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Reading and learning from screens versus print: a study in changing habits

Part 2 – Comparing different text structures on paper and on screen

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Abstract

Purpose – The aim of this paper is to research the difference in reading and learning from print versus electronic media in a professional and educational setting. To what extent does the materiality of the medium influence the efficiency and effectively of the reader? What is needed to create “digital born” information rich texts? In part 2 changing presentations of educational texts on paper, LCD screen and through a mind map are addressed.

Design/methodology/approach – In depth comparative tests with a great number of subjects between print-on-paper, e-ink screens and LCD screens. In part 2 the results of learning from differently structured texts from paper, screen and mind maps respectively are reported. The subjects had to read the texts and subsequently had to answer knowledge questions about the content. Group discussions have been carried out thorough the test.

Findings – All tests show that print-on-paper is still a superior medium for learning and digesting complicated and elaborate texts, while electronic screens are appreciated for quick information gathering, communication and navigation. Electronic representations of information and knowledge demands that the structure of the writing has to change.

Research limitations/implications – Given the rapid development in electronic displays, many issues – in particular ergonomical – become a “moving target”. An important limitation – which is one of the quests of this research – is the lack of sufficient genuine digital born texts.

Practical implications – The need is to start and review the writing process; the appearance but also the structure of information and knowledge rich texts. A second issue is the need to develop easy capabilities to make electronic texts as easy a “tool” as the print text with underlining, comments and notes.

Originality/value – This is deep qualitative research in comparison with quantitative tests and a comparison between professional information acquisition and learning

Keywords- Electronic publishing, Digital libraries, Learning, E-books, Information dense texts, Reading.

Paper type- Research paper

1. Introduction

In part 1 of this report “Reading long information rich text” on the results of the research project Amsterdam E-Boekenstad (Book City)[1] the context of emerging e-reading is extensively discussed. The authors refer the reader to the paragraphs 1. Introduction and 1.1. Measuring usage, for a discussion on the general aspects of the quest for understanding reading from various substrates such as paper, LCD computer screens and e-ink (Stoop et al., 2010).

In the tests reported in part 1 the subject was reading long informative and information dense texts. In the first test, members of city councils in and around Amsterdam tested the usage of E-readers, with a large screen that allows for full page reading, as substrate of their complete reading load as council member, which are about 100 pages a week. In the second test a comparison was made between reading a complete book by students for an examination from paper, laptop and e-ink reader respectively.

The important conclusion from both tests was that intense reading in order to internalize information and knowledge rich texts demands leafing, browsing, and annotation. The substrate paper was considered superior to electronic displays, as they do not allow (yet) the flexibility of paper.

In the tests reported in the following, the emphasis is to understand if and how a different structuring of text will help, or is necessary, in the transition from paper to screen presentations of complicated texts.

In the third test, reported in the following, with 196 students, the scores are compared of text comprehension where the same content was differently arranged on paper and on a LCD screen. In this test the authors collaborated with the educational publisher SDU (www.sdu.nl)

In the final test with 173 students, in collaboration with the educational publisher Noordhoff (www.noordhoffuitgevers.nl) a comparison is made between the results of learning from a paper source, with the aid of a web site with complementary materials, and from learning with the use of a mind map, with various add-ons integrated in a digital úle on a computer.

The authors analysed the results of these last two studies statistically. In addition, extensive group discussions were held with the participating students in order to interpret the results qualitatively.

2. Third test: learning from paper versus computer screen

2.1 Introduction

After two more qualitative tests, reported in part 1 of this study on sustained reading from screens, in this controlled test students were confronted with new material, not part of the curriculum, but still within their intellectual reach. The main, practical, reason for this was the availability of teaching material from the publisher partners.

A group of 196 students from the authors’ school took part in this third experiment. Here, a text on internal communications within companies was used (van Riel, 2010). This text was not part of the curriculum, but had relevance within the broader reach of the study programme. An important aspect here and in the subsequent test is that it dealt with a single aspect of a larger treatise. As it became clear from all discussions, students have the tendency to read only those parts of a book the teacher prescribes, therewith limiting their self-education to the formal minimum of examination requirements. Hence, in breaking up learning lines into comprehensible chunk introduces the danger of a limitation of the context of the teaching material. Nevertheless, for the present research goal a single issue was sufficient.

