Paper and Digital

Current research into the effectiveness of learning materials

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Editor:
Åsfrid Hegdal, Norwegian Publishers Association

Translation and copyediting: **Kristin Rødland Buick** and **Ailsa Buick**
Layout and Design: **Iconic Media Solutions Ltd.**

Contact person for queries and updates: **James Taylor:** taylor@internationalpublishers.org

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TABLE OF CONTENTS

Introduction

By José Borghino, Secretary General, International Publishers Association

Educational publishers around the world are primary drivers for innovation in their field, adapting and blending the latest technologies to deliver reliable, high-quality, culturally relevant content for teachers in classrooms.

The COVID-19 pandemic has accelerated the diffusion of digital content in every publishing sector, and education is no exception. The closing of entire national educational systems and the need for individualized home-schooling in many countries has boosted the rate at which educational publishers' digital content has penetrated markets worldwide. This increased diffusion and penetration, however, should not be seen as the final word. A more qualitative appraisal of the efficacy of digital formats in education is clearly needed.

Publishers will always look to actual concrete evidence before committing the large investments required to produce educational resources. In fact, there is a growing body of research casting doubt on the efficacy of digital learning resources in some contexts. The papers gathered together in this report are examples of the type of research that educational publishers welcome and take very seriously.

Schools in many countries are making the transition to using digital tools for teaching and learning, but the pace of implementation is variable. Educational publishers, over the past decade, have been developing a wide range of innovative tools and content in digital, print and blended (or hybrid) formats that allow teachers to choose the best ways to teach a particular curriculum to a particular cohort of students.

Good publishers are technology-neutral and focus on what can be demonstrated to work in specific teaching environments. Constantly collaborating with teachers and researchers to find the best ways of delivering content, publishers will generally recommend a blend of print and other technology that works best in the classroom — always acknowledging that classrooms in countries with established infrastructure and fully integrated broadband services will be vastly different to classrooms in less-developed countries.

The Educational Publishers Forum (EPF), founded by the International Publishers Association (IPA), is unique in representing educational publishers from around the world working in the K-12 arena. Formed in 2009, the EPF has maintained a strong focus on the digital transformation of educational publishing from its inception. It is therefore fitting that the papers collected in this report be published under the EPF's aegis and the IPA looks forward to further updates and additions.

Executive summary

Introduction

Reading and writing are the cornerstones of learning and development. Developing students' literacy skills will remain a key pedagogical goal at school and at home, and a top priority for educational publishers. A central aim of this report is to further our understanding of how, and which, learning materials get the best results. This report summarises relevant research to date, and provides recommendations for best practices for developing new learning material. Artificial intelligence is a promising technology for use in the education sector. We were curious regarding how AI works, and how it can be put into practice in development of learning materials. The chosen articles explain this in an accessible and interesting way. The digital developments in the classroom raise ethical questions that need to be considered and discussed, and we hope that the summary of the Kennisnet report *A matter of values* sheds light on and spark interest for the most important ethical questions around digitisation in education.

Issues

How, when and in what formats we read pose questions about the influence on reading and writing skills of screens, digitalisation and social media.

- Do students learn better when they read on paper?
- Do digital support materials disturb readers' concentration?
- How can we combine paper and screen reading to achieve the best effects?
- In what contexts and for which readers is digital the most beneficial?
- Can blended learning be leveraged to deliver benefits from both print and digital?
- How does overconfidence in digital reading skills impact teaching and learning?
- How can educational publishers find the right balance between digital and print to support effective educational development?

These questions are some of the core issues for educational publishers today.

Methodology

We addressed researchers who have spent a long time exploring these questions. We were looking for answers regarding paper vs digital, what reading does to us when we read, the future of education materials and experiences regarding blended learning.

The papers by Miha Kovač, Adriaan van der Weel and Natalia Kurcikova were written exclusively for this report. The article by Trude Hoel is a revised version of a previously published paper. The papers by Hildegunn Støle, and Theresa Schilhab, Gitte Balling and Anežka Kuzmičová are reproduced with permission through a Creative Commons Licence, and we received permission from the rightsholders to translate the two articles

about Artificial Intelligence in education. Where no other authors are credited, the NPA editor is responsible for the text.

What does the research tell us?

One main focus at the moment is work on how to present text on a screen in a way that offers the same opportunity for in-depth reading as on paper. Giving children digital competence, it is also important to let them read on paper, so they can develop deep reading skills.

The COST E-READ project has researched the impact of digitisation on reading practices. The project concludes that the transition from paper to digital is not neutral. Comprehension of long-form informal text is stronger when read on paper than on screens, and paper is best for in-depth reading.

The findings **by Kovač and van der Weel** reach the same conclusions: when reading long informational texts or more complex texts, comprehension is better when reading from paper than on a screen. The sole use of digital tools in education is likely to make learning results worse than when combining print and digital mediums in appropriate ways. The transfer of knowledge that requires understanding of long-form content and the learning of complex information by heart should remain more paper-oriented, while teamwork, fast information processing, drill training and problem-solving ought to utilise digital platforms.

According to Kovač and van der Weel, the introduction of digital learning tools into educational settings requires a lot more research and evaluation – including an understanding that technologies don't always bring progress.

Natalia Kucirkova argues that digital books, when designed well, can add value to children's reading. Developing children's digital books needs close collaboration between publishers, teachers, educational professionals, librarians and literacy experts rather than from the polarising paradigm of print versus digital.

Trude Hoel's paper concludes that picture book apps present children with new digital storytelling experiences. They can also make reading more tempting for children who do not participate in other reading activities and language learning. It is important that children have access to picture book apps in their mother tongue, and that publishers, developers and researchers collaborate in order to provide a range of picture book apps of a high literary, linguistic, aesthetic and digital quality.

Why do digital natives need books? **Hildegunn Støle** argues that when tablets are introduced as learning devices to children starting in first grade in Norway, it is important that book reading continues to be part of their reading acquisition. As new technologies shift focus away from older ones, it is even more important that schools encourage book reading and provide for it at school.

Schilhab et al elaborate the importance of embodied reading. According to the authors, the shift from print to screen has physical effects on our bodies while reading. They suggest two distinct dimensions of this embodiment of reading: the spatio-temporal and the imaginary. The authors show that reading depends on direct experiences in the moment as well as in the past. Whereas printed text affords numerous stable material anchors for memorizing, digital texts are much reduced in this respect, and this changes how we encode and remember reading content.

Michael van Wetering explains how Artificial intelligence can be useful in the education sector, in the sphere of customised support: “AI applications are able to follow the learning process of a pupil ever more fully, and, on the basis of analyses and predictions, give targeted feedback and adjustments to the learning route. This means teachers are more able to focus on guidance and coaching, for example, in the teaching social-emotional skills, which pupils will need more than ever in the future”.

The digitisation of the classroom leads to issues around the privacy of pupils and teachers, but also raises questions about the effects of all those screens, on learning itself and on the relationship between pupil and teacher. Kenniset, the Dutch public organisation for Education & ICT, has published a publication discussing ethical questions around digitisation in education titled *A Matter of Values.* GEU’s **Lisa van Ginneken** gives a summary of this publication.

In Norway, a new curriculum will be implemented in primary and secondary schools in 2020–2022. We give an overview of the process and main principles in the new curriculum, and as an example of contemporary curriculum work, we show the implementation of core values for the subject Norwegian.

Print or screen?

COST E-READ Stavanger Declaration Concerning the Future of Reading

What makes us read? What challenges are there in the age of digitisation? What does science say about the relationship between reading on paper and reading on screen? As this is a matter of great interest to the international publishing industry, it is important to mention the work done through the European research initiative "The evolution of Reading in the Age of Digitisation (E-READ)", a COST-funded initiative bringing together expertise from almost 200 scholars and scientists of reading, publishing and literacy from across Europe.[1]

Over four years, members of the E-Read project researched the impact of digitisation on reading practices. The research specifically focused on how readers, particularly children and young adults, comprehend or remember written text when using digital materials compared to print. Signed by over 100 experts in January 2019, the Stavanger Declaration summarises the outcomes of this research. Its predominant conclusion is that **the transition from paper to digital is not neutral.**[2] "One of the Declaration's main findings is that although comprehension may benefit when digital text presentation is properly tailored to an individual's preferences and needs, readers become overconfident about their comprehension abilities when this is not the case, leading to more skimming and less concentration on reading matter when reading digitally."[3] Furthermore, a meta-analysis of 54 studies concluded that comprehension of long-form informational text is stronger when read on paper than on screens, particularly when the reader is under time pressure. Contrary to questions about the validity of this statement when concerning the ability of the behaviour of 'digital natives', such screen inferiority effects compared to paper have increased rather than decreased over time, regardless of age group and of prior experience with digital environments.

In addition to the reading itself, the benefits of reading go far beyond basic enjoyment of the content of books: The act of reading also "fosters mental focus, patience and discipline, offers emotional and aesthetic experiences, increases linguistic knowledge and enhances economic and personal well-being. Skimming texts does not bring such benefits."[4]

Today, both reading on paper and on screen is common. There is no reason to believe that there is no future in the reading of books on paper. However, we do see that there are some target groups that read less on paper and use the screen as their preferred medium when it comes to reading. Scientists are currently working on how to present text on a screen in a way that offers the same opportunity for in-depth reading as on paper. So far, however, the conclusion is clear: paper is best for long and in-depth reads.

[1] European Cooperation in Science and Technology provides funding for the creation of research networks.
[2] The Stavanger Declaration on the Future of Reading, E-readcost: http://ereadcost.eu/stavanger-declaration/, (accessed 17.12.2019).
[3] Ibid.
[4] Ibid.

Paper versus screen reading: what difference does it make?

By Miha Kovač and Adriaan van der Weel

Simply put: The introduction of screen environments for reading is not a neutral change. There are two, strongly interconnected aspects to this. The first concerns the differences between paper and screens as substrates for a particular act of reading; the second concerns the digital infrastructure that influences screen reading habits more generally.

A. Differences between the paper and screen reading substrates

As regards the screen as substrate (the material surface on which the text is presented) for a particular act of reading, in 2018 and 2019, four studies were published that presented an overview of about one hundred studies on the differences between print and screen reading (Singer & Alexander, 2017; Delgado et al., 2018; Kong et al., 2018; Clinton, 2019). All four came to the same conclusion: when reading long informational texts or more complex texts, comprehension is better when reading from paper than from screen. To arrive at this straight-forward finding was a complex process.

First of all, there is the matter of reading variables. In order to get comparable results in print and screen reading comprehension research, all participants must be similarly educated; they must be similarly fresh or tired when doing the reading as part of the research; and they must have similar attitudes towards the texts they read. Reading Margaret Atwood's latest novel on a tablet on a rainy Sunday morning after a refreshing night's sleep will probably result in better comprehension than reading it in print on a Monday evening after a harsh and demanding working day. The same novel will be understood differently by a sixteen-year-old teenager than by an elderly grown-up person, regardless of being read from screen or paper. Not only will different life experiences be a significant influence, but so may life-style differences. The teenager might be fresher on Monday evening than on the Sunday morning after the night before.

Also, using long-form books in a print/screen reading comprehension comparison is practically impossible. There is no way participants will spend a month reading a long-form novel or non-fiction book in identical conditions. Consequently, serious research on print/screen reading comprehension is never done by reading long books, but by reading much shorter texts in a controlled environment (such as laboratory or classroom), and by using participants of the same educational level. Unsurprisingly, the majority of reading comprehension and performance studies have been done in an educational environment.

However, even doing reading research in controlled environments with similarly educated participants don't make interpreting the results straightforward. First and foremost, there is no generally accepted standard measure for complexity of texts. As a result, in all studies the level of complexity of texts read in experiments was left to the subjective judgement of researchers. In addition, many studies didn't specify the length of the text read as a part

of the research; they didn't properly define differences between print reading and digital reading and/or failed to define and assess comprehension. As a consequence, results were often not comparable, as we shall see. In a literature review, Singer and Alexander (2017) detected more than eight hundred different studies on paper and screen reading. However, the authors of the four meta-analysis studies published in 2018 and 2019 (as mentioned above) decided to include only around 100 of those studies: ones that were done in a way that allowed a comparison of results according to criteria they considered most relevant.

The emergence of hand-held screen devices may be considered the real game changer not only in screen reading habits but also in reading research. Only since paper got serious competition from screens have we become aware that the reading medium is not neutral: asking such questions in the analogue era didn't make sense as there was only one omnipresent reading medium, i.e. print. The development of screen technology has made us aware that processing information that is a combination of text and (links to) audio and video is different than that of reading a linear text. The need to understand differences between print and screen reading and to assess comprehension accordingly has become urgent only in the last few years, with the rise of the ubiquitous hand-held screen device. This rapid development has meant that there has not yet been enough time to develop a standardised research methodology for this area.

While we may still be at the early stage of print and reading research, all relevant review studies published so far have presented essentially the same conclusions. This makes their outcome as solid as any fact in social sciences research could be.

Singer and Alexander (2017), for example, didn't pay much attention to whether the digital texts used in studies had hyperlinks or not; their main focus was length of texts and reading comprehension. (They considered texts with more than 500 words as long and texts with less than 500 words as short.) Additionally, the studies included in their survey were based on reading either the same or different texts in print and screen conditions. Almost 90 percent of participants in surveyed studies were school-aged children (early elementary through to college in US terminology) and they were reading either narrative or explanatory texts (the latter being considered as more complex and demanding). Their main finding was that "when longer texts are involved or when individuals were reading for depth of understanding and not solely for gist, print appeared to be the more effective processing medium." (Singer and Alexander 2017, 27.) Furthermore, they established that scrolling affects comprehension.

Virginia Clinton (2019) surveyed a set of 33 studies that corresponded to slightly different criteria. She focused only on studies in which the same text was read in print and screen conditions and didn't pay any attention to the length of the texts (the text just needed to be longer than one sentence). Similar to Singer and Alexander, she classified the texts as either narrative or expository (the latter ones being more demanding) and most of the participants were school children and college students. Again, similar to Singer and Alexander, she found that there is a (small) benefit when reading from paper compared to screens. This benefit appears to be primarily for expository texts with no reliable

differences for less complex narrative texts. In short, Clinton's literature review confirms that when reading complex texts, paper is better.

The meta-analysis done by Pablo Delgado, Christina Vargas, Rakefet Ackerman and Ladislao Salmeron, as a part of the COST-funded E-READ Action, was the most complex of the three. It looked at 54 studies, conducted in 19 countries with more than 170,000 participants in total. In comparison to Singer and Alexander, this meta-study doubled the standard for text length (texts with more than 1000 words were considered as long and texts with less than 1000 words were considered as short). They categorised texts as either narrative or informational or mixed, and considered scrolling as an important variable. Furthermore, they classified the studies as either within-participant design (studies where participants read the same text, both on screen and on paper) or inter-participant design (where some participants read the text from screen and others from paper) and looked at whether the participants were reading under a time constraint. Their meta-analysis confirmed the findings of the other two meta-studies: that comprehension is better when reading (more complex) informational texts from paper than from screen and that these differences are almost non-existent when reading (less complex) narrative texts. Furthermore, they discovered that these differences were exaggerated when reading under a time constraint.

What was new in the Delgado et al. findings, is that they also regarded the year of publication of the studies as a variable, thereby taking into consideration how differences between print and screen reading comprehension changed over time. It showed that the more recent studies found a bigger digital disadvantage than the 20-year-old studies. This leads to the conclusion that new generations are not overcoming the screen inferiority. On the contrary, digital inferiority has increased over time. In short, so-called 'digital natives' suffer a greater setback from screen reading than their coevals did 20 years ago.

It should be stressed that the difference between print and screen reading comprehension of expository texts found in these three studies is not huge. However, we should keep in mind that we don't know whether the number of years of schooling, and comprehension as a result of screen reading, are directly or inversely proportional. Furthermore, all three studies made the assumption that narrative texts are less complex than expository ones, which is likely not to be the case when comparing, for example, a Kafka short story with a chapter in a vegan cook book. We also don't know what happens to reading comprehension when the texts are too long to be included in a controlled environment and when time constraints increase (for example, when a student needs to read one hundred pages in a single day). As long as we don't have adequate research methodology, it is sensible to assume that in such circumstances, comprehension differences increase when using screen instead of print.

B. The digital infrastructure

Two findings in recent reading research have given rise to the assumption that it is not solely (or possibly not even primarily) the reading surface that is to blame for the screen disadvantage discussed in (A). Firstly, it has been found that despite growing up in a digital age, young people today perform worse than young people did 20 years ago (Delgado et al.

2018). Secondly, students have been found to take screen-based information less seriously than when it is on paper. That is to say, they are less inclined to apply metacognitive learning regulation to their screen reading (Ackermann & Goldsmith 2011). The current hypothesis is that not only does the digital infrastructure inculcate screen-based reading habits (characterised by shorter attention spans, more fragmented reading habits, a lesser depth of engagement with the text and less retention), these digital reading habits are actually spreading over to paper (Kovac and Van der Weel 2018). The explosive growth in the use of digital devices for social and leisure purposes (such as gaming, social media, texting, watching YouTube, series and films) has thus contributed to the decline in reading comprehension, as well as to the global decline in reading motivation as found in the PISA 2018 results.

