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The Changing Role of Textbooks in Primary Education in the Digital Era: What Can We Learn from Reading Research?

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Textbooks have been the primary teaching tool since the 19th century. By their nature, they contained a comprehensive compilation of the content of a particular subject with the intention of explaining it; this knowledge, in turn, was usually filtered to conform to a particular society's expectations of elementary knowledge about the natural and social environments. There has been a great deal of research on how the content of textbooks has changed in line with changing values in different societies and over different periods. However, little research has been done on how textbook reading substrates and design have changed and how these changes have affected learning and comprehension: studies that systematically examined the effects of different reading substrates and different layouts on reading and learning comprehension did not appear until the late 20th century and early 21st century. We examine such studies and PISA 2021 results to draw five conclusions for future textbook research. These conclusions indicate that screens are worse than printed texts for some types of reading, while interactivity and dynamic design are not values per se but require coherent design to improve reading performance and higher-level thinking skills.

Keywords: textbook, educational publishing, reading, audio reading, reading substrate

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Spreminjajoča se vloga učbenikov v osnovnošolskem izobraževanju v digitalni dobi: česa se lahko naučimo s pomočjo raziskav branja

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Učbeniki so od 19. stoletja osnovno učno sredstvo. Po svoji naravi so vsebovali celovit povzetek vsebine določenega predmeta z namenom, da bi jo razložili; to znanje pa je bilo običajno filtrirano tako, da je ustrezalo pričakovanjem določene družbe glede osnovnega znanja o naravnem in družbenem okolju. Veliko je bilo raziskav o tem, kako se je vsebina učbenikov spreminjala skladno s spreminjajočimi se vrednotami v različnih družbah in v različnih časovnih obdobjih. Malo pa je bilo raziskav o tem, kako so se spreminjale bralne podlage in oblika učbenikov ter kako so te spremembe vplivale na učenje in razumevanje. Študije, ki so sistematično preučevale učinke različnih bralnih podlag in različnih oblik na branje in učno razumevanje, so se sistematično pojavile šele konec 20. stoletja in v začetku 21. stoletja. Preučili smo več takšnih študij in rezultate raziskave PISA 2021 ter oblikovali pet sklepov za prihodnje raziskave učbenikov. Ti kažejo, da so zasloni pri nekaterih vrstah branja slabši od tiskanih besedil, medtem ko interaktivnost in dinamična zasnova nista vrednoti sami po sebi, ampak za izboljšanje bralne uspešnosti in spretnosti mišljenja na višji ravni zahtevata skladno zasnovo.

Ključne besede: učbenik, izobraževalno založništvo, branje, zvočno branje, bralna podlaga

Introduction

For a long time, textbook research was primarily concerned with the content of textbooks and their embeddedness in cultural contexts (for more on this, see Fuchs & Bock, 2018). This paper examines textbooks from a different perspective: it focuses on the changing materiality and design of textbooks and asks what technological, social, didactic, and economic forces were behind these changes, whether changes in design and textbook substrates affected learning and reading processes, and whether these changes correlate with students' abilities to higher levels of reading such as deep reading. In the context of this paper, we see deep reading as an 'array of sophisticated processes that propel comprehension and that include inferential and deductive reasoning, analogical skills, critical analysis, reflection, and insight' (Wolf & Barzillai, 2009; see also Baron, 2021; Wolf, 2016, 2018). In short, we consider deep-reading abilities as something going beyond the bare extraction of information from the text: it forms one of the foundations of critical and creative thinking.