Two groups were created. Half of the students worked with a paper version, while the other half used the computer. The paper version comprised a couple of paragraphs from the book, a separate dictionary and a separate list of rehearsal questions derived from the material at the end, all put together in a paper reader.

The other group studied exactly the same text, but presented in the form of seven consecutive web pages. In this version, the text was restructured to fit onto a computer screen. A mouse-over enabled the dictionary (so, a small pop-up window containing the lemma becomes visible if the mouse hovers over a word), while the rehearsal questions were situated together with the relevant parts of the text.

2.2 Research objective

In this test, the purpose was to test the following hypothesis: “When study material is offered in an interactive form, the learning results of the user are higher than when the same material is offered in print.” A secondary goal was to understand why one method would score better in learning results than the other method. Furthermore, the authors wanted to discuss the future of study material with these students in order to be able to make recommendations to the collaborating publishers. In this test, the authors worked together with SDU Publishers, who provided both the print version as well as the electronic version of the text.

2.3 Method

The first part of this third study entails a quantitative experiment to detect possible differences in “learning results” between the two groups. The groups read the texts and could check their understanding via rehearsal questions. The study results were measured in a separate knowledge test containing 24 questions that all participating students had to complete immediately following 25 minutes of study. The experiment took place in a controlled situation. The students were randomly assigned to the two experimental conditions:

- 1- Experimental group (n = 100) using the interactive version on a PC.
- 2- Control group (n = 96) using the print version.

In order to gain further understanding on why one method would score better than the other, group discussions with 31 students were held. These were mixed discussions that took place immediately following completion of the knowledge test and in a different room from that where the tests were carried out. Apart from gaining insight into how the students had experienced the way of learning, this opportunity was also taken to brainstorm them about the future of ‘study material’.

2.4 Sample

The participation of the 196 students was voluntary, but they received €10 as a teaser. They were randomly assigned to each one of the groups.

2.5 Results

2.5.1 Quantitative results.

In six of the 24 knowledge test questions, the “print group” scored better, although statistically speaking, this was not significant. On the other hand, in the remaining 18 cases, the “PC group” scored better, of which six had a statistical significance of 90 per cent or higher. Chi-square analysis was undertaken in order to determine whether or not there were significant relationships between learning result per test question and experimental condition. The results of these six questions that showed a significant relationship are presented in Table 1.

When one looks at the structure of these six questions, no striking similarities can be found. In other words, it is not a specific type of question which made the computer group score significantly better. This hypothesis can be confirmed for six out of the 24 test questions, with a level of significance of at least 90 per cent.

Table 1: Overview of test questions showing significant relationships

Question	% correct in print group (control group)	% correct in computer group (experimental group)	χ^2	% of significance
1	87.5%	97%	6.25	98%
4	90.6%	97%	3.46	90%
5	78.1%	89%	4.24	95%
8	85.4%	98%	10.34	99%
15	88.5%	95%	2.73	90%
20	61.5%	73%	2.97	90%

2.5.2 Qualitative: why the “pc group” scored better.

Group discussions were held with 31 students. In these mixed discussions, students explained how they had experienced studying in their respectively different ways. This helped to interpret the results of the quantitative part better. The conclusions can be summarised as follows.

Students have problems with long consecutive texts and prefer reading comprehensive chunks, immediately followed by exercises and questions, as was the case with the “computer group”. Contrary to the second study, discussed in part 1, where students had to read a whole book, this study material consisted of “only” seven web pages with auxiliary texts. These pages fitted the screen, so no scrolling was needed. None of the students complained about weary eyes or a lack of overview.

Students study actively, which means that they make notes and summarise the material read in their own words. This turns out to be very difficult on the PC. Scrap paper was available for all participating students. Although it was not measured how many of them used scrap paper exactly, it was clear from the amount of used paper that most did.