Conclusion

These findings point towards the need for caution when it comes to the promotion of digital reading. It certainly makes sense to use digital opportunities for embedding reading into the increasingly digital texture of people's lives for the purposes of marketing, discoverability, social reading and so on. However, there is a clear downside to this in that all screen-based reading will be affected to a greater or lesser extent by screen-based reading habits.

All this leads us to conclude that the sole use of digital tools in education is likely to make learning results worse than when combining the use of print and digital mediums in their appropriate ways. Even if digital is indeed capable of enhancing the reading and learning experience in many cases, it is inferior to print when it comes to long-form reading. In short, the introduction of digital learning tools into educational settings requires a lot more research and evaluation – including an understanding that technologies don't always bring progress. Going forward however, it is important to consider if we still consider long-form reading as an important part of the curricula? We'll try to answer this question in the following two short chapters.

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Technology in the classroom: a century of controversy

By Miha Kovač and Adriaan van der Weel

The introduction of technology into schools has a long history of enthusiastic prophecies about how it will improve education, being followed by its quiet disappearance through the back door. As early as 1913 for example, Thomas Edison proclaimed that "books in schools will soon be obsolete" as it is "possible to teach every branch of human knowledge with the motion picture," which he believed would completely change primary and secondary education in a period of ten years. In 1920, Sidney Levit Pressey invented the teaching machine, which was capable of administering multiple-choice questions to students and showing them which was the correct answer. His work was continued by B.F. Skinner in the 1950s but slowly faded into oblivion in the 1960s, when many started to believe that radio and television would become as common as blackboards in a modern classroom. Especially television was, for a short while, extremely popular. In American Samoa, for example, school authorities trying to cope with a shortage of teachers decided to rely on television in the classroom. By 1966, four out of every five Samoan pupils were spending from one-third to one-quarter of their classroom time watching television. Yet, after 1970, more and more concerns were raised against the experiment, and both Samoan pupils and teachers complained that television was used too much in classrooms. By 1973, the Samoan authorities had decided to shift authority away from the screen and towards the teacher.

Indeed, during the early years of their introduction in schools, computers seemed to be destined for the same fate. After the initial euphoria of the eighties and early nineties, their usage in schools became marginal. In 1992, educational specialist Larry Cuban proclaimed that when "computer meets classroom, classroom wins", exactly as classroom had won the battle with film, teaching machines, radio and television before. At the dawn of the twenty-first century, paper, notebooks, printed textbooks, chalk and human teachers still dominated classrooms all around the globe.

However, in the last decade, this has once again started to change. Blackboards, printed books and human teachers are still around, but the education system saw the large-scale introduction of digital technologies. The main cause was the ubiquitous acceptance of computers in society. The permanently connected, all-inclusive nature of the computer conveniently shrank to the size of a paperback book, with tablets and smartphones allowing for the integration of all media modalities into one ecosystem in which an individual can not only consume, create, store, and redisplay text, audio, and video, but also publish and distribute, as well as search for information. Technological development squeezed analogue media and media institutions such as books, libraries, bookstores, librarians, television, radio, film screens, printing presses, cameras, microphones, musical instruments, and a variety of distribution channels and online mega shops into a single device that could be put in a pocket, and at a price that almost everybody could afford.

Still, the ubiquitous acceptance in society of networked screen devices alone would not have sufficed for this second wave of digitisation of the education system to succeed. Crucially, it succeeded where film, radio and television failed because, like printed books, it was a textual medium at heart. Its potential in the classroom for combining text with other modalities proved irresistible. The evolution of the classroom interactive whiteboard, a personal computer/LCD projector hybrid, meant that chalk, blackboard, teaching machines, radio, television, and film were condensed into a single media environment that could be accessed with the hand-held devices of both teacher and pupils. In addition, the development of AI opened new opportunities for human and machine interaction in education. Just as Skinner's teaching machine operated on a similar principle as that with which Russian psychologist Pavlov trained his dogs, AI can adapt to the level of knowledge of each student and will soon be capable to react to their emotions.

Between the 1980s and the 2010s all instructional technologies merged into one media ecosystem. Concurrently, the devices that allowed access to this media became part of the daily life of teachers and pupils, and as such required only a little extra investment from parents and school authorities in order for it to be widely used. In these conditions, it is easy to understand how the voices clamouring for digital-only classrooms became ever louder among school administrators, parents and providers of learning tools. The trend has now become irreversible.

However, bearing in mind all previous education technology fads, we are still faced with the complex question of how best to accommodate screen technologies into the logic of the classroom. Superficially, the question seems to be simply how and when to replace old (books) with new (digital) technologies. But first of all, given the screen disadvantage discussed in Chapter 1, it is crucial to find a proper balance between printed and digital learning tools. And secondly, on an even more fundamental level, the question is how to find a proper balance between human instruction and the mechanical transfer of knowledge.

One part of the answer to this dilemma is in the chapter about paper and screen reading. Practically all studies show that we comprehend long-form expository texts better when we read them from paper than when we read them from screens. At least in the last decade, students' actual behaviour follows this finding. Many surveys (McNeish et al. 2012; Feldstein and Martin 2013, Baron 2015) show that they prefer printed books when they have to read long and complex texts. On the other hand, in 2015, Microsoft research on the human attention span in an online environment found that although attention span on average lasted only eight seconds when wandering in a digital environment, tech adoption and social media usage train consumers to become better at processing and encoding information through short bursts of high attention. In addition, a set of studies have shown that a digital instructional environment makes sense when training children in problem solving and team work, while virtual reality and gamification make sense in relation to drill exercises, information retrieval, and the visualisation of content (see the meta-analysis conducted by Merchant et al. 2014).

In other words, screen and book environments seem to have distinct types of cognitive effects: if screen media trains us to process large amounts of information in a very short

time, book reading on the other hand trains us to consume long-form linear information and sustain attention for much longer than eight seconds. Reading long-form texts and using digital media are therefore two different, complementary processes. The transfer of knowledge that requires understanding of long-form content and the learning of complex information by heart should remain more paper-oriented, while teamwork, fast information processing, drill training and problem-solving ought to utilise digital platforms. Crucially, the history of technology use in schools shows that this kind of blended education cannot be conducted without good teachers, and that the cognitive work required for learning can be aided, but not replaced, by technology.

However, some questions still remain. Do we need both screen-based and paper-based forms of reading in educational systems? Is deep long-form reading still relevant in a contemporary knowledge environment? Or can we substitute it with learning through short bursts of high attention? And can't we train our attention span through other means, such as playing an instrument or solving puzzles? These questions will be addressed in the last chapter.

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Challenges for future reading research

By Miha Kovač and Adriaan van der Weel

In contemporary reading research there are two pressing issues to which we don't have clear-cut answers yet. The first set of issues is more abstract than the second and could be compressed into a single question: How important is deep, linear, long-form reading in our culture today? Does reading long-form texts in book format still make sense in an era when almost all information (including summaries of important books) can be easily accessed in an online environment, predominantly in short, and often non-textual formats?

Long-form reading is not just about content (Kovač and van der Weel, 2018). It has a set of benefits that go beyond enjoying the plots and narratives of books. The first is vocabulary. As human beings, we express ourselves mainly with words. Therefore, the narrower our vocabulary and the less familiar we are with the fact that words can have more than one meaning depending on the context, the less capable we are of communicating our ideas. There is no doubt that the depth and breadth of vocabulary increases through the reading of long-form content in book format. The pressing question for future research is: if we regard this as a useful, positive effect of long-form reading, can we attain the same depth and breadth of vocabulary by using only digital media?

Another likely effect of long-form reading is what we may refer to as 'cognitive patience' (Wolf, 2018), which is the ability to bring patience and concentration, in a disciplined manner, to a mentally challenging task. As we have shown in the chapter about technology use in the classroom, the reading of long-form text requires deep, sustained attention, as opposed to what is required from reading most screen media. Therefore, an additional research question is whether the practice of reading long-form texts will increase the capacity for cognitive patience, and whether the ability to maintain such deep, concentrated and disciplined attention is a prerequisite for other tasks that are deemed positive and useful, such as thinking. If yes, is it at all possible to develop these same cognitive abilities through the use of digital media only?

If the answer to these two questions is yes, printed books don't have much of a future. If the answer is no, then long-form reading must be accommodated within the contemporary media landscape and, most importantly, proper ways to blend it into school curricula must be found if future generations are to build their thinking abilities. In sum, the future of publishing and the future of education depend on answers to such questions.

The second set of reading research issues are more technical but have similarly broad implications for educational publishing. Having established the screen inferiority effect beyond all reasonable doubt, the logical next step is to establish its causes. The current hypothesis is that the screen inferiority effect is due to two sets of factors. The first is differences between print and digital substrates (the reading hardware). These lie chiefly in differences in materiality in relation to our embodied cognition. The way our bodies relate to the material textual object is through our fingers, but extends to the expectations we have of all information having a fixed physical 'address' – and there is no such thing

when reading from screens. Lighting and resolution are also substrate issues, but thanks to technical improvements, these are thought to play a minor role compared to the early days of screens.

The second set of factors is perhaps harder to test. This two-tier hypothesis is based on the theory that not only does the digital infrastructure inculcate screen-based reading habits (characterised by shorter attention spans, more fragmented reading habits, a lesser depth of engagement with the text and less retention), but that habits formed in the screen environment (resulting in texts on screens being 'taken less seriously') are actually spreading over to paper (Kovač and Van der Weel, 2018). Consequently, what needs to be tested is whether over-exposure to screens reduces deep reading ability. If this is found to be the case, it would certainly help to explain the decline in linear long-form reading (as visible in declining library loans and sales in most book markets).

Testing both sets of hypotheses is a precondition for establishing ways to address screen inferiority and for deciding how to balance print and screen media in an educational environment.

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Children's digital books: some considerations for designers and publishers

By Natalia Kucirkova

There is little doubt that since their appearance on the market, tablets and smartphones have infiltrated our daily environment like no other previous technology. These technologies are small and light-weight (and therefore 'mobile' or portable), they are multifunctional with access to a camera, GPS receiver, messaging services and the Internet. To publishers and designers, smartphones and tablets represent a threat – and an opportunity. The technologies give us access to personal and fictional texts, as well as to news and novels; they allow us to read dynamically with hyperlinks taking us to various other texts, which we can digitally bookmark, annotate, or share with others anytime, anywhere. Moreover, the technologies allow us to produce texts, of unlimited lengths and types, enriched with sounds or images. At the same time, the technologies can be used to read traditional static long texts, and these can be recommended with artificial intelligence through subscription or commercial services ('if you like this book, you will like this') as well as our own curation practices (e.g., digital bookshelves or bookmarks). These opportunities for reading, producing, sharing and curating texts, are unprecedented and constitute a step change in reading. What do the new text opportunities mean for publishers of books for young children? How does the digital text revolution affect the youngest readers? This report points out some key trends in the research of children's e-reading and the consequences of the research findings for the design and publishing of children's digital books.

The first section is dedicated to the question of whether print books are better than digital books for children's reading. The focus is on children aged between three to eight years old, that is children beginning to identify as readers on their journey towards proficiency. Given that for this age group most research has focused on story-based texts, the research review highlights findings related to children's reading of narrative fiction texts on a smartphone or tablet screen. The review is followed by research-informed recommendations for the design of children's digital books, with a consideration of ebook features that are most beneficial for these young readers. The conclusion makes recommendations for collaborative design-research-practice models that bring together designers, researchers and practitioners to develop optimal texts for beginning readers.

What is a children's digital book?

The terminology around children's digital books fluctuates, which reflects their relatively short existence, as well as the many versions of ebooks on the book market. The various labels attached to children's electronic texts include: ebooks, digital books, iBooks, picturebook apps, literacy apps, storybook apps or story apps. The umbrella term 'digital book' encompasses all these labels but does not distinguish between fiction or non-fiction books, or the platform for access (ebooks are typically accessed on laptops and PCs while iBooks are for iPads or iPhones only). But just like the adjective 'digital' can be interpreted in relation to various digital platforms, so can the word 'book' be interpreted in terms of a set of pages of written text bound together or in terms of an audio text presented as one file. The fact that the definition of ebooks is far from straightforward is evidenced with *audio books,* which could be considered under the umbrella of digital books, but constitute a separate category for design, marketing and research.

The production of children's digital books

There isn't a clear sequence of transforming a print text into a digital text file, indeed many digital books are nowadays native to the digital medium (a story app designed specifically for the iPad or an audio book published directly in an audio format without first being printed). However, many books become digitised after they have been published in print. The key difficulty faced by producers of children's digital books is that the place of publication for children's digital books – the App store for Apple smartphones and tablets and Google Play store for Android devices – are shared with other children's apps designed for entertainment. Without any gatekeepers and proper quality checks in place, digital books can easily disappear in what has been described as the Digital Wild West of children's apps.

To make it to the top of the most downloaded apps, and thus have a visible place on the market, is very difficult for independent publishers. Those with larger budgets opt to collaborate with large entertainment companies, which provide content familiar to the mass market, such as Disney or Peppa Pig. Others try to break into the market through investing in highly creative one-off projects that may win an award or be picked up by the traditional press, thereby catching parents' or teachers' attention. This basic flaw in the distribution of children's digital books has contributed to the stagnation of development and the slow progress in content quality since their first appearance in early 2000s. European publishers increasingly produce web-based digital books that have slightly more limited interactivity than apps, but are easier to distribute and can contain embedded analytics, which can be connected to other websites and services.

One way of distinguishing children's print and digital books is to focus on the modes of communication they afford. A printed children's book typically contains images alongside text, which offers visual engagement. A digital book however, can also engage a young reader through sounds, multimedia and interactive features. It is these added features that have been the focus of most recent research on children's digital books.

The learning benefits and limitations of children's digital books

A body of research focused on comparing the benefits of reading digital versus print books on children's emergent literacy skills, has shown mixed results. For example, Strouse & Ganea (2017) found a positive effect of digital books on toddlers' learning of new words and engagement, while Krcmar & Cingel (2014) found a negative effect of digital books on four-year-olds' reading comprehension. Moreover, Lauricella, Barr and Calvert (2014) found no difference in four-year-old children's story comprehension when comparing digital and paper books, nor did Richter and Courage (2017) with three-to-five-year olds' story recall. Part of the explanation for these mixed findings is children's age: for children under the age of two, digital books have little, if any, added value beyond print books (Kucirkova & Zuckerman, 2017). For younger toddlers, the highly visually appealing and interactive nature of content presented on tablets often acts as a distraction and disrupts the reading experience with their parents (Munzer et al., 2019). On the other hand, for

older toddlers with an immigrant background living in the Netherlands, digital books add clear value to their language learning (Bus et al., 2020). The research field is coming to a consensus that it is not the format of a book that influences learning outcomes, but rather a combination of the child's characteristics, the content of the book, and the context of the reading activity.

When analysing the aspects of the reading session that proved most beneficial for children's learning, Bus (2020) highlighted the power of repetition. The significant advantage of digital books is that they can be read over and over, without the need for parents to re-read the text (the ebook can 'speak' the text as many times as the child desires). Repetition is beneficial for children's learning of new vocabulary and concepts; it consolidates new learning experiences and provides a feeling of familiarity and comfort. With a print book a child needs to request repeated readings from an adult or older reader (who may not be always interested or available), but with a digital book, the child can be in control of how often and which parts get repeated. Moreover, a child can choose various versions of the same story in the digital format, which further increases their sense of agency and independence. In addition to the possibilities of child-controlled repetition, the specific features of a digital book can also influence the learning outcomes.

Multimedia, interactivity and personalisation

There are three features that are more intensively experienced with the digital format of reading than with print books: multimedia, interactivity and personalisation. Multimedia refers to the combination of media available within a digital book, such as audio possibilities (sounds/music/voice-overs), visual depictions (illustrations/photos/drawings), text and with some book titles, also short videos or camera-zooming features. Interactivity is defined differently in different fields, but in relation to digital books it includes the possibility to interact with the story characters on the screen, such as moving them around a digital page, tapping hotspots that activate a voice-over, or exploring mini-activities embedded in digital books through touch. Multimedia and interactive features can provide a personalised reading experience, individualized to a single reader. For example, a story character can address the child by her or his name, or multimedia content can include the child's own photos. Some personalised reading experiences are provided automatically by the digital book, through the collection of data on user engagement, and algorithms provide personalised recommendations on which title or part of story to read next (e.g. Epic!, iRead). Other personalised reading experiences are generated by the readers themselves, for example when the readers make their own story, with their own voiceover, text or illustrations (e.g Our Story, StoryMaker).

All three features – multimedia, interactivity and personalisation – are embedded in the digital format of an ebook and are realised to a different extent with different book titles. The intensity of these features, and the extent to which they are related to the story children read, explain many of the effects documented with studies comparing print versus digital books. In particular, multimedia and interactive features that are not aligned with the story line, were found to have a negative impact on children's learning (Takacs, Swart, & Bus 2015; Bus, Takacs, Kegel, 2015). While interactivity strongly captures children's attention, it does not allow for the expression of their own meaning or conversation with adults co-reading the digital book with them (Tønnessen, & Hoel, 2019). Personalised features, such as the possibility to see or hear themselves in a story, motivate children's

engagement and interest in reading digitally (Kucirkova, 2018), they encourage creativity and children's autonomy in reading as well as pleasurable reading moments for families (Aliagas & Margallo, 2017). These findings lead us to several recommendations for designers and publishers of children's digital books.