The aim of this paper is thus modest; as the correlations and causations among textbook design, textbook substrates, reading abilities, and critical thinking are rarely systematically researched, we will outline the reasons for the relevance of such research. By doing so, we want to contribute to the debate on creative thinking assessment measures that will be at the centre of PISA 2022 (OECD, 2019)

As a starting point, we will examine changes in textbook design that occurred in the previous 150 years and show that these changes correlate with the development of printing technologies. In the second step, we examine the results of three meta-studies on correlations between reading formats and reading comprehension as a counterpart to research on the reading of digital texts for children enriched with digital objects and on the effectiveness of multimodal learning tools. As we will show in the third step, there is enough circumstantial data to hypothesise that transformations of the textbook substrates and design have not been neutral, either in terms of their impact on reading comprehension or in terms of the societal and economic forces that have prompted them.

A terminological note: we take textbooks to mean a long-form text with artwork in codex format accessed in print or on a digital substrate, 'containing a comprehensive compilation of content in a branch of study with the intention of explaining it'(Wikipedia, 2021). We leave aside the workbooks with practise exercises and blank spaces for answers to be written directly into the book, nor do we take into consideration the digital-only interactive learning tools used primarily for repetitive learning and drill exercises. In the previous two

decades, these learning tools have surrounded textbooks and, at least according to research in Slovenia, have begun to marginalise the role of textbooks in the learning process. The pandemic became an important catalyst for this process (Kepic Mohar & Kovač, 2021). We assume that similar processes are also taking place in other countries.

In the context of this paper, we consider textbook reading as decoding of content that is by default multimodal (i.e., textual and visual) and, in the case of digital textbooks, also auditory and augmented with mouse-over hyperlinks. Such an approach is based on the assumption that, even when using digital textbooks enhanced with audio and video objects, reading is central to learning. When learning is being done for the sake of memorisation, comprehension, inferential and deductive reasoning, reflection, and similar, we consider such reading to be long-form deep reading. When other modes of reading are considered, such as skimming and audio reading, for the clarity of argumentation, we avoid using the word 'reading'.

The Great Textbook Transformation

The history of textbooks in the late 19th and 20th centuries can be described in terms of changes in printing technology. For example, in examining how the visual representation of the same topic (i.e., history of ancient Greece in Slovene textbooks in the Habsburg Empire, Yugoslavia and Slovenia) has changed over the last 150 years, Kepic Mohar (2019) has shown how the layout has evolved from a linear text interrupted only by chapters, subchapters, and occasional boldface sentences in the 1870s to a linear text interrupted by occasional black-and-white photographs and captions in the 1930s. For the purposes of this article, we will refer to such linear text-based organisation of content as 'linear layout'.

Six decades later, in the 1990s, textbooks with similar content were printed in four colours; the text occupied only two thirds of the page and was supplemented with explanations, drawings, photos, and instructional coloured maps. In order to introduce various levels of text, different typography was used, which appeared against coloured backgrounds. In the 1990s, some textbooks were accompanied by CDs with additional instructional materials, and a CD icon marked the places where students could use supplemental digital learning materials (predominantly video or audio).

Over the next decade, the complexity of the printed textbook continued to evolve: in addition to icons directing students to the CDs, the double-page spread featured artwork with tables, keywords, and collocations in the outer

margins. The main text was printed in black, and keywords were in semi-bold type. Motivational texts were printed in different colours at the beginning of chapters, and metadata was located at the top and bottom of the page, indicating the main content as explained on the page. In general, numerous elements have emerged that no longer consist of text alone so that the reader decides immediately which block to read next, the reading order being dictated in part by the typography and the various graphic blocks and not necessarily by the linearity of the main text.

