we're looking for a very specific question. Other times, we just want to browse a book to find something interesting. The purpose of this paper is to examine if there is a difference in learning when using a traditional way of reading literature from printed material or reading from the screen of modern devices such as a laptop, a tablet or a mobile phone. Through a series of surveys and experiments, we will determine which way gives students better results.

**Keywords**: learning, education, technology, screen, paper

## 1.Introduction

Today, we spend most of our time using modern technology gadgets. Whether reading news, checking mail, watching movies or simply communication to each other, we find ourselves looking at some sort of a screen like computer or mobile devices. Students are one large group of users of this modern technology most of their time. But, not just their spare time. They are using it to record lectures, read them online, taking notes and to communicate with the fellow classmates. The use of Information and communication technologies (ICT) in the educational process has increased the use of the Internet in all segments of the educational process. However, greater use of the Internet has been noted in higher education. The use of computers and Internet enable the use of services and tools, as well as access to immeasurable information. This brings enormous benefit to teachers as they can meet the different ways of studying and to give their students' access to information that otherwise would be difficult to reach. But this technology should be seen as an aiding teaching tool, and not as a substitute for an educator. For all involved in the educational process, knowing whether computer-based learning is improving or regressing education is a subject of concern. With the inflow of e-books, online learning and open educational resources, researchers have been trying to resolve if students do as well when reading an assigned text on a digital screen as on paper. The research into the insinuation of this is still in the early stages, so little evidence indicates that printed material may be more used than the screen in relation to learning and

understanding the lessons. However, as screen technology continues to advance, interfaces become increasingly intuitive and personal preferences change from early exposure to reading on a screen, this may change —and may have already changed for some individuals (Salter, 2013).

### 1.1. Related work

When it comes to implementing technology in the classroom, many schools think it is the right way. After all, how can they provide students a solid 21st-century education unless they ensure classrooms are fully equipped with the latest technological gadgets? (Riebel, 2013)

Many people who have grown up reading printed material feel that their reading is more effective if they read from paper rather than from a screen. When describing why they feel this way, they refer not just to the visual sense, but also the way paper feels and is manipulated, which supports their comprehension. The discomfort that people feel when reading from a screen is defined by Gerlach and Buxmann as 'haptic dissonance' (Gerlach and Buxmann, 2011). A recent study conducted by Wu and Chen (2011) concluded that most of the students will begin their research using screen-based text where benefiting from advanced search functions. But, after finding the proper material they often print it to be able to better comprehend the text.

Few decades ago, Dillon (1992) revealed results of studies conducted in the 1980s and early 1990s where he stated reading from screens was less effective than print. Most results indicated that reading from screens is 20–30% less effective than reading from paper. More recent study conducted by Noyes and Garland (2008) suggests that results are inconclusive in comparing print or screens and that there is only a small amount of results that support the earlier findings. Other studies published have produced inconsistent results, with many finding few significant comprehension differences between reading on a screen or on paper. According to Peter Reiman and Anindito Aditomo most studies show only a moderate academic benefit from technology and that "the effect of computer technology seems to be particularly small in studies that use either large samples or randomized control groups." Around the globe, students are reading like never before and spend more time to a screen. In fact, we read digital media every single day, whether it is on Facebook or in discussion forums.

To conclude, researchers, including psychologists, computer engineers, librarians and doctors, all have investigated the same and by no means is it settled. In the 1990s people read slower, less accurately and less comprehensively on screens than on paper. Studies published around and after 2000 have created more inconsistent results: earlier conclusions were confirmed, but many have found few significant differences in reading speed or comprehension between paper and screens. Nowadays, results still imply that people prefer paper, but attitudes are changing as technology improve and reading digital books for facts and fun becomes more common.

## 2. Research Methodology

As stated before, most of the experiments regarding learning, reading speed and comprehension were made for English speaking students. In our country, not one similar research has been done. So we have no data to adjust earlier results for Macedonian language. So we created our own surveys and experiments to determine differences in learning with technology or printed paper. Our primary goals were set to determine which way students use to learn materials and if possible to resolve which is faster or better.

This study involved 60 students from the Faculty of Education in Bitola. First, we wanted to see which way of reading and learning students prefer: printed paper or device. Next, we conducted a survey to see if students own some modern gadgets and what are they using them for. Last, we want to measure reading and comprehension on different texts, using both types of learning and see if there is a difference.