Recommendations for designers and publishers of children's digital books

Designers should remember:

- Interactive and multimedia features that are not aligned with the storyline are not helpful for children's learning from the story. If the goal is to support children's learning, hotspots that activate interactivity/multimedia should correspond to the storyline. All interactive and multimedia features should be clearly indicated and offered as optional.
- Pauses and gaps in text, illustrations and/or audio, support child-adult dialogue around stories and are part of best practice design.
- Personalised features encourage children's authorship, enjoyment and engagement with stories. Personalisable digital stories need to be especially careful to follow national and international regulations designed to protect children's privacy and security.

There are two exciting design possibilities that have been, thus far, little explored by research. Platform-agnostic apps (such as Web Apps) are free from commercial constraints imposed by App stores and offer greater potential for innovative design and privacy/security of personal data. The use of personal data and adaptive algorithms in such digital books allow for dynamic adjustment of content in relation to pre-established reading profiles of individual children (for example based on the students' reading scores supplied to the system) or based on the reading scores obtained by readers in the process of engaging with a digital book. While the use of personal data needs to be treated with extra caution to avoid the exploitative nature of targeted advertising already present in many adult digital media, it offers a genuine possibility to support the reading outcomes and the reading process through personalised feedback and personalised reading motivation techniques. For example, a digital reading system could recommend students reading titles based on the students' own interests as well as titles based on the school curriculum and/or family history. The reading difficulty could gradually advance as the student progresses in selecting and reading the individual titles.

Another exciting possibility is to combine multimedia with print and connect reading of various media through one story arc. For instance, the Internet of Toys could be employed more strategically to connect digital and print texts with apps for augmented reality experiences that bring story characters to life. Several storytelling platforms that allow children to interact with digital content through the manipulation of physical blocks, are gaining popularity (e.g. TinkrBooks from MIT).

Whatever exciting format possibilities we follow, it is important to invest resources into high-quality content to ensure an optimal format-content interplay. The quality of narration

is as important as the quality of images or text, and should be developed with allocated budgets and professional insights. Notwithstanding the exciting developments in the format of story representations, it is the quality of content that remains the key decision factor concerning the quality of children's books.

Conclusion

Digital books represent a considerable shift in our reading culture, raising questions about their welcome opportunities or unwanted changes. Research shows that digital books, when designed well, can add value to children's reading. Designers need to collaborate with children's authors and illustrators to produce digital books of high literary quality and innovative format options. To achieve the educational benefits of children's digital books that have already been documented by research, there needs to be a close collaboration with teachers, educational professionals, librarians and literacy experts. Collaborative research-design-practice initiatives, such as the International Collective of Children's Digital Books, are one way of connecting the key decision-makers in the area. The Collective is free to join and welcomes any publishers or designers interested in children's reading on screen: www.childrensdigitalbooks.com

Teachers (together with parents in the case of pre-school aged children), act as gatekeepers when it comes to facilitating children's access to reading materials. Curated lists (subscription models) of well-designed, expert-selected children's digital books can be offered to schools and homes on a sustainable basis.

In sum, the development of children's digital books needs to be approached in a productive manner, rather than from the polarising paradigm of print versus digital.

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Photo: Inge Schreuder-Lindløv

Digital picture books with children: possibilities and limitations

By Trude Hoel

Many associate reading together with children with reading a print picture book. One or more children and an adult sit with the book between them. Eyes are turned towards the illustrations, index fingers used to direct attention to various details, the adult reads the verbal text out loud, the children listen, and comment. They chat. What might happen on the next page? What thoughts spring to mind from the words and pictures? Reading together gives shared experiences; laying the foundation for conversation, wonder and play. In this reading community the children experience a language more complex than their everyday language, and the reading contributes to the children's language development.

Traditionally, it is the print picture book that has taken centre stage when reading with children, although this may be about to change with the entrance of tablets into homes and Early Childhood Education and Care institutions. Picture book apps, or digital picture books for children, present literary texts and are often based on printed originals. In the process of transferring the text and images from paper to digital technology, new modalities, or resources, are added, such as sound and animation. Sometimes elements are borrowed from the world of computer games, where readers for instance are invited to perform tasks. Picture book apps present children with new digital experiences of storytelling. It can also make reading more tempting for children who do not participate in other reading activities (Sokn, 2018), and otherwise miss out on literary and aesthetic experiences, as well as language learning.

Accessibility and quality

Reading picture book apps with children obviously requires sufficient access to apps of high literary, aesthetic, linguistic and digital quality. Children need to hear and use their mother tongue in what is a decisive phase of language learning, still the majority of digital resources for children are English. This is a challenge in many countries. In a status report from 2017, the Language Council of Norway (Språkrådet) expressed their concern regarding the overwhelming use of English in digital media. The report showed that only three out of ten children under the age of 11 meet Norwegian language when watching videos on YouTube and playing computer games. This results in less usage and less knowledge of their mother tongue.

An EU funded network of researchers, The digital literacy and multimodal practices of young children (DigiLitEY), have compiled a survey of younger children's access to picture book apps (Bus et al., 2019), with a particular focus on countries that do not have one of the international languages (such as English or Spanish) as their main official language. The research has in particular looked at:

- Access to picture book apps in the children's mother tongue: quantity in relation to the children's age.
- Picture book app quality: literary and linguistic quality, quality of user interface and interactive opportunities.
- Accessibility: how do parents and teachers find picture book apps, reviews, where to download them and what they cost?

Using Norway as an example, the survey shows that there are more picture book apps in Norway, including for the youngest of children, compared to other countries in the survey. Most of these picture book apps are only available in Norway's majority written language (Bokmål), with significantly less available in the minority written languages. Overall, there are far fewer picture book apps than print picture books. Furthermore, the majority of Norwegian picture book apps are merely digital versions of printed picture books, with added audio narration (Bus et al., 2019). The Norwegian picture book apps are consistently of a high linguistic and literary quality. However, it seems as though picture books produced specifically for the digital market may not meet the same quality requirements as the printed picture books – unless they come from experienced publishers.

In all of the countries surveyed, picture book apps are cheaper than their printed counterparts, although some apps may stop functioning after software updates. Furthermore, it is often more difficult to find high quality picture book apps for parents and teachers who want to read together with their children.

Research on children's reading of picture book apps

New international research has emerged with regards to children's reading on various types of screens.[5] The research is looking at both opportunities and limitations.

[5] See for example the themed issue of AERA Open, red. Bus, Neuman & Roskos, 2020

Findings show, for example, that although interactive elements in picture book apps may engage child readers, they can also be distracting and don't always contribute to the child's comprehension or aesthetic experience.

The innovative Norwegian project *Books and children: Developing an evaluation tool for children's ebooks*[6] financed by the Norwegian Research Council, has developed a research based educational evaluation tool to help teachers and parents find out whether a particular picture book app is suitable for dialogue based reading with children (Mangen, Hoel, Jernes, & Moser, 2019). The premise of dialogue based reading is for children to be encouraged to explore and talk about the story during shared reading. Children can be encouraged to actively participate through, for example, exploratory questions (Mangen and Hoel, 2017), as well as in the design of the reading situation (Hoel and Tønnessen, 2019).

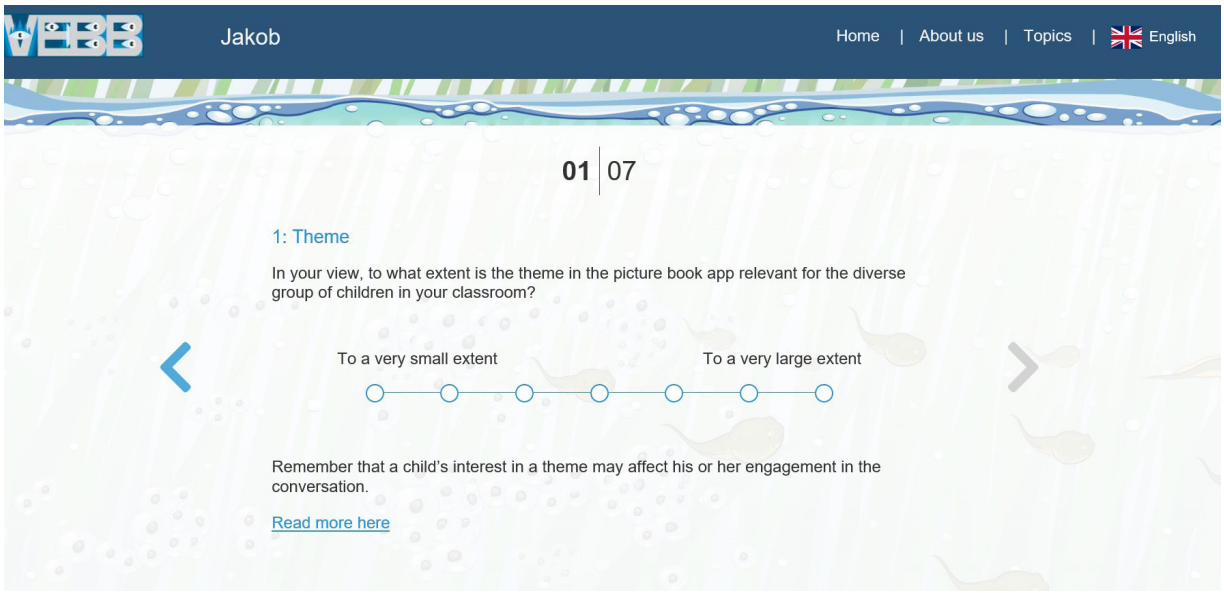
Photo: Inge Schreuder-Lindløv

The assessment tool

The assessment tool is digital, free to use and comes with a choice of Norwegian or English text in the programme interface: http://vebb.uis.no.

Several of the indicators highlighted in the tool are applicable to both printed and digital picture books, such as an evaluation of the book's topic. The children's initial interest for the topic can be crucial, when the goal is to engage children in conversation about the book. Children's interests may be connected to cultural background, experiences, age, gender and previous reading experiences. The advantage of choosing a book with a topic that appeals to the child, naturally applies regardless of media.

[6] Bøker og apper: Utvikling av vurderingsverktøy for e-bøker for barn, VEBB



The same applies for the length of the book. Some stories are disseminated over many pages, perhaps with long and elaborate text, whilst others are shorter or more uncomplicated. The duration of a book, regardless of media, must be evaluated according to its target audience; their collective reading experience and their ability to concentrate. Furthermore, good and rich conversations during reading, which is after all the goal of dialogue based reading, will affect the duration of the reading session.

Other indicators that are emphasised in the evaluation tool are specific to digital media, such as audio flexibility. Most picture book apps contain a sound track with a professional narrator, and many also include background sound, music and other sound effects which can be activated by the reader. Both the narrator and other sounds may contribute to children's understanding of the story, if sounds are close to the narrative.

Flexibility in the app's soundscape can mean the opportunity to regulate the sound levels of the narrator and the background music separately. However, while a parent or teacher may be able to stop and start reading according to the input and engagement of the children, the automatic play of the narrator is not characterised by the same degree of flexibility. If choosing to use the narration integrated in the app, long verbal texts may limit the opportunity for spontaneous input from the children during reading. This will affect both the social and the verbal interaction during reading.

Furthermore, automatic page turning functionality in some picture book apps means that the reader is not directing the tempo of the story, and that the book is presented in a film like fashion, without pause or room for reflection, will also influence the opportunity for conversation during reading.

Another media specific indicator is connected to the interactive functions of the picture book app. Touching the screen can start animations and/or sound sequences. A finger can be used to mark a surface, draw a drawing or follow a track. Tablets are developed for

individual usage, which means that when reading picture book apps in groups, there are often many hands reaching for the screen. Children's attention can be quickly distracted from the story, focusing instead on the interactive functions.

Children's expectations of interactivity in digital media is based on their experiences, and exploration of the interactive functionality may sometimes be of value itself. When the goal is dialogue based reading, parents and teachers can decide whether to activate the interactive functions. They could also choose to use the interactive elements of the picture book app that specifically support the children's understanding.

Collaboration on developing picture book apps

Publishers, developers and researchers must collaborate in order to provide a range of picture book apps of a high literary, linguistic, aesthetic and digital quality. Knowledge based development will serve to increase children's engagement and linguistic participation during shared reading of picture book apps.

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Why digital natives need books: The myth of the digital native.[7]

By Hildegunn Støle

Preface[7]

This article is concerned with children's reading development in the important years from when they begin learning to read to the age when the child reaches adequate reading comprehension to read to learn from a variety of texts on diverse subjects. Like any skill, reading skill requires relevant and extensive training. We have tended to think that children growing up in the digital era get plenty reading training from digital devices and that this is as efficient as reading books was for earlier generations. Due to this optimism, we have paid too little attention to whether extensive use of digital devices actually provide children with relevant reading training during the important years that efficient reading is developed. The author holds that book reading still has its place in education.

Introduction: The myth of the digital native

How do children acquire good reading skills in our digital era? In answering this question, focus will be on the youngest 'digital natives', *i.e.,* pre-schoolers and children in their first years of schooling from around 5 to 12 years of age. The term 'student' in this article thus refers to a rather different age and skills group than the late teens or twenty-something students that so often occur as informants in research on (digital) reading competence. Quite a few studies have explored reading comprehension of older students comparing effects from paper versus screen (see Singer and Alexander, 2017, for an overview). However valuable, such studies do not tell us how college or university students have acquired the reading skills that first prepare them for reading well (or not so well) in diverse media. This article aims at clarifying some issues in this regard: Is it true that young digital natives learn better from digital technologies than they do from print? Do education systems prompting the use of digital technologies in school get value for money in terms of higher skills levels, as measured in international surveys? What does recent research tell us about successful reading development among young digital natives in media-rich environments?

The term 'digital natives', coined by Prensky (2001a; 2001b), caught on among scholars and laymen alike, making us believe that children growing up in the digital age took to new ways of learning and interacting and, as a consequence, required the same technology-rich learning environment in school as they experienced in their spare time. Prensky (2001a; 2001b) described the Digital Native thus:

> "... they are used to receiving information really fast. They like to parallel process and multi-task. They prefer their graphics before their text rather than the opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards. They prefer games to 'serious' work."

[7] This paper was first published at First Monday, through OJS; Støle, H. (2018). Why digital natives need books: The myth of the digital native. *First Monday,* 23(10). https://doi.org/10.5210/fm.v23i10.9422 https://www.firstmonday.org/ojs/index.php/fm/article/view/9422 (accessed 15.5.2020) https://www.firstmonday.org/ojs/index.php/fm/issue/view/608 (accessed 15.5.2020)
This paper is reprinted with the permission of the author and *First Monday.* The publication translated into Spanish can be accessed here: https://cerlalc.org/publicaciones/dosier-lectura-en-papel-vs-lectura-en-pantalla/ (accessed 15.5.2020)

These sweeping generalisations of an entire generation of students emphasise preferences without considering that what learners prefer is not necessarily what they need for successful learning. Singer and Alexander (2016) found that 90 undergraduate students preferred reading digitally and believed that they performed better on a digital reading comprehension test than on a print-based test, but their results did not support their suppositions. On the contrary, the students were overconfident with their digital reading results and more precise regarding their print performance. Further, they recalled key points better from paper reading.

The 'net generation' (Tapscott, 1998), is another term applied for these students. They were characterised as "exceptionally curious, self-reliant, contrarian, smart, focused, able to adapt, high in self-esteem, and has a global orientation ... there has been a change in the way children gather, accept and retain information" (Tapscott, 1997). However, empirical research of actual digital native behaviour has since shown that the digital native is a myth (*e.g.,* Bennett and Maton, 2010; Moran, 2016). Among digital native university students in the U.K., Jones and Shao (2011) found no evidence of a uniform requirement for education to adapt new digital tools for learning.

There is not one digital native profile, but many. Some play games extensively, while others do not. Many are avid users of mobile technologies for socialising; they are on Facebook, Snapchat, Instagram, Messenger and they tweet. A few have blogs or vlogs (video logs rather than text-based blogs), while others 'couldn't care less' about blogging or vlogging. Most digital natives consume, rather than actively create, digital content (Fraillon*, et al.,* 2014). Many check news and other short text on digital devices, but few read lengthy text unless they have to for school or study. Further, the typical multitasking behaviour described by Prensky comes with a cognitive cost also for digital natives (*e.g.,* Moran, 2016): it is detrimental to effective learning. Neither is there a clear generational divide between the technologically competent, critical and autonomous digital native and the older incompetent digital immigrant who always lags behind. These profiles are oversimplifications of digital users, young as well as adult.