On the other end of Europe, in the United Kingdom, similar transformations of textbook layout were described by Bezemer and Kress (2016), comparing English textbooks for Science, Mathematics and English in the 1930s, 1980s, and 2000s:

> Textbooks from the 1930s are A5 sized or smaller. Their pages are, typically, designed following a rigid grid, in a single column, with consistent margins, baselines, headers and footers, allowing the writing to flow continuously from one column to the next from top left to bottom right; it runs across pages. In the 2000s, the book is bigger, and we see a move away from the rather rigid, writing-driven grid which was common in the 1980s. We also see an increase in the use of the two-page spread from the 1980s, providing an entirely different 'canvas' or 'site of display'. Most textbooks now use varying numbers of columns per page, varying column widths, allowing writing to be 'wrapped around' - often irregularly shaped - images. Writing may still be running across pages but more often page breaks coincide with separations of different parts of the text, marked off by line boxes and background colours. (pp. 15–17)

This complex structure finally migrated from the printed page to a digital textbook with a reflowable layout and hyperlinks. In this way, the limitations of textbooks by the codex format were put to an end and (with a series of hyperlinks and digital materials) a book with no real beginning or end was created, allowing the learner to access a variety of online content (more Kepic Mohar, 2019). For the purposes of this article, we will refer to such complex organisation of content either in print or on-screen as a dynamic layout.

As if in a parable, with all these layout changes, in a hundred years, an ordinary spruce became a Christmas tree. All these changes correspond with developments in printing and screen technology. In the 1870s, the use of photography in printed publications was still in its infancy and far from mass use; in the 1930s, the development of printing enabled the mass use of photographs, especially in monochrome publications; and in the 1990s, four-colour printing

became economical enough to be widely used in publications with relatively large print runs, such as textbooks (see more: History of printing timeline, 2020). Last but not least, in the second half of the 2010s, especially after the wide usage of the mobile phone, screen technologies became commonplace in education, and all kinds of educational content moved from print to screen media and (as we have indicated above) textbooks were no exception. Much like their counterparts publishing magazines, newspapers, mass-market non-fiction books and commercial catalogues, educational publishers went with the flow, changing and improving textbook layouts at the same pace as print and later screen technology evolved and made such changes possible.

As the results of studies done by Kepic Mohar (2019) and Bezemer and Kress (2016) indicate, at least in Europe, these changes occurred at about the same time, yet they were introduced without any systematic didactic evaluation of their impact on the learning process: with our modest research reach, we could not find any study in the 20th century that addressed the question of whether students understand and memorise information better when they learn from textbooks with linear text occasionally interrupted by photographs, chapters, and subchapters, or whether the learning process is more effective when they use textbooks with dynamic layouts. The didactic superiority of multicolour textbooks with dynamic layouts compared to their older relatives with linear layouts was simply taken for granted.

We can only hypothesise why this change has occurred without in-depth debate and research on the didactic implications of different textual and graphic design of learning materials. The simplest and most straightforward answer seems to be that, for practical reasons, it has been almost impossible to design such studies. For measuring the impact of layout on the learning process, it would require a group of students to learn from two types of textbooks with the same content, one with a linear layout and one with a dynamic layout (research with within-participant design) and then, using interviews to assess how their understanding correlates with the layout of the textbooks with which they used to learn. Alternatively, each participant could read on both paper and digital presentations and then, their comprehension when learning from each type of layout could be measured and compared.

The lesson of current reading research on comprehension differences between reading from print and screen is that such studies are not replicable in the same way as experiments in natural sciences: no two texts are exactly alike, and because of a set of uncontrollable variables, the attitudes and focus of participants in study can vary from experiment to experiment, thus leading to variations in results. Therefore, these results can only be considered significant

when a set of studies using the same methodology, conducted in different countries by similarly educated participants of similar age, yield similar results. (For more on this, see Clinton, 2019; Delgado et al., 2018; Singer & Alexander; 2017).

As far as we know, throughout the 20th century, there was never a situation in which textbooks with linear and dynamic layouts coexisted, so there were no tools at hand to conduct such studies, even less in a number that would allow meta-analysis. More to the point, because of the slow pace of textbook development (as mentioned, the evolution of layout from linear to dynamic was gradual and took about a hundred years), it is likely that it never occurred to researchers that there might be a correlation or even causality between textbook layout and comprehension. The social and historical context simply did not lead to such research questions being asked and studied, thus turning the impact of long-term changes in textbook design on learning and comprehension into a blind spot of pedagogy.

