

Screen vs. paper: what is the difference for reading and learning?

Based on a breakout session presented at the 38th UKSG Annual Conference, Glasgow, March 2015

We have all seen the newspaper headlines: screens make us read slower, learn less deeply, remember less and sleep worse. Is this why students prefer to print out their electronic textbooks? We suspected it was habit and attitude rather than measurable cognitive effort during reading that made people prefer print texts, but we needed evidence. We decided to find out what recent research had to say on the subject and read scholarly articles addressing the issues of the actual reading and/or learning processes involved in reading on screen compared to on paper. We then considered these results in relation to our own experience of using tablets and teaching scholars and students how to use their tablets/smartphones in their work.

Habit and attitude appeared to be important, and a digitally born textbook is by far the best alternative to a print textbook when it comes to studying. But even those who prefer to read on screens are originally native paper readers, and as long as the existing application interfaces cannot address the shortcomings of screens regarding spatial landmarks, we will keep returning to paper under certain circumstances.

We would like to see developers make more user-friendly e-readers, and authors and publishers learn to fully utilize of the potential of the e-book.

Introduction

It all started with a project at Uppsala University Library in Sweden called 'Mobile Academics', where we held seminars on how to use the library's e-resources on a tablet computer and gave tips on different apps to use when studying. This project led to another seminar about the difference between reading on screen and on paper. To prepare for it, we read scientific articles and picked out a few of those as examples. We chose to focus on the articles that were more current, since studies made on screens from 1985 cannot be compared with the studies made on today's screens. It is not only the devices that have evolved, either: people have, too. Back in the 1980s not many people owned their own computer, whereas today a great many more people do.



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Is it dangerous to read from a screen?

In the early years of the railway, people were seriously concerned about how the speed (18 mph or 30 kmph) would affect the human body. *The Lancet* published a landmark series of articles about the dangers of railway travel to public health in 1862, and at the same time 'railway spine' became a common diagnosis.¹

New inventions do make our lives easier in many ways, but they can also cause worries and troubles – both actual and imaginary. The trains did most certainly cause distress when they first came along and so does new technology today.

These days, no one is diagnosed with 'railway spine', but we do get 'iPad neck', 'computer vision syndrome' and screen-related sleeplessness.

Computer vision syndrome, a temporary condition with symptoms like headaches, fatigue and strained and dry eyes, can be prevented by closing your eyes or looking away from the



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50 screen every now and then. Reading on newer tablets with higher pixel densities spares the eyes, too.² As with any sedentary work, it is always good to take regular breaks to prevent strain injuries like iPad neck.

It can be advisable to shut off your screen a couple of hours before bedtime, even when you are 'only reading', because the blue light of the screen may suppress the body's production of melatonin, and this can disturb your sleep. Other ways to reduce blue light could be switching to 'night mode' in your reading app or installing a programme on your device that makes the colour of the display warmer at night.³

Is it more difficult to read from a screen?

Kretschmar et al. did a study in 2013 that compared reading effort on three different media: a paper page, an e-reader (e-ink) and a tablet computer. They studied eye movement, brain activity and reading speed. The participants also answered a few questions to determine reading comprehension. The interesting thing was that all participants said that they preferred reading on paper, even though the study found no support for it being more effortful to read on digital media. On the contrary, the older participants read both faster and with less effort on the tablet computer, due to the back lighting giving a better contrast, and because of this being better for older eyes.⁴

But why did all the participants still prefer to read on paper? The authors suggest that it is more about people's attitude towards the digital media than the actual reading experience: 'The present findings thereby suggest that the scepticism towards digital reading media ... may reflect a general cultural attitude towards reading in this manner rather than measurable cognitive effort during reading.'⁵

A study was undertaken in 2013 with tenth-graders in Norway, where the students were divided into two groups. One group read two texts (1,400–2,000 words) in print and the other group read the same texts as PDFs on a computer screen. In the reading comprehension test that was administered, the students who read on paper scored significantly better than those who read the texts digitally. It was easier for those who read on paper to remember what they had read. Mangen et al. say that this is because paper gives spatio-temporal markers while you read. Touching paper and turning pages aids the memory, making it easier to remember where you read something. Having to scroll on the computer screen makes remembering more difficult.⁶

'Touching paper and turning pages aids the memory'

Do you learn less when reading e-texts?

Studies that control for factors like experience and attitude among respondents are uncommon. In a study from 2012⁷, the authors Ackerman and Lauterman let 80 undergraduate engineering students read five texts either on paper or computer screens. After each text they completed a test, but before the test they had to make a prediction on how well they would perform in the test. They studied the texts under three different time conditions: for two texts they were allowed only seven minutes to read (pressured), for two texts they were allowed as much time as they needed (free) and for one text the participants thought they could use as much time as they wanted, but were interrupted after seven minutes (interrupted).