It is true that children and adolescents spend much time using digital devices of many sorts, but they tend to use them for entertainment, socialising and information seeking (Livingstone, *et al.*, 2014; Fraillon, *et al.,* 2014), not for creative or critical use. To illustrate, a smartphone user may, in just a few minutes, download an app to find information about when the next bus leaves; send a message to a friend about a possible delay, while at the same time checking out what happens among a group of Facebook friends, and watch a funny YouTube cat video shared by a complete stranger. It is fast, practical and fun, and many so-called digital immigrants master it, too. In contrast, only few exploit the possibilities offered by digital media of creating content on their own or developing technology skills beyond that of a user, skills predicted by digital learning optimists to be widespread among a generation growing up in media rich environments (Fraillon, *et al.,* 2014).

Children have become an important market for new mobile technologies, such as tablets and smartphones — parents buy them for ever-younger offspring. None of us wants our children to lag behind their peers, do we? There are many reasons to provide youngsters

with their own mobile devices: we want to be able to communicate with them when they are away from home, or even track their devices; youngsters themselves want to be able to communicate with friends. It is also very convenient if the tablet keeps the toddler busy while mum (or dad) is busy working on the home office computer (or checking Facebook).

Yet, many parents are aware that they should place their toddler on the lap and read kids' books together. This parent-child-book interaction prepares a child for successful literacy development (Valencia and Sulzby, 1991; McCardle, et al., 2001), the initial grasping of the essentials of script: letters, signs, the direction of text (left to right in many alphabets, right to left in others etc.). These are foundations of script literacy whether the script is printed or electronic, but for a small child they are probably more easily presented in the form of tangible books than from screens. Children who come to school without such experiences risk lagging behind in reading development permanently. We can only hope that parents will continue acknowledging such emergent literacy (Sulzby, 1990) practices even when they are digital natives themselves.

Learning to read in a digital era

Many studies on children's media use around the turn of the millennium related observations of how easily and willingly children seemed to adopt new digital media. Such observations often gave the optimistic impression that 'all' children mastered new technologies, they enjoyed using them and they were not afraid of clicking buttons. These studies most often did not check learning effects or individual differences. Since then, of course, computers have become more user-friendly for adults and for children, and more child-friendly and pedagogical content has entered the market. The smartphone and the tablet opened up digital resources for ever more varied use and new groups of users.

Many toddlers show an interest in phones and tablets as toys. Little wonder, when they see their parents use them constantly. Such toys can be highly engaging, and they can no doubt be used to learn. For instance, the alphabetical principle, that letters relate to sounds, can be learnt via fun games. However, this technical aspect (decoding) of reading acquisition is merely a first step to reading. From this initial foundation, it usually takes years of training and literacy experience before the child can read and comprehend a variety of unknown texts for learning purposes (Chall, 1983).

Selecting pedagogically sound games depends on parents' awareness that they exist and their engaged support in a child playing them. Not all children have access to pedagogical games and not all children prefer them to games that might be more fun but not as useful. We may learn in the future that rather than having plentiful access to digital devices, the important differences among learners will be what they choose to use their devices for. Those who like to challenge themselves and expand their knowledge base, have many opportunities to do so from digital devices and the Internet (and books!), while those finding life more pleasant without such challenges, can choose to engage in digital media merely for relaxation. In most workplaces, the first category would be preferred.

Talking of the workplace, this is another arena for digital learning. Many digital immigrants, the old and wary among us, have had to learn new information and communication technologies (henceforth ICT), such as various search engines, electronic documentation, registering for a seminar or booking a flight. (Once we master it, though, the workplace replaces our computers, intranet system, travel agency, communication platforms and other ICT software.) How come we digital immigrants cope? And why is the slogan 'Learning for the future' so often associated with learning digital skills, when the most ephemeral phenomenon we presently have, is digital technologies including software? If there is one thing of which we can be certain, it is that the digital tools we learn to use today will not be those of the future.

There is good reason to believe that some of the digital skills children need for the future, they learn effortlessly and informally at home, while other, critical skills they should learn at school (Fraillon, *et al.,* 2014), and the future will still provide them with opportunities to master new technological developments. What children need is the ability to read well in order to navigate the new media, to read information critically whether it be on paper or screen and to meet ever new demands put on them as adults in rapidly changing work landscapes. Children will need to be able to read well in order to, for example, correctly program the robot that will be sterilising surgical instruments in the future. In many countries, there are hardly any jobs any longer that do not require reading skills beyond those of the generations before us. Learning to read well is therefore more important than ever.

Reading and learning from screens and from paper

It is often assumed that digital technologies are equal to or better than paper for all kinds of learning. Digital technologies no doubt make possible new activities in the classroom, and with didactically sound implementation, they can help student reach many of their learning goals (Sung, *et al.,* 2016). Students growing up in countries investing in ICT for education, typically use these learning resources for seeking information, writing essays and producing presentations, because school requires it of them. Sadly, only few young people use their digital devices for spare time in-depth reading. One reason may be that they find other digital activities more appealing (chatting or gaming) or necessary (school tasks), than reading longer texts for enjoyment and learning. Another reason may be that such reading is more difficult on screens than on paper, especially if the screen has Internet connectivity and therefore many possible distractions.

Concentrated in-depth or immersed reading may have become harder for anyone who uses digital media and the Internet extensively, as typical fast-paced reading patterns connected with online reading seem to influence all kinds of reading, whatever the purpose. Several reading researchers suggest explanations. For instance, Liu (2005) found that reading behaviour changed during the decade of mid 1990s to around 2005, probably due to changes in skimming and scanning patterns that we often employ when reading online. Googling information, we skim results quickly to find the most relevant hit, while we scan online newspaper headlines in search of news that interests us. We read quickly and respond quickly to messages in social media. Baron (2015) suggests that such fast and shallow

reading behaviour may spill over also to reading purposes that demand concentration and immersion: what Wolf and Barzillai (2009) call “deep reading”. Deep reading allows for comprehension and critical reflection, which are skills that we need in order to perform successful Web searches, for example. Children easily learn to search in Google, but this does not mean that they find the most relevant and reliable sources — they might just pick the first source they retrieve. Paradoxically, it may be that deep reading best prepares children for successful online ‘shallow’ reading like searching, skimming and scanning.

Deep reading can be performed on screens. In fact, some digital devices, such as the Kindle, are specifically designed for reading long text, typically novels. However, as suggested by van der Weel and Kovač in the their initial paper in this special issue[8], ebooks seem to substitute rather than complement print book markets. Already avid book readers invest in an e-reader dedicated to book reading, and they are most likely adults with surplus income. Students prefer more flexible digital media that can also be used for Internet searches, spellchecking, downloading films and music etc. There are most likely very few who start reading ebooks if they do not already enjoy reading in print form.

Research supports that young students tend to underutilise digital devices for deep reading. Merga and Roni (2016) found among a sample of Western Australian children 8 to 11 years old, that even those students who reported reading books daily, did not often do so on their digital devices. Contrary to expectations, access to a diversity of digital devices does not lead to more reading of long text. Reading frequency of long text in fact decreased systematically with the number of personal digital devices children had. Access to mobile phones, especially, was associated with infrequent reading.

There is a tendency among educational authorities to assume that children prefer reading on screens for all kinds of texts, and thus Australian authorities decided that school and public libraries opt for ebooks at the expense of printed matter, even if the loan rates for ebooks were low (Merga and Roni, 2016). It remains to be seen whether children will start preferring ebooks to print, but thus far, there is little to support this expectation. Children who do like to immerse themselves in reading seem to prefer print, while they use their digital devices for other things.

As mentioned in the introduction to this special issue (Kovač and van der Weel)[9], reading long text is demanding. Reading them on screen may be even harder, especially for beginning readers. Therefore, homes, kindergartens, school libraries and classrooms should continue to stock printed books for children, to provide for emergent literacy skills in kindergarten, and to provide primary school children with plenty opportunities for extensive reading. International large-scale reading assessments tell us more about reading for enjoyment and its correlation with reading comprehension.

Discussion: What do large-scale reading assessments tell us about reading?

International surveys of reading competence have started assessing how well children read on screen. The Progress in International Reading Literacy Study (PIRLS) has assessed

[8] https://www.firstmonday.org/ojs/index.php/fm/issue/view/608
[9] https://www.firstmonday.org/ojs/index.php/fm/issue/view/608

print reading literacy among 10-year olds since 2001 using a paper booklet of text and items probing a variety of reading processes that together measure reading comprehension. The PIRLS survey is repeated every five years among new cohorts of 10-year old students. In 2016, this assessment for the first time provided an additional test of online informational reading that the students responded to using computers (Mullis, *et al.*, 2017b).

In addition to the skills test, PIRLS includes a range of questionnaires, probing, for instance, students' reading habits and ICT use. What emerged in Norway from ePIRLS 2016, was that the amount of spare time book reading showed a linear, positive correlation with student results from an online assessment of informational reading; the amount of computer use at school did not (Støle and Schwippert, 2017).

It may seem unexpected that reading books for fun should be related to reading achievement in a test of informational reading only, and in an online environment at that. Both the reading purpose (information rather than fiction) and the medium (computer rather than paper) differ from the factor demonstrating the strongest correlation with good e-reading performance, namely spare time book reading. This result, however, is in line with recent research (Pfost, *et al.* 2013; Duncan, *et al.,* 2016) which has found that book reading is indeed the best predictor of reading skill among children who have grown up with digital devices, the so-called digital natives.

Another large-scale survey, the Programme for International Student Assessment (PISA) for 15-year olds, has implemented additional digital tests every three years since 2006 (from 2018, PISA will be digital only). The PISA study measures not only reading, but also mathematics and natural science. PISA measured screen reading for the first time in 2009. It appeared that computer use at home was related to digital reading performance, whereas computer use at school was not, even after accounting for students' academic abilities, *i.e.,* subtracting students who use computers as special needs compensation48[10] The PISA report – *Students, computers and learning: Making the connection* (based on the 2012 survey) – concludes:

> … while PISA results suggest that limited use of computers at school may be better than not using computers at all, using them more intensively than the current OECD average tends to be *associated with significantly poorer student performance.*[11]

Further, PISA trend measurements show no evidence that increased access to digital technologies over time improved student results in reading, mathematics and science. Contrary to the expectations of many, the OECD could not report any clear relation between a country's investment in digital technologies in education and its results in reading, mathematics and natural science.

The patterns in Norway for ePIRLS 2016 resemble those of PISA 2012 (OECD, 2015): frequent, *i.e.,* daily, computer/tablet use for school tasks at school or at home, is related to relatively poor results on the digital reading test. The best results occur among those students who report less frequent computer use, once or twice a month at school (Støle and Schwippert, 2017). As of yet, these are correlations only, not explanations, and must

[10] OECD, 2011, pp. 20–21
[11] OECD, 2015, p. 16, my emphasis

be studied further in the future. We shall know more after 2021, when the second round of ePIRLS has been conducted.

In the meantime, Norwegian educational authorities have decided that each child acquire their own tablet at school from the first grade in 2018. From PIRLS we know that more than 99 percent of Norwegian students have at least one computer or tablet at home they can use for study, and more than 98 percent report that they have Internet access. International test results show that extensive computer use at school does not enhance key skills, such as reading. Whatever learning computerised school tasks may lead to, there is good reason to believe that reading comprehension is not one of them. For this, students had better spend their time reading a book.

Book reading

Unfortunately, book reading is in decline among both 10-year-old children and their parents according to their respective responses to the PIRLS questionnaires since 2001 (Mullis, *et al.,* 2017a). For close to two decades, the PISA survey has also measured spare-time reading, documenting a reduction in spare-time book reading among 15-year olds. One possible explanation for declining reading rates is that of displacement, meaning that children spend increasing amounts of time on digital media, leaving less time for pleasure reading. Even if they can use their devices for book reading, few of them do so (Merga and Roni, 2016).

When fewer parents read books (Mullis, *et al.,* 2017a), fewer children will see book-reading role models. In many cultures, it is also likely that fewer parents read print magazines or newspapers, as so much of the former print-based material has moved online. What many children see is parents reading on computers and laptops, tablets like iPads and smartphones, or dedicated e-readers, such as Kindles. The latter two offer very different opportunities for immersed reading (see the introduction to this special issue, “Reading in a post-textual era”[12]), but they both look like a tablet or mini-computer. To a child, there is no telling whether mum or dad is engaged in immersed book reading or scanning through Facebook posts.

In fact, parents’ book ownership has been a stable indicator of childrens’ school success for decades. The most recent PIRLS survey employed a combined variable to cross-nationally express children’s “home resources for learning”[13] to detect the relationship between home background and reading achievement. Nonetheless, the simple measure of how many books parents own, still shows a linear, positive relationship with their children’s reading comprehension, both in the paper-based and in the digital reading test, even in a technology-rich country such as Norway (Støle and Schwippert, 2017).

Evans, *et al.* (2010), exploring relevant data from old and recent surveys from diverse cultures and political systems, found that “scholarly culture”, simply expressed by number of books, better accounted for children’s future academic success, than did factors such as father’s level of education, occupation or class.[14] Children from poor and under-educated

[12] https://www.firstmonday.org/ojs/index.php/fm/issue/view/608
[13] This combined variable ‘home resources for learning’ consists of number of books, number of children’s books, parents’ education level and occupation, and digital resources.
[14] Evans, *et al.,* 2010, p. 171

families gained especially much from growing up in a home with books compared to in a bookless home. This finding held across cultures and across time (1940s to 1980s), and it has yet to be disproved. It still appears that those families who keep their bookshelves and provide their children with printed reading material, pave the way for children's reading literacy better than families who prefer digital devices to books.

Recent reading research across media

One drawback of such surveys as PIRLS and PISA is that they give us facts and figures, but not explanations. We find evidence that paper book reading frequency correlates strongly and positively with reading achievement in both studies, which suggests that there is a true connection, but there may be other contributing factors that are not surveyed. The positive effect of book reading on reading fluency, comprehension and vocabulary is well documented in pre-digital reading research (*e.g.,* Cunningham and Stanovich, 1997; Guthrie*, et al.,* 1999). Cunningham and Stanovich (1997), for instance, found that print exposure predicted reading ability in a student sample 10 years later: first graders were tested on diverse reading tasks, and plentiful print exposure (*i.e.,* reading) together with initial reading skill, accounted for growth in reading comprehension, vocabulary and general knowledge. First, we need to find out whether the fundamental relationship between print reading and reading ability is still true in a time when we have so many other devices at hand that can be used for reading. This is what Duncan, *et al.* (2016) did. Their study of two groups of school children, aged 11–13 and 14–15, revealed that traditional extended reading was the only factor that predicted "inference-making in comprehension and [...] distinguish[ed] skilled from less skilled comprehenders." These students spent more time on reading on screens than on print, but the digitised reading behaviour did not lead to better reading skills, only traditional print reading did so.

Secondly, in order to figure out what causes good reading comprehension, we must look at development from young to older students in so-called longitudinal studies (like that of Cunningham and Stanovich, 1997). Pfost, *et al.* (2013) used longitudinal data from the same students from the fifth to the seventh grade in southern Germany. They included many kinds of print and online reading and different kinds of text: comics, magazines or newspapers, novels/stories/tales, non-fiction books, online encyclopaedias, e-mail and online forums/chats. The students were asked how much time they spent on each of these types of traditional print and online content reading. All the variables were included in a regression analysis to calculate how much each of these kinds of reading contributed to measures of reading comprehension and vocabulary.

Pfost, *et al.* (2013) confirmed pre-digital research that traditional book reading still accounts for positive development of reading comprehension and vocabulary, even when early reading achievement was accounted for. This means that even if reading comprehension and vocabulary were already good in the fifth grade, continued growth in seventh grade was explained by book reading, and further, the same pattern is true for poorer fifth grade readers; if they read books their reading ability improved. Comparing book reading to the other reading activities in the study, Pfost*, et al.* (2013)

found that "online activities such as e-mail or chatting related negatively to reading achievement". In other words, these online reading activities had a detrimental effect on reading competence.

There is a logical explanation to why chatting and e-mail does not enhance reading ability. Chats and e-mail messages are often short text closer to oral than to written language. The much richer language of long text helps to develop fluency in decoding, internalise knowledge of syntax, enlarge vocabulary and build background knowledge of the world and of text types. These are necessary skills in order for children to become competent and critical readers. Further, research comparing children's handwriting and typewriting has shown that the movements involved in writing by hand facilitate aspects of beginning reading, such as letter recognition. (For more on handwriting, see Mangen's contribution in this issue, "Modes of writing in a digital age: The good, the bad and the unknown".[15])

Should education adapt to children's digital media usage?

Around the turn of the century, induced by theories of the new digital natives by Prensky and others, there was a heated debate in many countries on how education must change to meet the needs of these very different children. Some even claimed that schools should adapt to the learner and provide students with learning opportunities that were as close to their spare time technology use as possible. Gee (2012) suggested that instruction should utilise examples from gaming.

Many schools have adapted, but rarely to the extent that formal curriculum- and text-book-based learning is 'out', while informal free online learning is 'in'. There is no reason that book reading should not still be encouraged in school along with didactically effective employment of digital media. Neither should we seek to replace formal learning with self-paced self-selected learning from computers and the Internet, based on the idea that digital natives learn important things for the future on their own. Formal education aims at ensuring a shared knowledge base for all in a structured and pedagogically relevant manner (Bennett and Maton, 2010).