With the digital transformation, all that changed. Its pace was faster than the evolution of print in the 19th and 20th centuries, and suddenly, with the advent of e-books and electronic textbooks, the same fiction and informational texts existed in print and on the screen. Since the late 1980s and early 1990s, this triggered a body of research in reading studies on the differences between print and screen reading. By the 2010s, there were a few hundred research papers on this topic (for more, see Delgado, 2018; Singer & Alexander, 2017). However, the methodology used in these papers was not consistent, making the overall comparison of results quite complicated. These discrepancies led to three different meta-studies comparing reading studies with similar research designs (Clinton, 2019; Delgado et al., 2018; Singer & Alexander, 2017). Surprisingly, all three meta-studies came to similar conclusions: When reading long informational texts, comprehension is better when the text is read in print than in the screen version. Furthermore, Delgado et al. (2018) found that the effect of screen inferiority has increased over the past 18 years, which is consistent with findings that digital technology is having a detrimental impact on students' comprehension skills and indicates that so-called digital natives perform worse in screen reading than digital migrants (see for example also Duncan et al., 2015; Pfost et al., 2013). In summary, as long as the replicability of research results remains the golden standard of science, we can conclude that print is a more suitable medium for reading longer linear informational texts than screens.

All of these studies were primarily conducted with university students and never considered primary and secondary textbooks. How can such findings about the reading of long-form linear texts be applied to textbooks, where the linear layout was replaced by a dynamic one some sixty years ago?

Not all textual digital content is created equal

One of the clues to how textbook layout affects comprehension may be hidden in a few reading studies on how the understanding of digital texts changes when enriched with various digital objects. In a research synthesis of 29 studies involving 1272 young children, Takacs et al. (2015) found evidence that multimedia stories were more conducive to story comprehension and word learning than when children were exposed to the same stories in a linear format in print without adult support; moreover, there were no differences between the benefits of multimedia elements embedded in the text (such as animated illustrations, background music, and sound effects) read without an adult and reading the linear text with adult support. However, interactive elements such as hotspots and games were not found to be beneficial for story comprehension as they require switching between the story and the interactive elements, thus interfering with story comprehension and language acquisition. Similarly to Takacs et al. (2015), Bus et al. (2014) also point out that interactions that have only a decorative function interfere with reading and learning, thus undermining comprehension. We can therefore hypothesise that the detrimental effects of overly dynamic print layout are similar to those of overly enriched digital texts; furthermore, if the visual elements are not decorations that distract attention from the main text but reinforce its content and help the reader follow the narrative in a way that visual and textual elements are coherent, a dynamic, multi-modal print layout could enhance comprehension.

Another interesting reading study was conducted by cognitive and metacognitive researchers (Sidi et al., 2017), who tested the inferiority of reading on screens compared to paper in effort regulation, test performance, and levels of overconfidence. The researchers hypothesised that the medium would provide a contextual cue that would lead to shallower on-screen processing regardless of text length, especially when task characteristics indicated that shallow processing was legitimate. The results suggest that metacognitive processes are sensitive to contextual cues that indicate expected processing depth, regardless of the associated reading burden involved (Sidi et al., 2017). Similarly, several studies show that a smartphone is a distraction even if it is just sitting on the table next to us (Thorton, 2014; Ward, 2017; for more on smartphone distractions and downfalls, see also Spitzer, 2019).

There is one more layout and substrate caveat coming from reading studies: not all screen media are created equal. Dedicated reading devices, for example, are used only for long-form reading, and they do not allow distractions, thus providing different contextual cues than smartphones: consequently,

it might make a difference whether reading the text on a dedicated reader like Kindle or Kobo than on a smartphone. Again, we did not find any study examining such differences. However, there is some circumstantial evidence to suggest that such differences indeed do exist: Mangen et al.'s (2019) study of the differences between reading on a print medium and reading on a Kindle suggests that comprehension of long narrative texts does not differ when reading on these two media; the differences only occur in terms of temporal and spatial orientation in the text, with reading on a print medium yielding better results than reading on a Kindle. The authors concluded that this is likely because the reading device does not provide the same sensorimotor cues as the printed book, where the reader can tangibly see how much they have read and how much is left to read in the book (see also Baron, 2021).