All materials were on different topics, but prepared to match the academic level the students were at the moment. Text was written in same font and size, both for printed and online material. After the reading they had to answer a small test regarding the material they finished reading. Only for participants with over 50% correct answers time stamps were taken into consideration. So, each participant had to read text on paper and four other media:

- desktop monitor, 19" screen, simple document, black letters on white background
- laptop 15" screen, simple document, black letters on white background
- mobile phone, 4.5" to 5.7" screen, simple document, black letters on white background
- tablet, 7" to 9" screen, simple document, black letters on white background

After completing the reading of each material, they were asked to answer basic questions related to the topic of the text. The total time to perform each task was recorded using a stop watch.

**3.Results**

**3.1. User preference**

The first survey was for participants to state which way they use for learning, printed or screen learning. Figure 1 shows that more than half of the students prefer reading from printed material. Only a third of them are using e-devices to read, and only small portion watches video tutorials as a way for learning. Main reason for choosing paper over screen is the past experience. Students acknowledged they are more familiar with reading books, as they have done this for most of their lives.

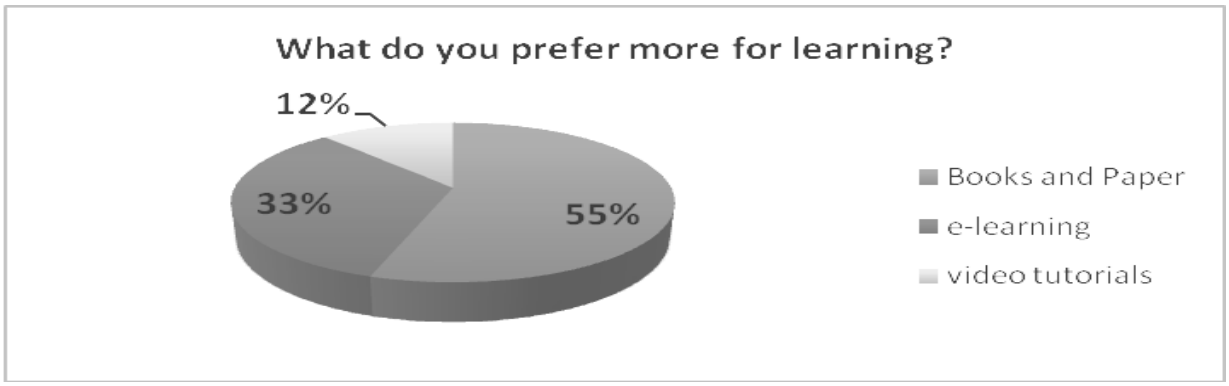


*Figure 5. Students' preference for learning*

The second survey participants have answered was about the number and type of devices they own and the reason they use them. Table 1 shows this data:

Table 4. Number of participants' devices

| **60 participants own** |
|---|

| | | |
|---|---|---|
| **Desktops** | 48 | 80% |
| **Laptops** | 56 | 93% |
| **Smart phones** | 60 | 100% |
| **Tablets** | 20 | 33% |

This means that every student has smart mobile phone and every student has at least 3 electronic devices that he uses on a daily bases. We have divided their devices in two groups according to their dimension and similarity in usage. First group was desktop and laptop computers and second one consisted of the smaller items like phones and tablets. In the Figure1 below we show for what purpose students use their devices for.