Children at different ages are at different stages of learning and development, and they require instruction to develop further, be it digital skills or reading comprehension. Even Gee (2008) contends that students in the digital era need teachers. No one is born a digital expert, nor is anyone born with the ability to read (Wolf, 2007).

All humans are however, born with an ability to learn. To foster learning in young children, a competent adult, a parent or a teacher, is more efficient than a laptop and Google. To foster sufficient reading competence to enable efficient learning from text, be it print or digital, is one of the main goals of school. Typically, the first school years are dedicated to 'learning to read', while children in the middle school years should be able to 'read to learn' (Chall, 1983). It is becoming increasingly clear that extensive print reading is the best didactics for this, even in the digital age.

[15] https://www.firstmonday.org/ojs/index.php/fm/issue/view/608

Conclusions: Book readers become better screen readers

Healthy reading development must remain a goal in education in order that students learn to comprehend digital texts successfully in their future studies and work life. For children to become skilled readers, it appears that book reading still is preferable to screen reading during those crucial early years of reading development (*e.g.,* Pfost, et al., 2013).

Returning to the results on digital e-PIRLS assessment among Norwegian 10-year olds, it is likely that these stem from book reading programmes in Norway in the past 10 to 12 years. Since the discovery from PIRLS 2001 that young Norwegian students lagged behind their peers in many countries, primary education was encouraged to focus on reading development by employing book reading programmes. Teachers and school librarians rose to the challenge, many such book reading programmes were implemented, some of them especially focused on engaging boys in reading.

Norwegian children have improved their results significantly both in 2011 and in 2016, when also e-PIRLS evidenced reading achievement above the international average. When tablets now (in 2018) are introduced as learning devices to each child starting in the first grade in Norway, it is important that book reading still continues as part of the children's reading acquisition in a balanced approach to reading instruction. There is a risk that the focus on new technologies has to some extent taken focus away from older technologies (yes, paper), even when we know that the old technology works well. As children's access to personal digital devices in the home increases, it is even more important that school encourages book reading and actually provides for it at school.

Even though digital devices offer many opportunities for reading, they may not be ideal tools for training and improving reading skills. In those years when children move from learning to read to becoming fluent and experienced readers they should read extensively. Like any skill, reading benefits from the right type of training. With appropriate and sufficient reading experiences, the child will be able to apply solid reading skill when reading unfamiliar texts for comprehension, be they print or digital, for learning or for pleasure. The use of digital technologies versus print during this important period of reading development has received too little scholarly attention, and even less attention from educational agencies and the media. Perhaps we have been so preoccupied with the new technologies to see that there are some advantages to the old ones: the printed, stable text format?

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Decreasing materiality from print to screen reading

By Theresa Schilhab, Gitte Balling and Anežka Kuzmičová

Preface[16]

The shift from print to screen has bodily effects on how we read. We distinguish two dimensions of embodied reading: the spatio-temporal and the imaginary. The former relates to what the body does during the act of reading and the latter relates to the role of the body in the imagined scenarios we create from what we read. At the level of neurons, these two dimensions are related to how we make sense of the world. From this perspective, we explain how the bodily activity of reading changes from print to screen. Our focus is on the decreased material anchoring of memories.

The embodiment of reading

In recent years, the transition from print to digital reading has accentuated reading as an embodied practice (Mangen and Schilhab, 2012). Literally speaking, the embodiment approach to reading assigns a role to the body in what is otherwise primarily a mental activity. Such a move is overdue (*e.g.,* Schilhab, *et al.,* 2008). The body has been off the radar in most treatments of human accomplishments for two millennia. Since ancient Greece, philosophers have tended to praise the achievements of the mind as if there was no body involved.

Embodiment in reading has two distinct dimensions: the 'spatio-temporal' that relates to what the body does during the act of reading and the 'imaginary', that relates to the role of the body in the imagined scenarios we create from what we read. The spatio-temporal dimension accentuates that, like the human body, all texts are material and exist in time and space. Hence, this dimension is about the presentation and tangibility of the text and how it is sensed through the body. The imaginary dimension accentuates that texts point to phenomena and events we imagine while reading. Especially literary texts elicit experiences in the reader that in so-called immersed reading feel like real experiences. Arguably, it is for that reason that literary reading appeals to most readers. But feelings of real life experiences may also arise as part of reading non-fiction. When reading expository texts like recipes and manuals, the reader imagines what is the case in real life (Schilhab, 2015a). The bowl with eggs and sugar exists in time and space along with the whisk that fits the palm of the hand.

From a biological perspective, the two dimensions are related effects of how we make sense of the world. In biological terms, we incessantly interact with the environment. This applies not only to the macro level where we read books or tablets while seated in

[16] Schilhab, T., Balling, G., & Kuzmičová, A. (2018). Decreasing materiality from print to screen reading. *First Monday*, 23(10). https://doi.org/10.5210/fm.v23i10.9435,
This paper first appeared in First Moday and is reprinted with the permission of the authors and *First Monday*. https://www.firstmonday.org/ojs/index.php/fm/article/view/9435, (accessed 15.5.2020).
 Spanish translation:
https://cerlalc.org/publicaciones/dosier-lectura-en-papel-vs-lectura-en-pantalla/

chairs or sofas. More surprisingly, perhaps, interactions apply especially to the micro level, the level of neurons. On that level, an action such as 'reading book A' becomes a distinct interaction as it connects with a particular location, such as 'a car', 'the living room', or on 'a mountain top'. Similarly, reading book B in a different location would lead to different connections. Therefore, at this level it is clear that the act of reading becomes connected to what the body is doing while reading, thus influencing what (and how well) we remember the text we are reading.

In this article we explore what the incessant embodied interaction with the environment means for the embodiment of reading in the shift from print to screen. We ask whether the different materiality of the screen radically changes the connections formed between what we read and what the body does while reading.

The spatio-temporal dimension

Although texts have semantic meanings, they are also material. The marked sensitivity to the materiality of the world is deeply ingrained in all organisms alive (Sheets-Johnstone, 1998; Schilhab, 2015b; 2015c). During reading we interact physically with the materiality of the reading substrate to decipher the text. Like a mountain top differs physically from the living room, different texts have distinct materialities. We react to the light conditions, the sensed weight of the platform and the physical touch of the substrate that holds the text. We engage with the strings of words in their quality of being a physical object with a certain appearance that takes up a particular part of space in time.

At both the macro and the micro level, the materiality is connected with the textual meaning. In attempts to unlock the meaning of the text, say the characterization of a culprit, or descriptions of an architectural masterpiece in town, concurrently we process where and when in the text we stumble across this information. The processing of time and space in our reading occurs in much the same way as we process objects and events on our walk to work. Processing of time and space also occurs while at rest in our living room, or while climbing the top of Matterhorn.

Hence, when reading we engage memory features supportive of ongoing cognitive events in general. This is not surprising. In the evolutionary perspective, reading is a much newer activity than walking and resting for which our memory features were developed.

Some of these features are known as so-called episodic memory, a concept introduced by Endel Tulving (1993). Episodic memory records a person's experience relating to personal spatio-temporal relations. Hence, among other things, episodic memory processing encodes events in the order of their occurrence and their sensory-perceptual-conceptual-affective characteristics, most often in the form of visual images. In other words, we process and store memories about events from how they are sensed, experienced, consciously understood and emotionally felt. Also, the memory always presents itself in a first-person perspective depicting encounters and events *as they are experienced* in time and space. Consequently, the reading substrate is important for the processing of the

text and the subsequent recollection of the content of the text. How the body moves and interacts during reading is processed along with the unlocking of the meaning of the text.

Obviously, the solidity of the *printed* text fixed in size and space and anchored to, say, a distinct cover, renders it readily available to perceptual and sensual processing. By contrast, the digital text is fluid, often without fixation of font size, place in space or even anchorage to a particular substrate (*e.g.*, a particular printed item with a particular cover). For example, an e-reader can contain a huge number of texts and is therefore not associated with any particular text. Rose (2011) describes how reading a continuing sentence is disrupted when the swap from one page to the next is done by scrolling in the text on screen during reading in portable document format (pdf). With printed text the swapping of pages would have had a coinciding recognisable feeling to it constrained by the feeling of the concrete pages.

In effect, whereas the description of a culprit's personality would automatically be linked to say, the left bottom corner of the page around 40 pages into the printed book, such concrete linkages are unavailable for the on-screen reader. Studies have shown that the transition from print to screen entails a shift in readers' spatio-temporal relation with the text (Hillesund, 2010), and readers sometimes report a general sense of changed memory capacity in digitised reading (Kuzmičová, *et al.*, 2018).

How does research examine the differences between print and screen reading? Traditionally the differences have been associated with better memory for the content of the text in print readers. Mind, however, that cognitive processing during reading differs from that occurring while remembering the reading.

How exactly does the particular availability of printed text to the senses impact on readers' abilities to remember the content? At issue is to what extent momentary embodied processes are actually supporting the reading process and to what extent these are used later for remembering. Crudely put, it seems as if in the very course of reading, in the so-called encoding phase, the materiality of printed text increases one's ability to recall the content of the text. In the following we will expand on how the materiality impacts on encoding and recall when reading in print and on screen, respectively. To that end, we first address what happens at the micro level.

Biological sensitivity and multimodality

With printed text, the tangibility of the reading substrate lends itself to the kind of cognition that we are biologically adapted to and therefore comfortably employ. Most of these cognitive processes occur outside of our conscious mind. Crudely put, the reading activity 'speaks' to us at several levels: the sensory, perceptual, motor, conceptual and affective level. All of these levels participate in forming the so-called neural correlate, which is the bundle of neurons active during the reading (Schilhab, 2017a). To grasp how much is going on in each moment, imagine the simple act of holding a hot cup of coffee. In your mind's eye, go to the particular, combined sensation at your finger pads. Simultaneously, you may

sense the heat from the porcelain; the smoothness of the surface and the weight of the cup. These sensations all point to further information. They help you deduce the hotness of the coffee, how much of it is left, and whether it is yours to drink in the first place.

In the words of Cashman[17], from whom this example is borrowed, the amount of neural activity is overwhelming:

> When I hold a cup of hot coffee in my hand, my finger pads are physically made to curve in an iconic match to the curvature of the cup. Certain nerve endings embedded in the finger pads are triggered by this change of shape in the pads. At the same time, the skin of these finger pads is warming up because of the transfer of the heat (speed of molecules) from the porcelain cup to the fingers. Other specific neurons, that are unaffected by shape, are sensitive to changes of heat in the fingers. They are triggered to fire by the warming of the fingers. If, in addition, I squeeze the hand on the cup, still other neurons in the finger pads and in the joints of the hand are triggered in response to the increased pressure.

The question is what happens to the bundle of active neurons, when we switch the reading substrate from paper to screen?

With digital text, the tangibility that helps us literally navigate the text is markedly reduced. Accordingly there is a significant lack of so-called 'material anchors' with which the meaning of the text might become associated (Hutchins, 2005).

Barrett makes it clearer what changes with a switch from print to digital reading[18]:

> Every moment of waking life, the human brain realizes mental states and actions by combining three sources of stimulation: sensory stimulation made available by and captured from the world outside the skin (the exteroceptive sensory array of light, vibrations, chemicals, etc.), sensory signals captured from within the body that holds the brain (somatovisceral stimulation, also called the interoceptive sensory array or the internal milieu), and prior experience that the brain makes available by the reactivation and reinhibition of sensory and motor neurons (*i.e.,* memory). These three sources — sensations from the world, sensations from the body, and prior experience — are continually available, and they form three of the fundamental aspects of all mental life.

Two things become apparent. First, according to Barrett, at each instant our mental life is drawing on multiple sources. At any given moment, cognitive occurrences — be they ideas, desires, the needs for actions — are composed of many different processes. Hence, the three components: stimulations from the external and internal milieu, and memory. These comprise both conscious and unconscious processes. Some of the processes emerge 'bottom-up'. They are initiated and proceed without the individual recognizing and controlling them.

The multimodality of every moment means that we habitually couple sensory knowledge with the concurrent mental processes. Clements (2000) refers to 'sensory-concrete'

[17] Cashman, 2008, p. 51
[18] Barrett, 2009, p. 330

knowledge, which is knowledge that emerges from the association of sensory material to thought processes while grasping an idea. A typical example is when younger children can only perform mathematical operations such as count, addition and subtraction with the aid of material objects. Here, seemingly the concrete provides the child with 'external crutches' in the shape of material anchors.

Second, when we move from print to digital texts we rely less on what Barrett defines as sensory stimulation 'captured from the world outside'. When reading digitally, solid external crutches formed by different sensory processes are almost absent. Therefore, the unfolding meaning attribution to the text occurs without much material anchoring.

Digital reading compares to print reading as walking blindfolded compares to walking visually aware through a busy street. For the blindfolded pedestrian, the recollection of the content of conversations along the route must be processed and maintained entirely in the mind's eye. Conversations are memorized by their occurrence in time *in the string of conversations*, which are maintained without engaging perceptual qualities: that is, exclusively mentally. For the visually aware pedestrian, the conversations during the passing may be associated with a particular fence, zebra crossing or house facade. Space and time are now tangible and their impact on our bodily processes acts as anchors for later memories.

Material anchors in memory

When we neurally associate the processes that sustain abstract mental content with processes that sustain concurrent perceptual and sensory processes, the memory product is more easily re-enacted (*e.g.,* Kontra, *et al.,* 2015). The effect of using the external world as anchor for otherwise abstract memories was exploited in the ancient mnemonic technique known as the 'mind palace technique', an established aid for recalling larger amounts of linguistic content. While rehearsing items to remember for, say, an important speech in the Roman senate or a festive birthday speech for a loved one, a sequence of visual images of a familiar environment can be used to prompt recall. Familiar rooms in your childhood home or the home of your grandparents are easy to re-enact because they are multimodal like the walk made while visually aware. You instantly visualise their atmosphere, odour, tactility, light conditions, sound pattern and so on, which can be used as material anchors while preparing the speech (see Fassbender, *et al.,* 2006). When performing the speech, all you have to do is to enter your well-known 'palace'. Now the associations with somewhat arbitrary strings of information are easily triggered, as if they were inhabiting the rooms recalled in memory.

Memory artists like Solomon Shereshevsky, Alexander Luria's famous patient, have also exploited how easily experiences with material objects come to mind and can form a background tapestry for memory. Shereshevsky, who showed extraordinary capabilities for memorising, often used a village street from his childhood. Here, he mentally dispersed the items to remember. In the recalling phase, he would stroll along the street and pick up the items mentally placed (Johnson, 2017; Foer, 2011).

We all outsource otherwise fragile and costly mental processes to the environment as we integrate the materiality of the text in our memory. The materiality of the printed book makes it a stable environment in the same sense as the familiar rooms. The features that made the familiar room in your mind palace so easily revived are shared by all concrete objects and environments. They repeatedly stir voluminous motor-sensory and emotional activity in us to which we can return later and very often in a kind of simulation. Concrete phenomena like coffee cups influence you in similar ways. They activate more or less the same neurons in much the same way. This explains why you can make reliable predictions about the temperature of the cup's content and the amount left. Similarly, the same printed book elicits neural activity in much the same way every time you leaf through its pages, whereas sensations that apply from book to book leave you with the more general impression of 'bookness' (Barsalou, *et al.,* 2003).

The culprit's characterization is invariably accessible on the fortieth page, whether you look up the text from the middle section or the last third. The number of pages you keep between your fingers in relation to the thickness of the book roughly correlates with the length of the story. And the distinct odour of dust and age and indents on the cover all add to the aura of that specific text. Hence, alongside the reading, the material anchors become stable non-arbitrary cues at work automatically and bottom-up. The arbitrary strings of words then become entangled with the stable and repeatable external world. Recollection of the content of the text may therefore occur by recalling the smell, the feel or the sensation of the weight of the book in your hands.

The encoding processes occurring during reading of the digital text, on the other hand, are very different. In comparison, they have very few and rather unstable anchoring points in time and space. Therefore, they are formed around solely mental associations controlled top-down by the individual. Completely mental processes without hooks into the material world emerge exclusively as meaningful conscious associations. Thus, we have no material entries, like the memory of a stained page or the feeling of a certain number of pages between the fingers, to re-enact them. All we have is the sheer remembrance of words. Surely, these are extremely fragile, whimsical and easy to forget. Think of how difficult it is to remember the name of someone you have never met and how much easier it is to remember the name of an acquaintance with a photo present. Facial characteristics, like specific pages in a book, are stable cues for arbitrary names (Goldberg, 2013).

With decreased materiality, is the spatio-temporal dimension of reading then irrelevant for on-screen reading? Certainly not, although the view on the spatio-temporal dimension is turned upside down. Cognition and metacognition researchers find that reading expository texts for learning on screen is typically associated with shallower processing as demonstrated by weakened effort regulation and test performance (Sidi, et al., 2017). Since the reading of all texts occurs on the same physical substrate, the perceptual cues have no discriminative properties to anchor one's memory. Irrespective of the genre of the text, be it self-help medical entries, news, literary text or social media, there are no stable external features. Therefore, the mind is similarly rather than differentially attuned to all of them. According to the researchers, the perceptivity to the text on screen has decreased, simply because readers lack material anchors to guide their engagement with the text.