These findings were confirmed, again circumstantially, by Salmeron et al. (2018), who conducted a study on the differences between reading photocopies and reading authentic documents such as books, magazines, and printed newspapers. The study found that students remember better when they read from authentic documents. Again, the researchers assumed that this was due to the visual and tactile characteristics of the documents used (see also Baron, 2021). Another factor that contributes to decreased spatial and temporal orientation when reading from screens might be scrolling, as it does not provide markers for beginnings and ends, while the borders of a particular page give the reader a sense of location (for more on this, see Baron 2021, pp. 87–91).

To summarise, if there are no significant differences in reading comprehension when reading print and from dedicated reading devices, but there are differences in reading comprehension when reading print, and from phones/tablets, we can assume that there are also differences in reading comprehension when reading from phones and from dedicated reading devices. This allows us to hypothesise that what also matters in digital reading is what kind of device is used for reading. Less distracting devices allow for better comprehension, but when temporal and spatial information is important, print is still better than digital.

If we apply these findings to textbooks, we can hypothesise that the adverse effects of the contextual cues of screen medium and of the (too) dynamic layout on comprehension might be replaced by a) dedicated reading/learning devices and b) artwork (in print) and multimedia elements (on-screen medium) that support rather than interfere with the main text; if the latter is the case, the detrimental effects of screens and/or too dynamic layout are exacerbated.

These findings correspond with the cognitive load theory (Clark et al., 2006) and the cognitive theory of multimedia learning theory (Mayer, 2020)

which postulates that optimal learning occurs when visual and verbal learning materials are presented simultaneously (Torkar, 2021). Similar to Takacs et al. and Bus et al., on the basis of a set of studies on this issue, Richard Mayer states (in Torkar, 2021):

> If I had to choose one principle for revising textbooks, I would start by choosing the coherence principle and seek to remove irrelevant and distracting elements so students can focus on learning the essential material in the lesson. Next, I would add the spatial contiguity principle, which calls for removing the captions on figures and moving the essential text (in segments) next to the corresponding part of the graphic. When a textbook has graphics with long captions or legends, that is an indication of poor design. (p. 3)

Such findings should be seen as an additional warning that dynamic layouts and highly interactive and multimodal textbooks are not by default a value per se, yet when adequately designed, they could represent a better match. The PISA 2021 Report on 21st Century Readers (OECD, 2021) confirmed such conclusions and underscored the importance of linear fiction texts for reading comprehension as it found that:

> […] a higher frequency of reading fiction texts, texts that include tables and graphs, and texts that include diagrams more frequently is significantly associated with reading performance after accounting for students and schools' socio-economic profile on average across OECD countries' (p. 121)

In contrast, digital texts with links 'show a negative association with reading performance after accounting for students and schools' socio-economic profile' (OECD, 2021, p. 121), while countries in which students have to read 'longer pieces of text for school (101 pages or more) achieved 31 points more in reading than those who reported reading smaller pieces of text (10 pages or less) after accounting for students' and schools' socio-economic profiles and students' genre' (OECD, 2021, p. 120).

In the language of this paper, using only digital learning tools with an overly dynamic layout leads to lower reading performance.