The rehearsal questions were appreciated by both groups, but used differently. The “computer group” used them intensively, while the “print group” hardly used them at all. Rehearsal questions help to determine what the main issues of the text are. The fact that in the electronic version the questions are bound to the relevant part of text, contrary to the print version where the questions were placed at the end of the text, acted as stimulation to the groups to answer all the questions and to do so immediately. Students of the “computer group” even first read the question, and then the text, in order to gain a better understanding of the text. Students of the “print group” did not attempt to check the questions while reading (although the introduction indicated that there were questions offered at the very end of the text), and only consulted them after reading, and only when they had time left. If they had more time, they would have liked to have a better look at them. So, these students kept a linear reading pattern.

For the “computer group” the dictionary was enabled by a mouse fly-over. This acted as stimulation for them to use the dictionary actively while reading the text, whereas the “print group” only consulted the dictionary after reading, at the end of the text where it was situated, and only if they had time left.

Of course, a correlation cannot be proven between actively using the rehearsal questions and the dictionary on the one hand, and having better scores on the test on the other hand (because there might have been other influences as well), but this is likely to explain the higher scores of the “computer group”. Students were better able to digest the knowledge if the primary text, the dictionary and the rehearsal questions were intertwined. Of course, this tells us something about the modes of learning of the students in this applied educational environment. This might be different in a research university setting and hence suggests the need for comparative tests.

2.5.3 Qualitative: the future of study material.

The group discussions with the students ended with a brainstorming session about the future of study material. Thus this part of the study might help to promote an understanding of what the actual future will look like as seen from the present. It indeed helps to understand what these students think, here and now, and what is realistic and/or useful to them.

An interesting result is that these students would like to get rid of the term “book”. Why should study material be presented (mainly) as books? With new technologies and interactive possibilities, one might wonder whether a book is still the most effective way to transfer knowledge. Almost all of the students considered a kind of web site or computer program that would replace books in the future. It could be something that would consist of multiple layers. The upper layer would be a sort of summary and, if one wants to know more about a topic, one can click to enter deeper levels of understanding. Written text, as a way to transfer knowledge, will always remain the basis, according to these students. This is mainly due to the external pacing of written text. The texts should be short and manageable. Scrolling should become something of the past. Having a good overview is very important. Texts should be accompanied by video, audio, interactive tests and games. In this way, studying could become more of a “total experience”.

All students spoken to during these different studies said that they like to study in a more active fashion. That means “doing” something with the material. In the easiest way, that can be explained as marking, making notes and making summaries, but with new technologies “doing something with the material” could mean much more, such as conducting tests, interactive games, rehearsal questions, etc. Furthermore, social media could be integrated within the material, so that people can work together on topics and/or ask questions to each other, and have discussions. Furthermore, one last advantage of “e-study material” is that the author can update the content.

One of the most interesting results of the brainstorming sessions, however, is that almost all of these students became really excited and enthusiastic when thinking about future possibilities. They thought that study could become a really pleasant and exciting activity this way.

2.5.4 Conclusion of test three.

The authors’ hypothesis that the general learning results would be higher in the group that studied in the interactive form can be confirmed for 6 out of the 24 test questions. Probable reasons for this result are that students who used the interactive form were more likely to use the dictionary and use the rehearsal questions as part of their learning process, whereas the students in the “print group” only consulted these two “extras” at the end and only if they had time left over. For this last group, these features were not perceived as an integrated part of the learning material. Therefore, it can be tentatively concluded that the order and way in which learning material is presented influence the degree in which it is actually used and consulted. Extra features, such as a dictionary or rehearsal questions, should be firmly tied in to the relevant parts of the text.

3. Fourth test: interactive mind map versus printed text with additional web site

3.1 Introduction

A one-to-one translation of a traditional printed study book into an electronic book, e.g. in PDF form, does not provide any significant added value, as the first and second study illustrated. Only if the electronic book has some additional interactive features, such as a dictionary that pops up via a mouse-over, and where rehearsal questions are related to the relevant text parts, does the learning result appear to become affected positively, as the third study indicates. Now what happens if this electronic form is taken one step further? That is what happened in the fourth study. Here the collaboration was with the educational publisher Noordhoff, who provided the test material. For this test, ten pages from the book *Geowijzer* by Peters and Westerveen (2010) were used. These are texts about Dutch landscapes. This

subject has no direct relation to the curriculum of these students, but provides a nice mix of text and video and is intellectually on a par with the level of the students.