The imaginary dimension

The extensive neural coupling traversing the sensory, perceptual, motor and conceptual level also grounds the imaginary dimension of embodiment in reading (Kuzmičová, 2014). The imaginary dimension is based on the connections the reader has made in the spatio-temporal dimension when first learning to speak (*e.g.,* Schilhab, 2018; 2017a). From your first breath, your environment is both material and linguistic. Your environment is replete with concrete phenomena, events, processes or occurrences with tangible feels to them (*e.g.,* Wellsby and Pexman, 2014). We learn language in much the same way as we walk visually aware down a busy street. And we learn linguistic meanings by forming connections with linguistic practice. This is also why your grandparents' or your childhood home is so easily remembered. This fact pertains to most experiences of your childhood. Specific sensory feels and emotions are just beneath the surface of your memory. While your caretakers are quite keen on sharing the linguistic mastering of this world with you, concurrently you experience the physical setting. You perceive and interact with dogs, cutlery, daddy, liquid, clothes, apples and mosses, as well as sisters, insects, the globe, trees, stars and radio broadcasts (Schilhab, 2015c; 2011). This insight has come from studies that show activity in brain networks based on sensory experiences when readers passively encounter words with strong olfactory associations such as 'cinnamon' or 'garlic' (González, *et al.,* 2006).

Seemingly, meaning attribution during reading involves re-enactment of real-life experiences in memory (Schilhab, 2018; 2017a; 2015a; 2015b). Thus, mere reading of words that refer to real objects with sensory features recruits brain areas normally active during the actual experience of the object. Researchers propose that neurons activated as a result of real-life experiences with the referent of a word (*i.e.,* garlic) later participate in the bundle of neurons of the concept even without simultaneous presentation of the actual object (Pulvermüller, 2005). This bundle is then involved when we read the word referring to the object.

As infants, when we acquire language, simultaneously we perceive and talk. Hence, we associate the perceptual processes in the interaction with concrete phenomena and events with linguistic processes of sounds, articulation, facial activity etc. (Glenberg, 2008; Öttl, *et al.,* 2017). In this process, the simultaneous exposure results in the co-wiring of perceptual and linguistic networks that will become active together during later recall. For example, when talking about bananas, infants are typically also perceptually engaged with concrete bananas (*e.g.,* Glenberg, *et al.,* 2008; Pecher, *et al.*, 2011). When children later hear or read about bananas they reactivate the sensory-motor areas active during perception. Comprehension of narratives, therefore, relies at least partly on simulations of sensory experiences (Speer, *et al.*, 2009; Engelen, *et al.,* 2011).

As a result, competent readers re-enact prior experiences when they read. Sadoski, *et al.* (1990), point to the many spontaneous imaginative responses associated with understanding and experiences of living through literature. When we imagine while reading we seem to reproduce images from memory that can be used to animate the text[19]. In the Sadoski study, students were exposed to differently paraphrased written instructions

[19] Sadoski, *et al.,* 1990, p. 56; see also Burke, *et al.,* 2016; Kuzmičová, 2014

that emphasised either surface or deep reading. In spite of this, all participants seemed to engage in mental imagery when reading a 2,100-word typical adolescent adventure story. Students "formed powerful visual and affective images that were generally consistent with the text, and elaborated and synthesized portions of it, but also constructed images involving importations from other experiences[20]".

Deep reading

To engage prior experiences while reading is in a biological sense cognitively demanding. Biologically, cognitively demanding is used for imagery that is not supported by the surroundings (Schilhab, 2018). When we attribute meaning to a text, we rely less on sensory stimulation and more on memory. Reading where we are engaged in interaction with a text, either in the immersed/absorbed or the in-depth sense (Kovač and van der Weel, this issue[21]) relies on such memory processes.

Birkerts coined the concept of 'deep reading' in 1994 as "the slow and meditative possession of a book[22]" which catches that we are engaged by a universe constructed by prior memories. Deep reading in this particular understanding, and not in the in-depth sense discussed by Kovač and van der Weel relates to our ability to focus and sustain our attention for a longer period and on one task, and is especially related to the reading of longer literary texts such as novels or to following an argument in continuous reading of an academic book (see also Wolf and Barzillai, 2009).

Many scholars have pointed out the challenges of sustaining our attention when reading using a multifunctional digital substrate (Hayles, 2007; Baron, 2015; Lui, 2005; Hillesund, 2010; Mackey, 2011; Socken, 2013). Research shows that reading behaviour changes with the screen. We tend to read more selectively and shallowly when we read on screens. In an early survey study among academic staff (engineers, researchers teachers) and students Ziming Liu asked about time spent on sustained deep reading and shallow reading and on frequency of annotation in texts over a 10-year period. The result among the 113 participants showed a change in reading behaviour:

> The screen-based reading behaviour is characterized by more time spent on browsing and scanning, keyword spotting, one-time reading, non-linear reading, and reading more selectively, while less time is spent on in-depth reading and concentrated reading.[23]

Other similar studies (Hillesund, 2010) support this picture. Screen reading such as reading on Web pages prompts searching for keywords and specific information, and a reading mode characterized by discontinuity and focus switching. When searching the Internet for information or gaming online this behaviour makes perfect sense. Certain reading modes require shallow reading. N. Katherine Hayles distinguishes between deep attention and hyper attention where deep attention is associated with concentrating on a single object for a longer period and hyper attention "is characterized by switching focus rapidly among different tasks, preferring multiple information streams, seeking a high level of stimulation, and having a low tolerance for boredom."[24] Hayles points out that each cognitive mode

[20] Sadoski, *et al.*, 1990, p. 69
[21] https://www.firstmonday.org/ojs/index.php/fm/issue/view/608
[22] Birkerts, 1994, p. 146
[23] Liu, 2005, p. 700
[24] Hayles, 2007, p. 187.

has advantages and limitations. Still the above-mentioned research suggests that our time spent at screen activities influences our ability to engage deep attention and thus our deep reading ability.

One way to explain this change in reading mode is the affordances of digital substrates. Affordance theory (Gibson, 1986) states that we not only perceive the world in terms of object shapes and spatial relationships, but also in terms of object possibilities (affordance). Affordance points at the transactions that are possible between an individual and their environment. A printed book requires one type of interaction whereas a tablet requires another. For example, it is possible when reading on your smartphone, to swipe between pages and press on hyperlinks with one hand. Thus, different reading substrates and different forms of reading require different forms of interaction and different forms of attention.

The paper book is characterized by a high level of stability, deriving from its materiality. The codex format as we know it has more or less looked the same since it outcompeted the scroll in Late Antiquity (Manguel, 1996). The substrate, in the form of the paper book, has become such an ingrown part of reading that it has become transparent to a degree where we almost forget the existence of the container and focus solely on the content (Bolter and Grusin, 1999). This is due to the fact that a physical book is a unique reading machine whose single function is to hold a text. It is not of much other use. The printed book therefore seems perfect to motivate to contemplation. A tablet or a computer on the other hand is a multimodal and multifunctional machine. Our laptops, our tablets or our smartphones hold potentially all our communication and interactions with friends and work, our banking business, our entertainment channels (gaming, music television), our food recipes, holiday plans and tickets, our self-monitoring in relation to sport, health etc. As we read we might be tempted to click to other sites, to open other apps, or we are interrupted by notifications, social media etc. (Hillesund, 2010). This is exactly why many point at the paper book as more suitable for contemplation and deep reading (Birkets, 1994; Hayles, 2007; Baron, 2015; Mackey, 2011; Socken, 2013). This is also why the imaginary dimension of reading is better served by paper than by screens: if the reading is shallower, as it is in the case of screens, then the reproduction of images and what we can do with them cognitively is shallower too.

How to deep-read on screen?

The question we would like to raise is how to combat the negative impact of the decreased and unstable materiality of the screen on deep reading. Given the multifunctionality of digital reading substrates, how may we stimulate the practice of deep reading for future readers? Are there any obvious biological quick fixes?

One option is to reserve particular reading substrates for particular reading modes. This approach acknowledges the finetuned neural sensitivity to the materiality. Dedicating a specific device to, say, academic texts will ensure the stability of external cues for that genre and thus at least to some extent improve memory processes. However, more conscious actions are also available. In studies showing shallower reading of expository texts on screen, engaging in concrete memorizing procedures such as generating key

words seemed to counteract screen inferiority (Lauterman and Ackerman, 2014). Hence, encouraging in-depth cognitive interaction with the text overcame the cruder qualities of the reading substrate. Shallow reading is also counteracted if readers improve their self-regulation abilities to sustain their attention on the text (Schilhab, 2017b).

The problem that remains then is how to stimulate better self-regulation when it comes to securing deep attention. When a reading technology also affords watching videos, gaming or establishing social contact online, the reader's attention is likely to float (Hayles, 2007). We must then counter the distracting effects by learning entirely new habits such as how to actively restore our self-regulatory abilities (*e.g.,* Schilhab, *et al.,* 2018).

Screen use affords new ways of reading and therefore calls for new kinds of behaviour and attention regulation, as also suggested by studies emphasizing risks of addiction (Wei, *et al.,* 2012; Tarafdar, *et al.*, 2013). We must learn to control the habit of checking for messages and updates (Lee, *et al.,* 2014) when engaged in activities that need our full attention like deep reading and the company of others (Radesky, *et al.,* 2014; Turkle, 2015).

Here, another challenge calls for future research, since people seem to differ in their abilities to self-regulate as viewed from the perspective of multitasking (Ie, *et al.,* 2012; Alzahabi and Becker, 2013).

Concluding remarks

The shift from print to screen has physical effects on how we engage the body while reading. This has led to a general awareness about the embodiment of reading. We have suggested that two distinct dimensions of the embodiment, the spatio-temporal and the imaginary, result from the same biological principle. Together they show that reading depends on direct experiences in the moment as well as in the past.

At the neural level the change from print to digital reading is obvious. Whereas printed text affords numerous stable material anchors in the moment for memorizing, digital texts are much reduced in this respect. This may change how we encode and remember reading content. Also digital reading substrates impact on how easily we re-activate past experiences when we read. The multifunctionality of the device threatens the cognitively demanding engagement with a text while increasing shallow and fragmentary reading.

If we wish to keep supporting deep reading, the lack of material anchors and the inclination to engage in selective reading on screen must be addressed.

We suggest that future research should explore what readers do to secure room for deep reading. Do they mute notifications, use dedicated e-readers, or in other ways solicit time spent alone with the text? Maybe we will find that experienced readers excel in abilities to switch off or ignore distractions that depend on the full attention of the conscious mind. Such studies would shed light on whether self-regulatory abilities are in high demand in literary readers in a world of technology-induced quick fixes.

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Artificial intelligence explained

By Michael van Wetering

Artificial intelligence (AI) is a promising technology for use in the education sector. How exactly does AI work, which types of AI are there and how can we apply AI be put into practice? We will explain all of these things in the following article.[25]

What is artificial intelligence?

The rapid advancement of chip technology has meant that AI can store, process and analyse a great deal more data than the human brain. Yet despite its brute calculating power, it is a long way off from being able to do all the things human beings are capable of.

An AI-system that can mimic the full spectrum of human existence is something we will not see for some time yet, as opposed to task-specific artificial intelligence. This can be found in all kinds of products. In order to work, this type of AI-technology needs to be made suitable for a particular market or a particular sphere of activity. There are great expectations around AI in education, for instance, but for the moment we see this only in limited form in specific educational products.

How does AI work?

In essence, AI comprises two components: a self-learning algorithm, and data. An algorithm is a series of instructions that lead to a specific result. In computers, these take the form of a computer programme.

An algorithm we encounter and use daily is the ‘recommender system’. For instance, based on our viewing habits, video streaming services make recommendations for other videos we may find interesting. In order for these recommendations to be made, data is required. In this case, our viewing behaviour and that of others. Data is the raw material which allows AI to work. By analysing more data, the algorithm can make better recommendations.

Learning capability

An important distinction between programmes that use AI and those that do not, is their learning ability. A good example would be chess programmes. We can programme these with all kinds of strategies, decisions and rules. In terms of what it can do, the end product will be limited to what programmers have instructed it to do with respect to effective strategies.

[25] This article is a translation of the following text: https://www.kennisnet.nl/publicaties/artificial-intelligence-uitgelegd/. Reproduced with permission from rightsholders. Kenniset is the Dutch public organization for Education & ICT.

In an AI chess programme, we not only think up all the steps in advance, but we make an algorithm that is capable of learning from the data. We feed it millions of chess games that people have played. The algorithm analyses everything and, from this, extracts strategies, rules and decisions. It would be impossible for people to analyse that amount of data, but an AI programme is capable of doing just that. Once the algorithm has been trained, it can play chess with people in the form of a computer programme.

Snapshot

Programmes that have been trained with AI do not necessarily learn constantly. It's more a snapshot of all the knowledge and experience that has been acquired up to that point. How well or poorly this works depends on the algorithm that has been devised by human beings and on the data with which it has been trained.

The algorithm takes decisions based on what it has learned prior to our using it as a programme. The programme obviously gathers new data while we are using it. To enhance AI even more, this data has to be processed anew and a new snapshot taken. A snapshot like this is comparable to a software update.

Types of AI

There is not one specific type of AI. The various types of AI use different approaches, each with its own strengths and capabilities. AI products and services use one or several types of AI. We discuss the four most commonly used ones here.

Supervised machine learning

In supervised machine learning, the correct outcome is known in advance, and we teach the algorithm what the relationship is between the data. The used data has all been labelled by a human being, rather like the way we label each column in a spreadsheet.

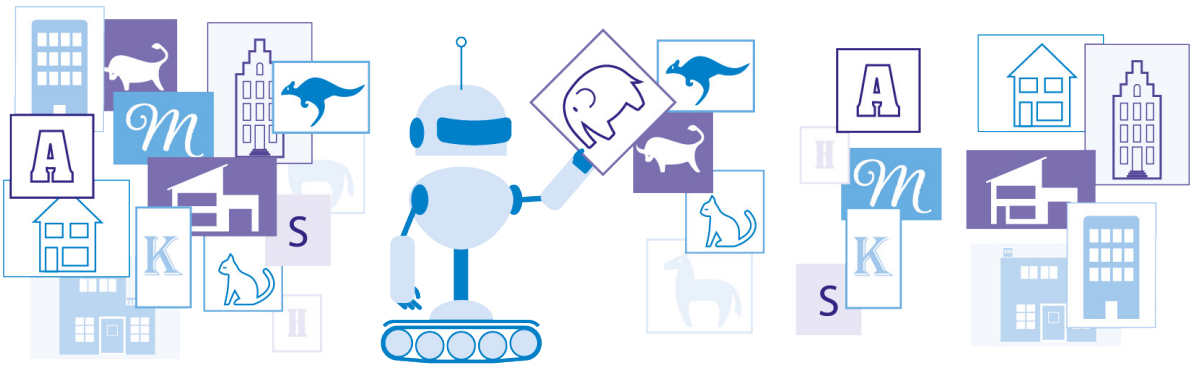
The algorithm itself does not need to work out what the data means and which data belongs together. By feeding the algorithm more and more data, the results become ever more accurate. An example would be working out the sale value of a house. By feeding an algorithm a great deal of historical data about sold properties in the area with their final sale price, their size, location and other features, it gets better and better at learning to get to know the relationship between these aspects. And is therefore better able to determine a sales price.

In supervised machine learning, the correct outcome is known in advance and we learn the algorithm what the relationships are between data. ***© KENNISNET***

Unsupervised machine learning

In unsupervised machine learning we do not programme what the correct outcome is and which data is relevant, but instead ask the algorithm itself to cluster data and find patterns in a dataset. We can use such algorithms if we do not wish to, or cannot, classify all data ourselves, or because we want to find new correlations of clusters.

A practical example is a video service which recommends videos, increasing the chance that we will find these interesting as well. For this to happen, we do not want to devise all kinds of categories ourselves, instead we want the system to determine and continue to recognise these and keep them up-to-date.



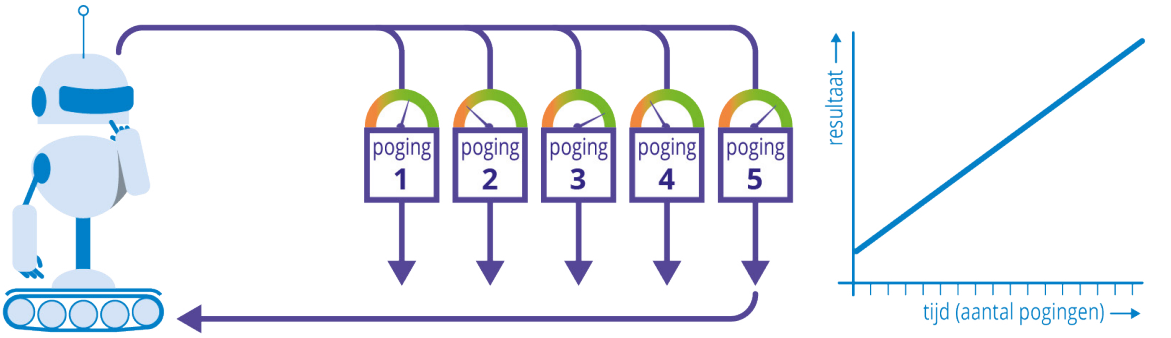
In unsupervised machine learning, we ask an algorithm to cluster data itself by finding patterns in a dataset. ***© KENNISNET***

Reinforcement learning

In reinforcement learning the algorithm learns to perform a task by getting rewards for the actions that produce the right outcome. These are the kind of algorithms we can use when there is little data available.