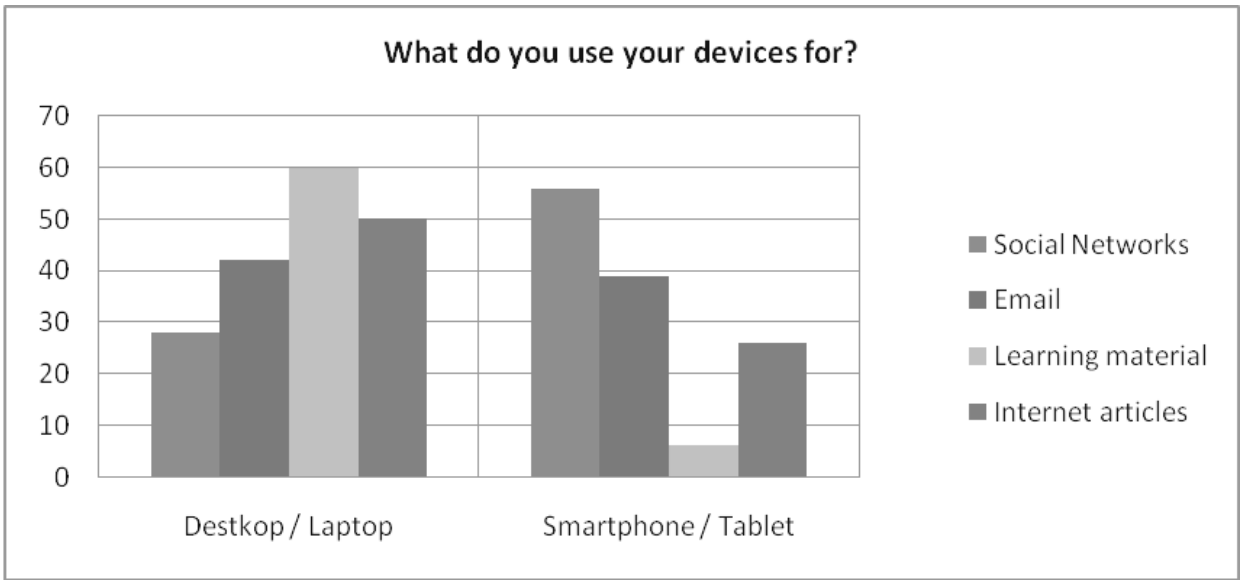


Figure 6. Everyday use of e-devices

Here we can see that students use their small devices, mostly phones, more often for social networking. This is understandable considering they have their devices with them, which means they are available online most of the time. Looking at the email stats we can see equally usage of the two groups of devices. Very large difference is notable when choosing the device for reading texts. Either reading internet or school articles, students choose the larger devices. On the question 'why' students answered that phones and tables are often distracting them when reading text. Frequently, phones send various notifications to users and while they are concentrating for learning, they get distracted by the messages. Using larger devices, with better control of the text, easier for scrolling, makes them more comfortable for reading on their screen. We will analyze the data by measuring reading speed and reading comprehension.

### 3.2. Reading Speed

Regarding previous experimental findings, reading from screen is considerably slower than reading from paper, where data imply a performance deficit of between 20% and 30% when reading from screen. But, the evidence for this argument is less than conclusive. A number of intervening variables, such as the size, type and quality of the screen may have contaminated the results in these modern days. Considering this fact we have tested reading speed on different screen sizes, starting from mobile phones to 22" monitors.

General results for reading speed on all mediums are shown on the table below.

Table 5. Average reading speed

| | |
|---|---|
| **Speed** | 225 words per minute |
| Min | 131 words per minute |
| Max | 345 words per minute |
| Standard Deviation | 59 words per minute |

According to the table, average reader can read 225 words per minute text written in Macedonian language. But the main question is whether reading from paper is faster than reading from screen. Here are the results comparing both speeds.

Table 6. Reading speed paper vs. screen

| | Paper | Screen |
|---|---|---|
| **Speed** | 233 | 232 |
| **Min** | 135 | 131 |
| **Max** | 345 | 338 |
| **Standard Deviation** | 64 | 58 |

We can see that the results are almost the same, which indicates that there is no significant difference in the reading speed. Applying T-Test to both sets returns P value of 0.9286, and that is greater than 0.05 which means there is no real difference in stats. Here we can conclude reading speed is the same.

But, are all screens readable at the same speed? Let's see if there is difference in speed between each medium.

Table 7. Average reading speed on different mediums (values are words per minute)

| | Paper | Desktop Monitor (17"- 22") | Laptop screen (14"- 17") | Tablet (7" – 10") | Phone (4.5" – 5,7") |
|---|---|---|---|---|---|
| **Speed** | 233 | 199 | 191 | 285 | 253 |
| **Min** | 135 | 131 | 131 | 199 | 201 |
| **Max** | 345 | 280 | 268 | 338 | 311 |
| **Standard Deviation** | 64 | 49 | 45 | 40 | 38 |

Table 8. Average reading speed on mediums (values are words per minute)

| | Paper | Large screens (Desktop and laptop) | Small screens (Tablet and phones) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **Speed** | 233 | 195 | 269 |
| **Min** | 135 | 131 | 199 |
| **Max** | 345 | 280 | 338 |
| **Standard Deviation** | 64 | 47 | 42 |

Clearly we can see difference in reading speed. The fastest way of reading is using small screen devices with 269 words per minute (wpm), and the slowest reading comes to big screens, with reading speed of 195 wpm. In-between is reading from paper 233 words per minute. But are these differences statistically supported? In the next table are shown results of comparing the three sets of data with T-test to see if there is significant difference.