Again, differences in learning results were tested. In this case, roughly half of the participants studied from an interactive mind map (see <http://nyjmolen.home.xs4all.nl/mindmap.htm>), and the other half studied from a print reader supported by a web site (see <http://nyjmolen.home.xs4all.nl/geowijzer.htm>) offering video material, summaries, rehearsal questions and a dictionary. This combination was chosen, as currently more and more study books offer a supporting web site with additional features that students can consult. It is important to mention, that in this test, both experimental conditions offered literally the same text and the same additional features. However, the forms of presentation differed completely.

3.2 Research objective

The hypothesis to test was: “When study material is offered in an interactive mind map, the learning result is greater than when the same material is offered in print supported by an additional web site”. Even more than in the previous study (test 3), the relevant material was tied together, this time in an interactive mind map (i.e. video’s, dictionary, etc. were located right at the relevant part of text), whereas the students in the control group (print with web site) had to look up the additional features on a computer that was in front of them and preset on the right web page. A secondary objective was to gain insight into why one method would score better than the other.

3.3 Method

The first part of this study entailed a quantitative experiment to determine possible differences in “learning results” between the two groups. This was measured by a knowledge test of 24 questions that all participating students ($n = 173$) had to answer directly after 30 minutes of study. The experiment took place in a controlled situation. The students participated voluntarily, but received a €10 reward, and were randomly assigned to the two experimental conditions. The first experimental group of 82 people used the interactive mind map; the control group of 91 people used the print version with a supporting web site.

In order to gain a further understanding as to why one method would score better than the other, group discussions with 25 students were held. These were mixed discussions that took place immediately following the knowledge test in a separate room.

3.4 Sample

A total of 172 of all 173 participating students studied at our School of Design and Communications of the University of Applied Sciences in Amsterdam.

3.5 Results

3.5.1 Quantitative.

The group which studied from print with supporting web site scored better on eight out of the 24 test questions. The mind map group, on the other hand, scored better on the remaining 16 test questions. The first impression is therefore that the mind map group had a higher learning result. However, when restricting to statistically significant differences only, it appears that the print group scored better. On the eight test questions on which this group scored more highly, in three cases it was significant, hence meaningful. Conversely, the mind map group scored significantly more highly on only one question. Table 2 provides an overview of the questions where significant differences between the two groups were found. The calculated χ^2 should be greater than 2,706 for a significant difference with a reliability of at least 90 per cent. The higher the calculated χ^2 value, the more meaningful the observed difference

and the higher the reliability rate are.

Table2: Overview of test questions showing significant relationships between the groups

Question	% correct in print group (control group)	% correct in mind map group (experimental group)	χ^2	Percentage of significance
1	83.5	93.9	4.55	95%
5	65.9	48.8	5.20	95%
16	92.3	84.1	2.81	90%
20	93.4	82.7	4.77	95%

It appears that the non-significant differences were often not even “almost significant”, and where they are, they equal out for both groups. It must be concluded that the results are far from unequivocal. Nor can it be concluded that one study method works better than the other. Increasing the sample size would probably not lead to clearer results, as there is no evidence that this would be in favour of one of the test groups. For the learning results, it did not matter much whether participants were studying from print with supporting web site, or from the interactive mind map. Both forms had advantages and disadvantages. This is further discussed in the group discussions. Thus, the hypothesis that the interactive mind map provides better study results in this context has to be rejected.

3.5.2 Other interesting quantitative findings.

Apart from answering the 24 test knowledge questions, the participants also answered some other questions about their behaviour. These responses are analysed below..