Compare it to training a dog. We give him a reward when he does something right; if he doesn't, he doesn't get a reward. Thus, the algorithm learns what the desired actions are that contribute to achieving a particular goal.

These kinds of algorithms are used in self-driving cars, so that while they are learning from the driver, they take ever better decisions. Or in robots, using trial and error, they are taught how big each step should be when learning to walk.



In reinforcement learning, the algorithm learns to perform a task by getting rewards for actions that yield a correct outcome.
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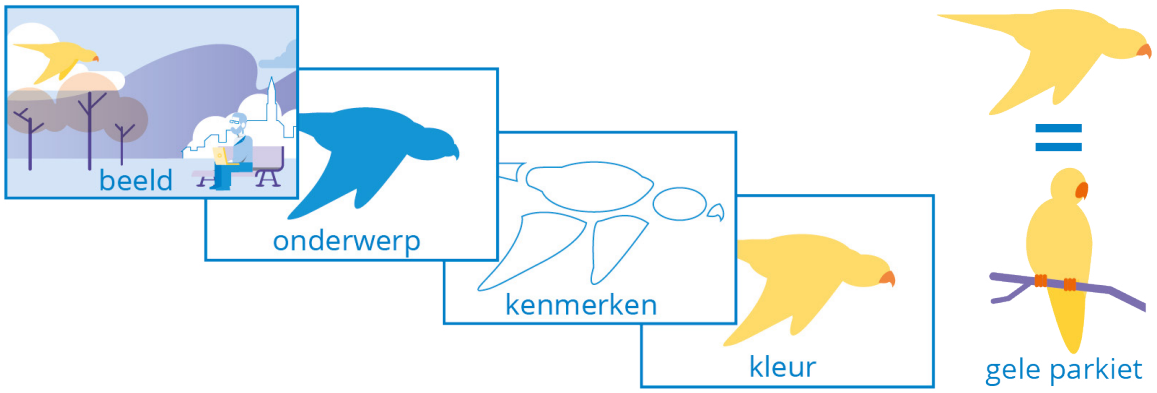
Deep learning

Deep learning is used in so-called unstructured data, such as images, videos or sound recordings. Compared to other AI learning methods, deep learning needs much more data, but it may produce even more accurate results.

Deep learning algorithms are made up of different layers. Each layer continues to learn new and more complex features from the data. For example, we can make an AI system that recognises animals. By feeding it large numbers of examples of birds, the system will learn to recognise their characteristics. One layer of the algorithm will analyse the shape of the object, for instance. By recognising wings and a beak it will know it is dealing with a bird.

Another layer analyses the colour of a bird and recognises it is dealing with a yellow bird. On the basis of these characteristics, a further layer might recognise the specific type of bird, for instance, a yellow parakeet.

When we then show the algorithm a new bird, which was not part of the training set, it will still recognise it on the basis of the prototype bird's characteristics.



Deep learning algorithms consist of several layers. Each layer learns new and more complex properties of the data.
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Robots controlled by AI – especially for physical labour and specific tasks

We frequently see impressive footage of robots who navigate all kinds of obstacles or answer a host of questions. This leads to high hopes. Does this mean that robots steered by AI will soon be able to take over various jobs? No. Robots appear clever, but they are not.

A walking robot functions only in a controlled environment. When we put such a robot on the pavement outside, it will not be able to function at all, and may even be a danger to people. Recently, a British Member of Parliament asked a talking robot some questions. Its extensive replies suggested it was conceivable that the robot understood and was able to answer any question. In truth, the replies were all pre-programmed. So, at the moment, robots are not yet suitable for both physical and cognitive interaction with our complete, complex reality.

Robots that can fully act like humans are miles away from us. However, they can perform specific tasks and thus supplement people.
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Cooperation between people and robots

Robots that can act like human beings are still a long way off. However, in being able to perform specific tasks they are able to complement people's lives.

In the warehouses of big online stores, robots transport shelves to the human order picker. The warehouse shelves can be positioned closer together because there does not need to be any space for human beings. The picker then manually takes the articles from the shelf, because robots are not very good at grabbing differing objects of various shapes or weights. What is perfectly intuitive for people, can be extremely complicated for robots.

Robots are also used in surgical procedures, which is changing human work in the operating theatre. The surgeon no longer does the incision himself, but steers a robot from behind a screen. Incisions are therefore becoming smaller and more precise, with less scar tissue as a result. Moreover, communication between the surgeon and his assistants is becoming ever more important because they are physically further removed from each other. But, after the operation, no robot stands next to the bed to explain how the surgery went. Because, although robots are very good at creating the illusion that they understand us and can simulate empathy, this is still the work of a human being who can relate to others with empathy.

For work which is physically demanding, or has to be executed with great precision, robots can complement the work of people. That's why it is important that, in technical and vocational training, as well as in other forms of education, robotics features prominently. Robots will increasingly influence our lives and work – though not in those tasks where our human abilities and strengths play an important role. Robotics is interesting as a study object in primary and secondary education. It will certainly play a role in students' future professions. But a robot in front of the class is for the future.

Artificial intelligence in education

By Michael van Wetering

Technology, such as artificial intelligence (AI), has the potential to deliver ambitious opportunities in education, for example in the sphere of customised support. This article will tell you that you need to know about AI in education.[26]

1. Introduction

Attention to the specific needs of children is a cherished ambition in education. Technology, such as artificial intelligence (AI), offers opportunities to realise this ambition. The technology that supports customised solutions is still very much in development, however. Schools, developers and suppliers need to acquire a great deal of knowledge and skill collectively before AI can be applied widely. But it is likely that this development will happen quickly.

There are also downsides. As AI systems become ever 'smarter' and perform more tasks for us, we must guard against pitfalls such as bias. A developer can, consciously or unconsciously, programme a bias into the algorithm. Likewise, the dataset on which the algorithm is trained can be incomplete, dirty or incorrect. It is also important that we continue to ask ourselves in which cases and under which conditions we will allow an algorithm to make decisions on our behalf.

What is covered in this publication?

This publication gives all the information about AI in education in one, well-organised place. It will:

- explain exactly what AI is (Chapter 2)
- consider the present state of affairs regarding AI in education (Chapter 3)
- show the potential dangers associated with AI (Chapter 4)
- give useful tips about how AI can be used in practice (Chapter 5)
- conclude with a sketch of the future: how will AI affect life, learning and work in 10 years' time? (Chapter 6)

2. What in fact is AI?

Artificial intelligence is the ability of computers to perform tasks for which humans use their intelligence. Examples of these might be observing, recognising, analysing, reasoning, problem-solving, predicting and interacting with one's environment. All this is inspired

[26] This article is a translation of the following text: https://www.kennisnet.nl/publicaties/kunstmatige-intelligentie-in-het-onderwijs/

by the way human beings use their nervous system and body to feel, learn, reason and take action.

As a result of its calculating capacity and the availability of huge quantities of data, AI is evolving rapidly. Data forms the basis for the training of algorithms which make AI possible. By processing and analysing this large and varied quantity of data, AI can improve.

How does AI work?

An important distinction between programmes that use AI and programmes that do not, is the ability to learn. Most adaptive learning methods are rule-based systems. They display intelligent behaviour that has been devised in advance. An example of this is a chess programme that has been programmed with all kinds of strategies, decisions and rules. An AI chess programme with self-learning capability analyses data – millions of chess matches, for instance – and, as a result, will itself learn the chess rules and effective strategies, and make its own decisions accordingly.

There are different types of AI. Examples include supervised and unsupervised machine learning, reinforcement learning and deep learning.

3. AI in education: the current state of affairs

When we look at the current application of AI in education, we tend to think of adaptive teaching materials which many schools are already using in their daily educational practice. They offer pupils the opportunity to learn at their own pace and at their own level, where and when they want. The data from the learning activities is collected, analysed and used to evaluate and adjust the individual learning process. By merging and displaying this data per pupil in a well-organised way, teachers can give targeted instruction and focus on coaching, education and the well-being of pupils.

AI vs adaptive teaching materials

We could consider most current adaptive teaching materials AI, but they do not tend to make use of self-learning AI. Adaptive teaching materials are expected to continue to evolve and their possibilities and effectiveness will increase as a result of the introduction of various technologies, including self-learning AI.

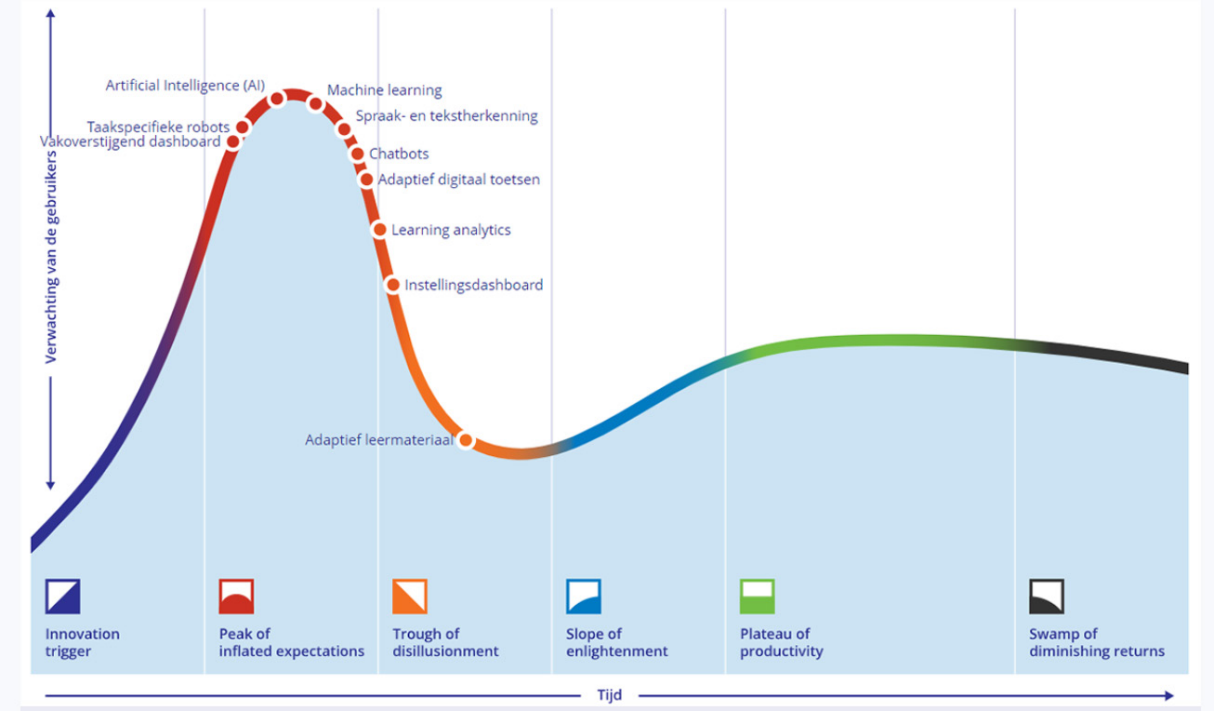
But we have not reached that point yet; adaptive teaching tools are very much still in the development stage. And although we know more about what works well and what doesn't when adaptive teaching tools are deployed, schools, developers and suppliers collectively need to acquire a great deal of knowledge and skill before AI can be applied widely.

Hype Cycle: AI maturity

The Hype Cycle charts how new technology is evolving from promise to accepted product.

The Hype Cycle below has ranked all technologies that are important for adaptivity and AI. The position on the Hype Cycle represents a snapshot of the relative maturity of a technology and its potential.

As an over-arching technology, AI sits at the apex of the inflated expectations phase. There is much interest in it, and expectations within education are high; it is believed that teaching materials that use self-learning AI might understand the pupil better and support them more. Meanwhile there are few institutions and products that make use of it, which means that these expectations have not been field-tested.



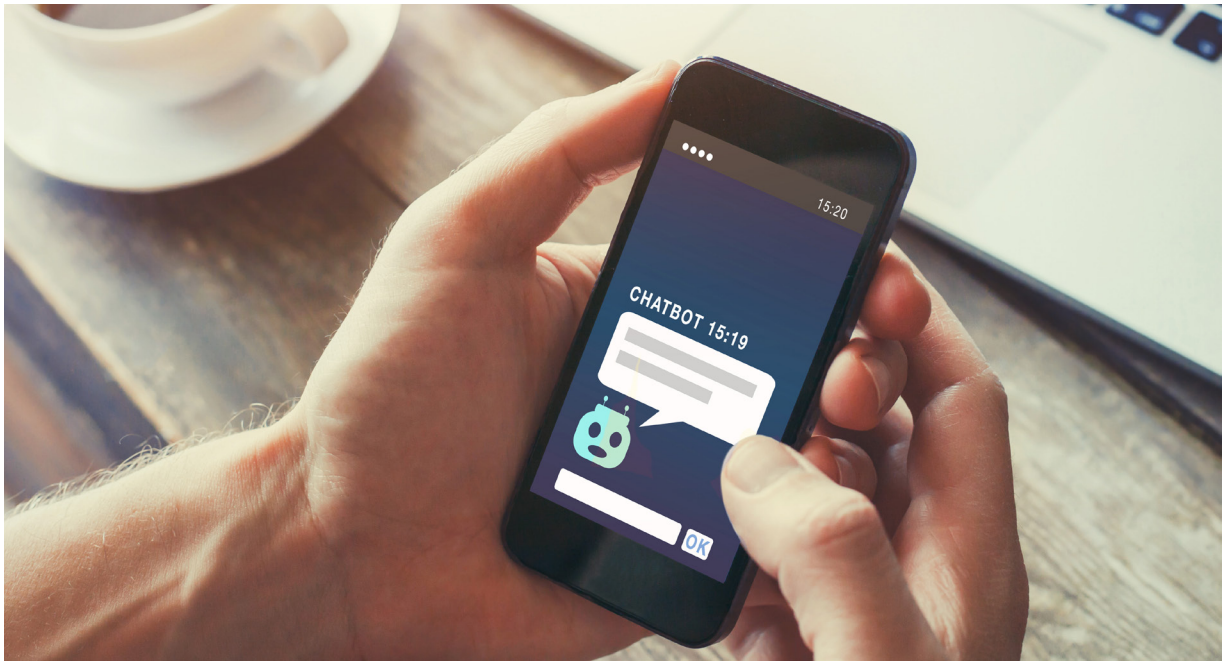
There is a lot of attention for AI and the expectations for education are high: teaching materials that use self-learning AI could understand and support the s¬¬tudent even more than now. ***© KENNISNET***

At present in the field, we primarily see adaptive teaching tools and adaptive testing, which do not tend to make use of self-learning AI, but do make use of data from the learning process. In its development, adaptive teaching tools have already moved on to the next phase. It is in the so-called trough of disillusionment, where the wheat is separated from the chaff. The other applications figuring in the Hype Cycle are discussed in the next paragraph.

Concrete AI-applications in education

In addition to adaptive teaching tools that use self-learning AI, or otherwise, here are some further concrete examples of applications that use AI:

- Various applications that use speech and text recognition. By analysing spoken text, these tools can support pupils in their speech development. Another example might be analysing how someone gives feedback in an exchange, by listening in on that exchange.
- Within the context of adaptive teaching tools, are **chatbots** (also called edbots, educational chatbots). Pupils can ask questions about the content of lessons, or the chatbot tries to work out whether the pupil has understood the lesson by asking questions about it.



For a well-functioning chatbot, 3 components are required: AI that understands what the user says, an interface and a design of the course of a conversation.

Interdisciplinary dashboards are increasingly being experimented with. These dashboards can provide an overview by (automatically) bringing together the progress and outcome information from different teaching materials and environments. This kind of dashboard offers the pupil and the teacher an interdisciplinary picture of the learning process and the pupil's development. AI could play a role in these dashboards by analysing pupils' progress and making recommendations.

Learning analytics has been drawn on for longer, for example in adaptive teaching materials within the educational process (such as the so-called settings dashboards in which all information about the organisation and its operational management is analysed and presented).

Task-specific robots are used widely in transport, healthcare, security and other sectors. An example might be factory shop floors, which do not require lighting because only robots work there. The school environment with all its complexity, including intensive human interaction, creates a setting in which robots are a long way off being deployed as a replacement for the teacher. In primary and secondary education, applications are primarily focussed on the robot as an object of study itself, supplemented by experiments aimed at using robots as an educational tool. In technical and vocational training robotics is an important subject, because robots take over tasks and are therefore something students need to learn to work and cooperate with.