The paper readers generally got better results, but not under the interrupted time condition, for which the results were similar for both groups (see Figure 1), which is very interesting because if technology-related factors were what caused the inferior results for the screen-reading group, the results should have been the same under all studying conditions.

Small differences between prediction of performance and actual test scores means the students made an accurate calibration. A good calibration often leads to better results simply because you do not stop studying too soon. As shown in Figure 1 paper readers

51 generally make a better calibration than the screen readers, who tend to be more overconfident.

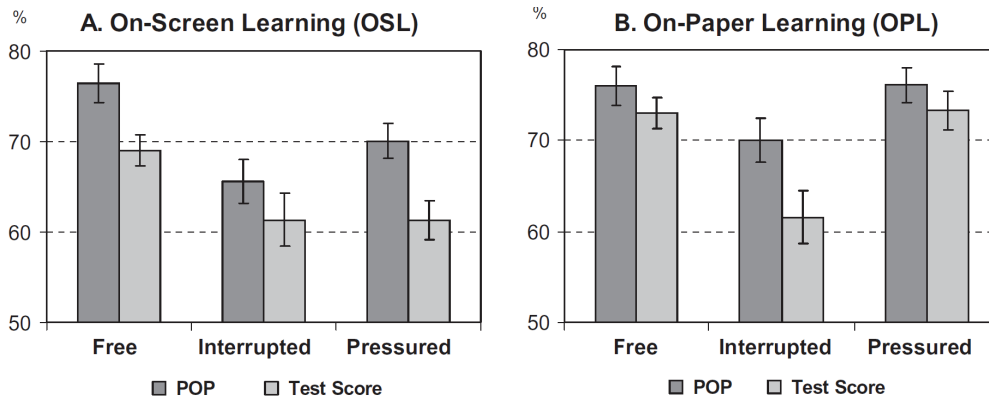


Figure 1. Mean test scores and predictions of performance (POP) for the three time conditions for screen and paper learning. Error bars represent the standard errors of the mean.⁸

The results of this study show that the problem with screen reading is more psychological than technological. But the study also argues that medium preferences matter, since those who studied on their preferred medium showed both less overconfidence and got better test scores.

‘the problem with screen reading is more psychological than technological’

Two years later Lauterman and Ackerman did another study⁹ to see if it is possible to overcome screen inferiority in learning and calibration. This time they let the students read six texts on either a computer screen or paper. The students were allowed seven minutes to read each text.

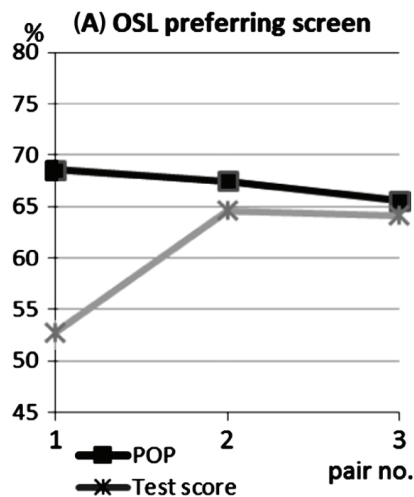


Figure 2. Mean test scores and predictions of performance (POP) for the three text pairs by their study order for on-screen learners (OSL) preferring screen.¹⁰

In the first pair of tests, the participants who studied on screen performed just as poorly compared to those who read on paper as in the study from 2012. But in the third test, already the screen readers who preferred reading from screens were getting scores similar to the scores of those who had read the texts from paper. Their calibration – the difference between the actual test scores and their prediction of performance – also got better and better for each text (see Figure 2). So, yes, it was possible to overcome screen inferiority in learning and calibration – but only for those who preferred reading from screens. They became less overconfident and got higher scores after only a few tests.

‘it was possible to overcome screen inferiority in learning and calibration – but only for those who preferred reading from screens’

What is the point of e-books?

There are many benefits of e-books, such as being able to access many books without carrying a heavy load. But as studies have shown, people still choose paper over screen. One big problem is that e-books are made to be read like a linear text, so the possibilities of the digital medium are not being utilized. The e-book just turns into a copy of the printed version, and why would anyone want to read a digital version if they are more comfortable reading a printed version?