First, it is interesting to know how many video clips the students had viewed. In the interactive mind map, four video clips (about the texts) could be found. The clips were related to the relevant text part (and therefore set apart from each other). For the other group, the four video clips were presented side-by-side on the supporting web site. The percentage of students who watched all four fragments is significantly higher in the print group (42.9 per cent), compared to the mind map group (22 per cent). However, interestingly, the percentage of students who did not watch any video at all is also slightly higher in the paper group (30.8 per cent) compared to the mind map group (26.8 per cent). The students in the print group were more inclined to view all videos, once they had decided to watch one, clearly because the 4 videos were presented side by side. In the mind map group, more variation can be seen in the number of videos viewed. This is presumably due to the fact that in the mind map, the video clips were spread out over the map. Students studying from the mind map watched two or three clips more often compared to the students from the other group. Thus, the study method has an influence on the number of videos watched, but it is not such that, with one method, more videos were viewed in absolute terms, than with the other method. χ^2 analysis confirmed a significant association between the study form and the number of videos viewed. χ^2 is 19,4, indicating a reliability of at least 99 per cent. If videos are offered together, the student is more inclined to watch all the videos. However, if videos are presented separately, but related to the relevant text parts, students are more inclined to watch the video immediately after or before reading the relevant text parts. Remember the results from the previous test, where rehearsal questions were located together with the relevant text. Clearly putting things in front of their noses makes students react. Table 3 shows the percentages.

Table 3: Amount of watched videos compared to study method

Did you watch the available video clips?	Total	How did you study?	
		Print, with additional website.	Interactive mind map.
	%	%	%
yes, I watched 4 videos.	32.9	42.9	22.0
yes, I watched 3 videos.	15.0	6.6	24.4
yes, I watched 2 videos.	12.7	7.7	18.3
yes, I watched 1 video.	10.4	12.1	8.5
no, I didn't watch any videos.	28.9	30.8	26.8
N	173	91	82

In the previous study (study 3), it was observed that many students used scrap paper. Therefore, in this test, this use was measured to see whether study method had an influence on the use of scrap paper. The participants were allowed, if they wished, to use scrap paper during the study but had to hand their notes in before the knowledge test started. However, there appeared to be no significant relation between the use of scrap paper and the method used (χ^2 is 0.82). The quantitative results are shown in Table 4. Qualitatively the way the different groups used scrap paper shows no remarkable differences.

Table 4: Use of scrap paper compared to study method

Did you use scrap paper while studying?	Total	How did you just study?	
		Paper, with additional website.	Interactive mind map.
	%	%	%
no, I didn't.	22.5	25.3	19.5
yes, I did.	77.5	74.7	80.5
N	173	91	82

Finally, the students were asked which group they personally thought would score better on this test. This led to an interesting result. The students believe that students from their own group would score better. In the print group 79.1 per cent shared this

opinion. The students of the mind map group were less outspoken. It should be noted that the students answered that question without actually knowing how the other study method worked. Hence, their belief is based on a prejudice. The relationship between study method and the expectation of which of the groups would score better, is highly significant (χ^2 is 27.33, so the level of significance is over 99 per cent). See Table 5.

Table 5: Expectation of test result compared to study method

With this experiment, half of the students studied from print with additional website, the other half studied from an interactive mind map. Which group scores better on the knowledge test (that you also just made)?	Total	How did you just study?	
		Print, with extras on the computer.	From the Mind map on the computer.
	%	%	%
The print group'	60.7	79.1	40.2
The 'mind map group'	39.3	20.9	59.8
N	173	91	82

3.5.3 Qualitative: the use of the interactive mind map.

Students first had to become accustomed to the mind map as for them it was a new way of representing teaching materials. In the discussions, the following items emerged. The largest, perceived advantage of the mind map is that, by itself, it represents a kind of folded “summary”. In particular, as these students had only 30 minutes to study the material, such a summary was appreciated. For larger amounts of material and, if they would be allowed to study for longer than 30 minutes, which is the case in regular learning situations, the mind map is considered questionable. A folded “summary” felt too constrained. They suggested a nervousness of missing important things.

On the other hand, a disadvantage of the interactive mind map is the perceived lack of overview. The computer screen becomes an obstacle between the students and the mind map. The unfolded mind map is very large and a large fraction does not fit the screen. This means that the screen window has to be manipulated over the map. In particular, this becomes problematic as at the start it is unclear how large the unfolded mind map actually is. Thus, the students could not easily estimate how much material they had to study and accordingly how to spend their available time. Although the mind map in the test was perceived as a summary, many students still felt the need to make their own summaries on scrap paper. Writing things down is part of the learning process. This brings us to an interesting conclusion that clearly flipping through pages does provide an easy understanding of the total volume of the material, while moving a screen window over a large two-dimensional map does not.