Table 9. T-test to determine differences between mediums

| | **Paper vs. Large screen** | **Paper vs. Small screen** | **Large screens vs. Small screens** |
|---|---|---|---|
| **Average speed** | 233 vs. 195 | 233 vs. 269 | 195 vs. 269 |
| **Standard Deviation** | 64 vs. 47 | 65 vs. 42 | 47 vs. 42 |
| **P value** | p = 0.0021 < 0.01 | p = 0.0001 < 0.01 | P = 0.0001 <0.01 |
| **Difference** | Difference extremely statistically significant | Difference extremely statistically significant | Difference extremely statistically significant |

Table 6 shows that the differences stated before in the text are very significant.

*The verdict is that reading is fastest when it's done on small screen, especially tablet.*

**3.3.Reading speed with comprehension**

Reading comprehension is the ability to read text and understand its meaning, ability to read text and integrate with what we already know (Grabe, 2009). Fundamental skills required for comprehension are knowing meaning of words, ability to understand meaning of a word from discourse context, ability to follow organization of passage and to identify antecedents and references in it, ability to draw inferences from a passage about its contents, ability to identify the main thought of a passage, ability to answer questions answered in a passage, etc. and finally ability to determine writer's purpose, intent and point of view, and draw inferences about the writer (Davis, 1944). An individual's ability to comprehend text is influenced by their skills and their ability to process information.

In this part we will determine which way is the best when it comes to comprehension. All of the participants had to answer questions regarding the text they read. As stated before, only participants with over 50% success were taken into consideration. Results are presented in the next table.

Table 10. Paper vs. all screens – reading speed with comprehension

| | **Paper** | **Desktop Monitor (17"- 22")** | **Laptop screen (14"- 17")** | **Tablet (7" – 10")** | **Phone (4.5" – 5,7")** |
|---|---|---|---|---|---|

| **Correct answers** | **76%** | **65%** | **70%** | **72%** | **68%** |
|---|---|---|---|---|---|
| Speed | 245 | 195 | 192 | 283 | 254 |
| ***P value*** | | *0.0079* | *0.0812* | *0.0412* | *0.3071* |

From table 7 we can see no significant difference between speed and comprehension. All of the learning mediums are at the same level of the number of correct answers. Maybe paper is a little in front but not as much as most students believe. When these results are compared with table 4 we can say: reading from a tablet *may* give better results when learning.

**General verdict is that when comprehension is at stake there is no medium that has advantage.**

**4.Conclusion**

There are many debates today about whether technology is helping the learning process. Many educational institutions want to be the first to adopt new technology. This is mainly to the fact to keep up with changing environment for learning. On the other hand, technology can be a distraction for students, as it leads to multi-tasking and therefore poor grades or knowledge. Maybe this paper doesn't give the best answers, but certainly gives a base for future research. Printed materials are very effective ways to learn since these traditional tools are less distracting and easier to rely on in all circumstances. We must continue research on this topic and provide examples and resources to help educators and parents understand the role that each mediums plays in the classroom.

There may be economic and environmental reasons to go paperless, but there's something essential that would be lost with paper's termination. In our academic surroundings, we have books and articles that we frequently browse. Often, these books are at our hands reach, and we know exactly where to find the necessary information. It's difficult to imagine a similar level of experience with digital gadgets. Probably, paper will always be there in students' academic lives - no matter how much technology in the classroom evolves and improves.

From what we've learned in this paper is that students still prefer books and papers. Even though reading from phones and tablets is faster than paper, students aren't ready yet to throw away their favorite books and replace them with Kindle or similar items. To refer the title of this paper, technology doesn't change the way students learn, but only at this moment. We are conscious that reading on modern devices will continue. On-screen texts have many conveniences, which include speed of access. Screens have less in-depth reading than a paper and especially E-books help readers become more interested. With digital books now more portable, we may say that in near future technology can replace the paper and its benefits to the learning process.

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