New kid on the block: audio

Audio brings additional complexities to the assessment of learning tools. Audiobooks have a long history, back to the days of vinyl records and

later audio cassettes. However, until the early 21st century, audiobooks remained a niche; other than being used by the visually impaired and commuters, they never gained a significant share of the book market (for more on the history of audiobooks, see Rubery, 2016). That began to change with the advent of smartphones. Data from the U.S. market for 2020, for example, showed that one in six books was sold in digital audio format, consumed predominantly through online audiobook subscription services accessed by smartphones. Adult non-fiction accounted for the highest share, and the most popular categories were business, self-help, and humour (Audio Publishers Association, 2021). On the other side of the Atlantic, in Sweden, digital books accounted for about half of the total fiction market in 2020, and about 90% of these books were audiobooks, consumed mostly on subscription platforms, similar to the US (more on the Swedish book market: Bokförsäljningsstatistiken, 2020 and The Swedish Book Market, 2020).

This considerable growth of the audiobook market has stimulated interest in exploring the comprehension and memorisation differences between reading and listening to textual content. Two views of listening to fiction and non-fiction trade audiobooks have emerged: the dual-process view assumes that listening and reading share some elements but are essentially two separate cognitive processes; the unitary process view, in contrast, assumes that the same comprehension mechanisms underlie both processes (for more on this, see Baron 2021, pp. 165–170). At the time of writing this text, the latter view seemed to prevail and even gave rise to the rather controversial notion of audio reading that was used not only in audiobook publishing but also among some researchers.

The reason we find this notion questionable is that it ultimately leads to a paradox: since audiobooks can be listened to by illiterate people, the notion of audio reading hints that illiterate people can also read or can learn to read by listening. However, reading and listening involve two different sensory systems, the auditory and the visual: when we read visually, we connect signs with sounds and assemble sounds into words and words into sentences, thus making meaning in our minds (for more on the reading process, see Dehaene, 2009; Willingham, 2017; Wolf, 2008;). None of this happens when an illiterate person listens only to audio-only content, clearly suggesting that audio reading cannot make an illiterate person literate.

From this point of view, it is not surprising that (as found by Diakidoy et al., 2005), children in early primary education have better comprehension when listening than reading, which is reversed when children are older and learn to read and write fluently. In psychological terms, younger children use

all of their working memory for decoding when reading, whereas older children, who have already automated their decoding system, have more processing space left in working memory for comprehension. These findings were confirmed by Daniel and Woody (2010), who conducted a study with two groups of older students, one of whom learned by listening to podcasts and the other by reading the text. The podcast group performed worse than the students who read the text, leading the researchers to conclude that while podcasts can be a useful tool for supplementing course-related material, they are not as effective as texts in teaching primary content.

As Baron suggests, the better comprehension in reading compared to audio is due to the absence of several aids and signalling devices that facilitate comprehension when reading printed text or on a screen: in listening, unlike reading written texts, we have no control over the pace, re-listening is much more tedious than re-reading, it is virtually impossible to skim pages, and there are no markers such as paragraphs and subheadings that are present in texts to help readers orient themselves (Baron 2021, p. 166). Even more, some studies have found that students digress more when listening than when reading (Barao Sousa in Baron, 2021).

Nevertheless, as the field of digital audio learning tools is still in its early stages, so is the research about it: more studies need to be conducted to draw definitive conclusions about the effectiveness of audio learning tools in primary and secondary education. Learning Ally (n.d.), a US non-profit volunteer organisation (previously named Recording for the Blind and Dyslexic) for example, developed a set of audiobooks that allow parallel listening and reading and, according to them, such texts with parallel audio input significantly help struggling readers and readers with dyslexia. In other words, we know from the pre-digital era that audio can be a helpful learning tool in language and music courses, and there is some evidence that the combination of text and audio helps struggling readers and students; nevertheless, it remains to be seen how audio can adequately complement text materials as one of the primary tools in education.

Conclusion: What does reading research tell us about textbooks?

If we summarise all that we have found about the impact of textbook reading substrates and design on comprehension and learning, five critical conclusions regarding the design of printed and digital textbooks stand out:

1. In the pre-digital era, changes in the design of learning tools were not systematically evaluated from the perspective of reading and learning

comprehension and were taken for granted as a natural result of technological development.