3.5.4 Qualitative: the use of the print reader with additional web site.

Almost everybody in the evaluation “print” group also consulted the additional web site. This mimics the situation that is now common practice, that study books offer an additional web site with extra material. There was no threshold in the setup to do so, as the computer was placed right in front of the students and pre-set on the specific web page. Interestingly, the students reported that they hardly ever consult the extra sites of their study books. They consider it too much trouble to swap from their paper book to the computer, find the specific web site and use necessary logins codes. This hurdle was removed in the test.

Again (as in the previous studies), it can be concluded that students use/read/consult study material when it is presented to them in a convenient and integrated way. Just packing together different technologies does not improve the learning experience. For the educational publishers, the students suggested that the additional material on the web sites must be advertised at the relevant place in the text of the book. They also should make it very clear what can be found on the site, and why it should be accessed. Then an additional web site can be very helpful, these students think. It could help them fulfil the need to study actively, by offering extra explanations, summaries, definition trainers, video material or even educational games. The conclusion of these discussions is again that various media

have to become integrated and mutually referenced in a coherent and systematic way. It must be clear from the learning process why, when, and how a swap between screen and paper is a favourable activity in the learning process.

3.5.5 Qualitative: the use of scrap paper.

In all previous experiments, the authors encountered the pressing issue of reader annotations. In this study, we followed Haas (1996), in particular ch. 4), by looking at the scrap paper used. White paper sheets were handed out to all participants and collected afterwards. Most students did indeed use scrap paper, see Table 4.

Interestingly, apart from scribbles, almost all paper was used to make notes, overviews and summaries, and in many cases just quotations. It clearly proves the old observation, everybody also knows from her/his own experience that writing up something is a most important mental aid for the memorisation and internalisation of knowledge. This is also stressed by Grafton (1999) when he discusses the new active way of reading, and a clear break with the scholastic past, by humanists in the late fifteenth century, when the book began to be used for annotations and for abstraction and reformulation of the content by the reader.

Summarizing is a filtering process. By summarizing, the reader emphasises her own priorities and decides on which topics is no further attention needed. More research is needed on the question of to what extent making notes on separate sheets of paper or making a summary by typing on a computer, makes a difference. Although, on a computer “cut and paste” is an easy way of summarisation, it misses the active reformulation of the content via writing. It goes without saying that on the computer, students are more able to create order, because that is what they are after. However, the didactic question remains to what extent rewriting helps in internalizing the content. Scribbles are found frequently – their role in the learning process also demands further investigations.

3.5.6 Conclusion of test four.

There are no clear differences in the learning results of the group that studied from the interactive mind map, compared to the group that studied from print with the help of an additional web site. The hypothesis, for this situation, that the mind map enhances the results in an unequivocal way has to be rejected.

The mind map was perceived as a summary, which was considered as most useful when one has only 30 minutes study time. For larger texts and more elaborated topics, an interactive mind map would probably be less practical. The main negative aspect of the mind map was that students felt a lack of overview, as they could not predict how large the map would become – the unfolded mind map did not fit the screen size by a long way. The screen actually stood in their way as a hindrance to a comprehension of the full richness of the mind map.

The students in the print group did visit the additional web site and found that useful. “Normally” though, they told that they are not so eager to consult additional web sites that come with study books. It is perceived as too much trouble and offering too little benefit. Therefore, additional sites should be clearly integrated with the text and each other, with high quality and relevance as well as being easily accessible. They should really offer added value, and when they do, these students would very much welcome them.

For the way people study, it matters in what order study material is presented. If videos are offered together with the other material, then students are more inclined to watch all the videos. However, if videos are presented separately, connected to the relevant text parts, students are more inclined to watch the video immediately after or before reading the relevant text parts.

Thus, in order to let students make optimal use of available material, material should be located at relevant places and not be “hidden away” at the end or put away on an additional web site with no “natural” accessibility. An important issue reported by Zacharis (2011), is the relationship between

learning style and material used. Further investigations along those lines demand longitudinal studies, which were unfortunately beyond the authors' reach, although Emerson and MacKay (2011) report better results for students who learned the lessons from print rather than online, no pertinent reasons could be identified.