In one study, a comparison was made between how well students learnt by using course material in paper format and the same material made into seven web pages, with no scrolling being needed. The paper format had a dictionary and study questions at the back, while the web pages had implemented a dictionary that was enabled by a mouse-over function, and the questions were placed next to the text where the answers could be found. The participants completed a knowledge test of 24 questions after reading their texts, and the web page group scored better on 18 of those questions, and significantly better (90% or higher) on six. So enhancing the electronic text instead of just turning it into a copy of the printed version seems to have helped the students to score higher on the test.¹¹

These students also had a brainstorming session on the future of study material. Most of the students said they preferred a web page or a computer programme over books, but they still thought that the written word was the best way to gain knowledge. The students wanted a total experience from their course material, with the texts being shorter and including a better overview, and being enhanced with video, sound, interactive tests and games. They also wanted their course material to be integrated with social media so they could stay connected with their peers and teachers, and they wanted their teachers to be able to update the material.¹²

'students wanted a total experience from their course material'

Are the users ready?

Last year, graduate students and faculty in science and engineering at the University of Kansas were asked about their e-book usage and preferences.¹³

Within the whole population, students *and* faculty, almost 40% preferred e-books. But among those of the respondents who primarily read on e-readers/tablets, 52% preferred reading on screens. Discomfort or difficulty in reading e-books on a screen was stated as the main reason they did not like reading e-books. Except for a preference for reading print books, 43% of the respondents said they were discouraged from using e-books because there are no relevant e-books available, 30% had difficulties in finding e-books and 15% were not aware that e-books were available at all. Interestingly, preferences were quite different between the departments. Physics & Astronomy had the highest preference for print books (80%), while the departments within the School of Pharmacy had the highest preference for e-books (59%). The authors suggest that the reason for this 'may be the curricular requirement to use the e-book collection, e.g. AccessPharmacy.'¹⁴

Does this mean that when our patrons have to read e-books, they get used to them, discover their benefits and start to like them? Since most libraries cannot afford to purchase all books in each format some users will have to read books on a medium other than their preferred one. So, while tablets are rapidly becoming everyman's property, perhaps libraries should purchase more e-books instead of print books. Then, if we manage to make them accessible to our users, perhaps there will eventually be no problem?

'perhaps libraries should purchase more e-books instead of print books'

Is the technology ready?

Many e-books at academic libraries have digital rights management (DRM) systems that restrict and complicate the downloading to tablets so much that some users avoid

53 reading the e-books at all. On some e-book platforms, you have to use Bluefire Reader for downloading books, even if you're an Android user, which is not ideal. Then if you do manage to download and locate the PDF file on your device, you can only use it for a few days and then you have to go through the whole downloading procedure again. But then all your notes and bookmarks will be gone. Then you try to read the e-book online, where you have to create another personal account to be able to save your notes and bookmarks. The online ebrary reader, for example, is by no means suitable for tablet browsers in any case: the text can appear rather blurry and you cannot highlight or underline any text at all, because when you try, you just move the whole text sideways.

Generally, the apps for e-reading lack the ability to present essential spatial landmarks, they give poor feedback on your progress as you read, and make it difficult for you to plan your reading since they do not show how much is left of the chapter/book in a direct and transparent way. Other drawbacks are that usually, the reading applications do not sync between devices and it is not always possible to adjust the text to the screen. Granted, you can reflow PDFs in most PDF readers, but then you cannot make any notes and all tables and pictures will disappear from the text.

There are exceptions, but the more user-friendly apps we have tried do not support DRM and can therefore not be used to read library e-books.

How will we read in the future?

You need to get used to a new type of medium before you can use it to its full potential, and feel comfortable doing so. Today, 57% of all two-year-olds in Sweden are using the internet – most of them on a tablet computer.¹⁵ Those children are used to the technology, but that is not enough to master the art of digital reading. We think that the way children are taught to read and study in school is vital. If schools were able to integrate digital learning better, it would probably make it easier for those students to use e-books, and make them want to use them instead of print. Digital literacy will be an essential skill as more tests (such as Sweden's nationwide school tests and exams) become available only in digital form – and if tests are only available in digital form, it might be more difficult for some just because they are not comfortable with the format.

'the way children are taught to read and study in school is vital'

In 2013 the medical student Joshua Harding spoke at the UKSG Conference in Bournemouth.¹⁶ He was completely paperless – he had all his notes and his books on his iPad – but most students are not there yet, and we believe there will be a mixed behaviour for many years to come. As long as we are not all native digital readers, there will be occasions when most of us will be more comfortable reading printed text, for example, when proofreading.

'there will be occasions when most of us will be more comfortable reading printed text'

More native paper readers will choose e-books when the online reading platforms and reading applications for tablets and smartphones are more user friendly and compensate for the lack of spatial landmarks that many native paper readers experience when they try to read e-texts.

When you can easily find and download a suitable e-book, that also utilizes all the possibilities that the electronic medium offers and is not just a direct translation from print, that may be the day when all students will prefer e-books.

Competing interests

The authors have declared no competing interests.

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