2. When reading long-form linear informational texts, print seems to be a better medium than screens. As this finding was confirmed in three meta-studies covering a few hundred studies, we can consider this difference between print and digital reading to be an established fact.
3. When reading from screens, circumstantial evidence indicates it matters what kind of reading device is being used. Less disruptive devices, such as dedicated reading devices, afford better comprehension than smartphones and tablets. However, when temporal and spatial information matters, circumstantial evidence indicates that print remains superior in comparison to all screen devices.
4. As shown by a meta-study, at least in reading materials for children, the inferiority of screens could be compensated by visual and audio objects that support the main narrative of the text. However, if these objects disrupt the main narrative (such as hotspots and games), the inferiority of the screen increases. Studies on multimedia learning tools produced similar conclusions. PISA 2021 results indicate that besides properly designed digital learning tools, long-form linear reading significantly contributes to reading performance and, consequently, to critical thinking (OECD, 2021). From this point of view, combining coherently designed print and digital learning tools could be the optimal solution.
5. Audio-only seems to be an inferior format to textual learning tools. However, there is evidence that in combination with textual media it may be helpful for struggling readers. This indicates that a combination of experimentation and evaluations will be needed to find the proper place for audio among learning tools.

When looking for answers to these dilemmas, two issues stand out: a technical one and a cultural one.

The cultural question refers to the general understanding of the role of long-form reading in contemporary civilisation. Authors from Birkerts (1993) to Baron (2021) have warned that with digital media, the human mindset is changing in such a way that our ability to read long-form texts is declining or not developing (see also Carr, 2011; Firth et al., 2019; Kovač & van der Weel, 2018; Wolf, 2018). The reason for these warnings is that one of the positive externalities of reading books/long-form linear texts is the broadening and deepening of readers' vocabulary and the training of focus, which is necessary for the acquisition of critical cognitive skills, such as logical and abstract

thinking. These positive externalities diminish with the use of digital media: As we have shown, screens are inferior to print when reading informational long-form texts. In addition, screens are primarily viewed as entertainment tools with which immersion is driven by visual stimuli, whereas the concentration required to read print texts is just the opposite: a concentration that is immune to distractions outside the text. As we have shown, coherently designed multimodal textbooks can surpass these flaws of screens in comparison to print, yet at least, for now, there are no studies showing that digital media can entirely replace printed books in performing these tasks.

Regarding long-form linear reading, print seems to remain the optimal medium. Therefore, if analytical thinking and the ability to describe and discuss complex social and natural phenomena remain desirable societal values and learning outcomes, schools should train students to use printed textbooks and read printed books in combination with using properly designed digital media, thus keeping the printed textbook as one of the core learning tools, at least until we have solid evidence that screen media can do this job better without exceptions than their printed predecessors. As shown in a study conducted in Slovenia, textbooks might be losing this position in learning processes (Kepic Mohar & Kovač, 2021). If we are correct, this might lower reading literacy as measured by PISA in the coming years.

The technical question relates to the evaluation of changes in the design of learning tools. Both the pace of technological development of screen and print media on the one hand and available research equipment on the other enable studying how pupils and students use the learning tools: by using eye trackers, for example, we can determine whether the design of the learning tool is distracting, or that allows students to use it in a way that makes it easy for them to follow the narrative and understand the content. PISA provides an enormous amount of data on correlations between reading performance and reading substrates and formats. As we have shown, the PISA data and results of studies on reading comprehension and on multimodal learning can produce robust results on correlations between the medium and reading performance, while raising a new set of research questions on why and when using which learning tools.

In short, for the first time in history, educational publishers will find themselves in a privileged position to develop learning tools by tinkering with them while evaluating their instructional impact. It would be a pity to squander this opportunity by taking the benefits of digital media for granted.

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