4. Summary, general conclusions, discussions and recommendations

After the investigations in sustained reading of information and knowledge rich texts as reported in the first part of this paper (Stoop et al., 2010), in this second paper the orientation is on the comparison of the same text in different presentations. In two tests reported here, both with almost 200 students, the students were asked to study a text for about 25 minutes and subsequently fill out a knowledge test. With a selection of the students, round-table discussions were held. The test students showed a great interest in a precise definition of the material, exemplified in the better results of the group who used well-defined chunks of text on the computer as compared to those who used the full consecutive print version. In the case of a mind map presentation the lack of overview was a serious point. Students commented that teachers often only prescribe parts of books and therefore inferred that only part of the material is worthwhile reading for an examination. Here a serious issue is encountered, as it exemplified the tension between the conscious build-up of the material by the expert author of a book on the one hand and, on the other hand, the course goals as defined by the local teacher. This goal is mostly defined by the demands for passing an examination and not necessarily for full comprehension of a field. This fact together with the conception of many students that you do not have to read whole books to pass the examination, we are immediately confronted with the challenge of how to write and edit study material that stimulates the students to read and view, in the case of videos more than the bare minimum. A deep knowledge of the various interactions between a basic text, auxiliary material, and related texts is needed and demands further longitudinal research. In all the tests, the use of scrap paper turned out to be a universal aid. The writing of keywords, short sentences or mini-abstracts helps to internalise the content. The same is true for scribbling in the margins, underlining and highlighting with a marker. In the various discussion groups, students stressed the tactility of the book. Having a document in your hand, and keeping it close is also a way for isolating the learning material from the outside world. Working on a laptop was distracting because of the many other applications "at your fingertips".

Two main conclusions can be drawn.

- (1) In the transition from paper study materials to electronic materials, a full capability for marking, scribbling notes, etc., is imperative. This does not mean that people cannot become accustomed to all kinds of note-making applications in document-handling software. However, there remains a big difference between writing, typing, and "cut and paste". In the authors' opinion, this conclusion is a hard demand for the development of educational learning materials.
- (2) The second conclusion is that authors have to be aware that reflective questions and exercises have to be designed differently when an e-reader or computer is used. The relation between questions, exercises and the running text must be integrated. Turning pages is something completely different from scrolling down screen text. The place and use of all auxiliary texts via mouse-overs, or hyperlinking, demands intense research in order to allow a new screen-based order in which the integrity and integration of the main text and other texts is guaranteed and where switching between the main text and auxiliary texts becomes fluent.

As mentioned previously, these investigations were carried out in the middle of a stream of changing technology. The screen technology and software developments are still changing continuously. In that way, the other bank of the stream is still ill-defined and receding. While in the first test, the speed of

turning pages on an e-ink reader was indicated as an obstacle, the latest versions of e-readers are many times faster. In addition, the screens of tablets improve year by year, slowly closing the distance in readability between e-ink screens and LCD screens.

In this paper, the first tests are reported in providing teaching material in different forms, using print text versus differently structured electronic text as well as a mind map and an auxiliary web site. Although we can be sure that the hardware and software in question will considerably improve over the next years, it can be concluded from these early tests that, in the presentation of educational material, form and content are firmly connected. The more data or facts, the easier an electronic model will work. The more reasoning, examples and digressions are needed, the more clearly will written text with integrated multimedia components and test questions be needed. This all indicates that electronic textbooks and other electronic learning materials are much more than a collection of snippets of text linked to a database of pictures, videos and audio files. The new way of reading and learning, using electronic devices, allows for fast and comprehensive delivery of materials but also induces new ways of composing, structuring and mutually relating the various presentations of the underlying knowledge and instructions.

Further research is needed in longitudinal studies to find out to what degree habituation plays a role, as well as in-depth tests with authors and students on how the print structure of a text-book can be transposed to the more flexible electronic future.

Note

All full reports of the entire project are available in Dutch online at <http://eboekenstad.nl>

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