4. Data use, privacy & ethics

All new tools that improve our lives involve risks. This also applies to AI. A developer may, consciously or unconsciously, programme a bias into an algorithm. Likewise, the dataset on which the algorithm is trained can be incomplete, dirty or incorrect. And even if an AI system has been constructed without bias, this does not mean that all problems have been eliminated. For instance, what if we cannot find out how an algorithm has come to a particular conclusion? In addition, the ever-increasing volume of data that is being collected and analysed about us leads to suspicion and wavering confidence in the digital world. How can we ensure that information, security and privacy have been effectively regulated and that we are acting in an ethically-responsible way?

AI is as good as the training data used

A famous saying in the design of processes and software systems is ’garbage in, garbage out’. In other words, if we throw rubbish into something, it will produce rubbish. This also applies to algorithms and AI. When an algorithm is trained with data that is incomplete, incorrect, or simply not representative, we can obviously not expect the outcome of that algorithm to be correct.

An example: when someone looks up ‘wedding dress’ in a search engine, the likelihood is great that the results will show a collection of white lace dresses. This gives a one-sided, Western view. If you look up ‘wedding dress throughout the world’, the results will give a much more colourful impression. In education, an example might be an algorithm for speech recognition that has been trained on the basis of exchanges between adults with English as a mother tongue. This is not immediately useful for speech recognition in children; speech recognition for children who are learning English as a second language will be even less accurate. One reason for this could be pronunciation and the range of vocabulary.

Handling user data responsibly

In addition to training data, real time user data employed in AI is a particular point of interest. According to the law, a school is responsible for careful supervision of such

measures, even if its implementation is invested with the suppliers. Not all types of data can be used for profiling, personalising or analysing groups of pupils.

Kennisnet's approach includes, amongst other things, 'privacy by design', which makes sure that the data generated in the learning process is only available to those who need it, a legal obligation as part of GDPR applicable to suppliers' software, but also to schools who 'design' their educational process. That way the data has been preventively protected against unauthorised use.

Prevent data against unauthorized use.

Insight into AI decisions

The careful handling of data that is used in training and analysis is important. But dealing with the conclusions and recommendations of AI systems is at least as essential. AI systems will increasingly start to give advice and predictions, for example about how pupils will perform the coming year, or even in their future career.

As users of a system which uses AI, we can have all kinds of questions about its workings. Why does AI come to this decision or conclusion? Which other options were there and why were these discarded? When is a conclusion good and when is it not? How can I trust AI? And what if I encounter a mistake, how can this be corrected?

Up until now, it has been possible to design systems in such a way that these questions can be answered. However, in the case of self-learning AI this is easier said than done.

Possibility versus desirability

In the future, predictions based on historical data and learning results will become ever more accurate. But when it is no longer possible to judge whether to agree with this prediction, there is a danger that the advice of AI systems will not be trusted – or, conversely, they will be trusted blindly. The question is whether we should want this? A closely related ethical question is: to what extent can we permit ourselves to diverge from the AI's advice without running into problems with pupils, parents or school management, as is sometimes the case with the results of final tests?

5. AI and education: what should be looked out for?

For the use of AI in education, the same advice applies that Kennisnet gives about using technology across the board. The Dutch model continues to be a guiding principle. The model describes the preconditions needed for using IT in education effectively:

- vision
- know-how
- content and application
- infrastructure

These conditions will have to be well-balanced if schools wish to achieve the desired output in terms of IT.

Regarding AI, it is important to realise that this technology is still in its infancy. There is much to be discovered about the way we can employ the technology satisfactorily and effectively. Widespread rollout of AI is not sensible, but experimenting in order to test expectations and possibilities does help to get a better picture of AI.

A broad roll-out of AI in education is not sensible. Experimenting to test expectations and possibilities in practice helps to get a better picture of A.I © ***KENNISNET***

In addition, cooperation with suppliers who apply AI in teaching materials and other educational systems is extremely important. Depending on how much the school itself is already engaging with AI, we would like to give the following advice:

For those who are exploring AI

- At principal-level, and throughout the school, there must be all kinds of views about AI's potential impact, both welcome and unwelcome. Discuss future scenarios together (both dream and doom scenarios). This obliges you to think about uncomfortable questions, for example, the duties and role of the teacher. Schools are thus better prepared for future dilemmas and create understanding for change, because they are including the teaching team in the change process from the earliest stage.

For those who want to make a start with AI

- Be aware that AI is not for sale as a stand-alone product. AI is a collection of methodologies and technologies which fall under this term but differ from each other, for example, in the degree of complexity and the applications for which they are suitable. Is a school intending to acquire teaching material or educational software that shows intelligent behaviour? Ask suppliers what specifically they use in their product, what they can tell you or what they know from studies about its effectiveness, and the preconditions that are necessary to employ the technology in an appropriate and satisfactory manner.
- Consider and discuss whether and under which circumstances it is a good idea to start using AI-based systems. The ethical discussion can be conducted on two levels: on the use of AI in education in general and, more focused, on a specific application or experiment. This discussion can help to formulate frameworks and basic principles.
- Make sure that attention is paid to the question as to what information is necessary to be able to understand advice, a decision or a conclusion.
- Start trying it out on a small scale, with experiments or pilots. Within one department, or within one year. By trying out AI applications in a small setting, you can see whether they live up to expectations, whilst keeping the risks minimal.

For those who are already using AI

- Make sure that clear goals and expectations have been formulated for the experiments, so that afterwards, as assessments can be made of whether they lived up to expectations. Modify the expectations. Evaluate the frameworks as well: were they too limiting, do we view matters differently in light of actual experience? Also have a look at the ethical principles formulated previously and amend these based on experience.
- Include suppliers in the experiments. This will give them a better impression of what the education sector wants, what it considers welcome or not, and under which conditions AI can be used. As a result of this, education can learn more about what is possible. Cooperation is essential to ensure that education can make good use of AI under set conditions.

Always a good idea

- Set up thorough preconditions around data. Algorithms in AI technology can only improve if they are trained and tested with data. AI uses these algorithms to analyse the data from the actual learning process. But in order for this to work, the systems have to produce sufficient, usable and exchangeable data. Privacy and GDPR must be an immediate focus of attention in the construction of experiments.

6. AI in education in the long term

AI is on the rise, which has far-reaching consequences in society and education. Although there is still a long way to go, the impact on specific duties and jobs is evident. Existing jobs are changing, and new ones are emerging. In education, too, adaptive teaching materials are taking over routine teaching activities.

And that's only the beginning: AI applications are able to follow the learning process of a pupil ever more fully, and, on the basis of analyses and predictions, give targeted feedback and adjustments to the learning route. This means teachers are more able to focus on guidance and coaching, for example, in the teaching social-emotional skills, which pupils will need more than ever in the future. We are thus no longer only training pupils for a profession, but also for a meaningful existence in a complex world.

Artificial Intelligence in society: living and working

AI is everywhere. It helps the police to predict burglaries or doctors to decide on the most effective treatment method for people with cancer.

In the future, the influence of AI and robotization will increase. Robots will perform surgery, and algorithms will predict new government policy. Human work will focus on the tasks and duties for which machines cannot be deployed cost-effectively or appropriately, such as handling objects with skill. Applying the right amount of pressure to various different objects is very difficult for a robot.

*The influence of AI and robotization will further increase in the future © **KENNISNET***

Jobs will change, especially those involving routine or even complex tasks that are easily captured in algorithms. Examples of these might be tax advisers, warehouse operatives and accountants. These professions are supported by AI analyses so that people can focus on differentiating activities, such as making decisions and taking actions which require empathy and moral awareness.

Artificial Intelligence in education: learning

The impact of AI on society will also be apparent in education: both in what we learn (the contents of the curriculum), how we learn (in which way and with what resources) as well as how we organise education (in which place and at what point in time) and the choices we make about pupils, subjects and schools.

Learning content to prepare for a society with AI

Pupils need to acquire the knowledge and skills that prepare them for an AI-suffused society. They need to understand what it means to be a human being in a world in which you constantly come into contact with AI. And they need to know how to manage the suggestions made by AI-analyses. That is quite a big deal for education. Which foundation for life and work do we want to give pupils in primary education? Which professions should they explore and focus on in secondary education? How do we develop and construct vocational training courses, taking into account the impact of AI on jobs and professions? And what perspective does this offer students for a career in a particular profession or trade? Questions that are not easy to answer, but which are relevant for educational boards.

Teaching materials to support more complex cognitive skills

Adaptive teaching material offers customised paths on an individual level and supports the development of simple cognitive skills. AI is evolving rapidly and will increasingly enable teaching materials to follow and gain a better understanding into the thinking process of a pupil, and, as a result, offer bespoke solutions on an individual level.

AI technology is already being introduced in niche products to support the marking of open assignments. This is where AI can read with technical proficiency but not with comprehension. It can count words, for example, or check grammar, but not judge what the aim, basis and structure of an essay are. However, this is being experimented with.

It is a matter of time before the teaching of more complex cognitive skills will be fully-developed in Dutch educational products, such as analysing, reflecting, evaluating, and applying existing knowledge and skills in new situations.

The learning process is supported at learning pathway level

At the moment, adaptive teaching material offers opportunities for customised paths at teaching resource or subject level. In the future, there may be further development towards customised programmes at learning-pathway level. Based on analyses of behaviour and results, and predictions about what this can lead to, AI will give targeted feedback per pupil, will make recommendations for subsequent steps, and help nip potential risks to learning development in the bud.

The teacher will take on a supporting role, will be able to make better decisions and pay more attention to overseeing and coaching pupils. For this to be effective, collating data from various systems with different scoring scales into one integrated view is a must. Although this is complex, steps are being taken in that direction.

Educational institutions to be better substantiated through data and analyses

A learning process in which data and analysis play a big part requires a different role from the teacher, school head, departments and board. Now that marking assignments is largely a thing of the past, time is becoming available, which can be devoted to thinking in a more informed way about interventions at student, subject or even institutional level.

We can process, analyse and present with lightning speed all the available data from AI based teaching materials, enhanced by supplementary information from the teacher, in dashboards at pupil, year, form, school, institute or educational level. This creates a learning pathway for the pupil optimised for him or her.

Departments, school heads and principals are thus able to take superior, informed decisions at a more over-arching level. An example of this might be starting up a new training course or dropping a training location as a result of declining pupil numbers and pupils' progress.

Ethics and digitisation in education

By Lisa van Ginneken

Conscious choices around digitisation

Education is not immune to the expanding role of technology in society. Digitisation creates opportunities to make education more attractive, efficient and customised. It introduces new ways of doing things into the classroom and new relationships into the sector. New players, sometimes big and internationally-oriented, come calling.

These developments lead to issues around the privacy of pupils and teachers, but also raise the question about the effect of all those screens in (and outside) the classroom on learning itself and on the relationship between pupil and teacher. Making considered choices around digitisation frequently leads to dilemmas; not only for schools, but also for the suppliers of teaching materials.

Dutch IPA-member, GEU, has informed its international colleagues about a recent Dutch publication on this topic, titled *Waarden Wegen (A Matter of Values)*,[27] published by Kennisnet, a Dutch public organisation that supports schools in the professional use of IT. This publication sheds light on the most important ethical questions around digitisation in education. The GEU is grateful to the authors and Kennisnet for this document and has summarised it for our IPA colleagues and their members. GEU thus hopes to be able to make an international contribution to the continuous process of innovation incorporating digital teaching materials.

Summary of the Kennisnet Publication: A Matter of Values[28]

Digitisation needs ethics

The Kennisnet publication has as its subtitle 'an ethical perspective on digitisation in education'. Ethics is a form of structured reflection on acting in a morally acceptable way. This reflection is needed in the digitisation of education, because education is above all based on values; what's more, technology is not value-free, either. Values are universal, abstract ideas or ideals to which we aspire and that give us direction in what we do.

As to the question of how education and technology can intertwine satisfactorily, there is no general answer. It depends on the values of the school and of those within the society in which the school and the technology's developer are located. In addition, the personal values of the teachers, school heads, principals and parents involved also play a role. Laws are a reflection of social values, but cannot replace ethics. Laws tend to describe a moral bottom line. Many things we consider good and valuable in our society have not been given a place in law. Nor is everything that has been laid down in law automatically ethical. 'If it's allowed, then it's right', works from a legal point of view, but not necessarily from an ethical one.

[27] https://www.kennisnet.nl/artikel/laat-waarden-zwaarder-wegen-bij-digitalisering
[28] By the authors Remco Pijpers, Erwin Bomas, Lotte Dondorp and Jasper Ligthart

It is often claimed that technology is neutral and that it is the users of technology who, because of their behaviour, decide whether the effect of technology will be good or bad. But technology is always designed for an intended use and therefore influences our behaviour. The developers of technology are people with values, too, and these values have influenced the design choices in a particular technology. In other words, we shape technology and technology shapes us.

You could say the same about education. Education's purpose is the development of (young) people and therefore inherently deals with the question: what is acting in the right way? Education, in other words, is a moral practice.

Developments in digital technology are characterised by speed and scale. Code and algorithms control the result in a way that tends to be invisible to the user and cannot be influenced by them, while their consequences can be impactful. An example would be fake news, which can spread like wildfire via social media. Technology sometimes appears to have an inevitable quality about it, but whether you use technology or not remains a choice. In the Netherlands, we do not clone people, fly drones in the inner city or follow children with a camera 24 hours a day, even though this would be theoretically possible. Moreover, you can set preconditions for the use of technology and, as a user of technology, you can affect its development.

In discussions about technology there is a risk that you end up doom-mongering or, conversely, have too much tech optimism. In an ethical reflection on technology the idea is to avoid these extremes and continue the conversation in a nuanced way.

Three developments, discussed below, cover the following eight important educational values:

1. Meaningful contact
2. The teacher's professional autonomy
3. Equal opportunities
4. Inclusivity
5. Education as a free space
6. Spare time
7. Space to practice and to fail
8. An open outlook approach

The shifting balance between human and machine

Webcam teaching can be a welcome solution to teacher shortages, but it can also undermine education. Digital teaching materials can impact on *meaningful contact* (1) between teacher and pupil. This contact is essential for good education: it can create a safe environment, provide space and responsibility and anticipate the unpredictability of a particular situation. Pedagogic tact (doing the right thing at the right time, in the pupil's eyes as well) cannot be encapsulated in prescribed instructions.

We know from studies that learning outcomes, both individual and in the classroom, are determined primarily by human interventions. Technology cannot take over this role yet, but works well as an add-on. For routine tasks such as marking or completing the register, technology can save the teacher time, which can then be devoted to meaningful contact. For that matter, meaningful contact between pupils themselves is equally important and technology impacts on this as well.

There are few guidelines, regarding a teacher's *professional autonomy* (2), about how he or she is required to act in specific situations. This autonomy can broaden if the teacher experiences greater freedom to act as a result of the support of digital teaching materials; an example would be letting one half of the class do digital exercises, while he or she discusses an assignment with the other half. The use of technology can also curb autonomy, however. Examples of this would be when an adaptive learning system based on artificial intelligence performs tasks which the teacher cannot steer, or when interpreting all the data being collected by the technology takes too much time. How much the teacher understands the technology and is able to influence it determines the degree to which the technology contributes to his or her autonomy, or limits it.

Equal or unequal: digital chances

Digital technology can both broaden and limit equal opportunities in education. Technology lowers the barriers for communication and exchange between pupils, teachers, parents and people with disabilities. But at the same time, there will exist a digital gap between those who do and those who do not have access to technology. In the Netherlands, almost every pupil can avail him or herself of a computer and the internet. But not all schools have the same amount of digital learning material available. A second digital gap concerns who can and who cannot access the internet and digital resources outside school.

Digital learning systems, such as adaptive practice software, have a positive effect on the learning outcomes of all pupils. However, the effect is greater for pupils who already have a high achievement level. Here technology simultaneously offers *equal opportunities* (3) and widens the differences in outcomes. It is an ethical question whether, as a school, you want to strive for equal opportunities or equal outcomes.

Using personalised learning you can optimise your contribution to pupils' individual development. Embedded in the choice of this type of learning are distinct values, namely individual achievement and personal ambition. How does this relate to a school's role as a community and its socialising function? Can everyone take part: is *education inclusive* (4)?

Big tech, big data and education

The *big five* tech companies Amazon, Google, Facebook, Apple and Microsoft offer useful products to education, often at minimal cost. The underlying cloud technology provides much data about the learning process. Does this data always lead to more insight and what

are the drawbacks? Are pupils still approached with an open mind and do they continue to have the space to practise and fail unobserved? Can the interest of the tech companies be reconciled with the interests of the pupil?

Free space

Educators and philosophers regard the school as a *free space* (5): an interspace in which pupils can learn and practise to act independently and make choices without direct manipulation. Free space has been under great pressure as long as schools have existed, but along with their digital tools, new players enter the scene that have a say in this. Big tech companies not only supply cheap hardware, but also tend to offer their software for free. The tech companies' online services are increasingly linked up to the school's digital learning environment and educational apps from other suppliers. This makes what is available in this field rich and diverse, with the role of the suppliers being less segregated than in the past.

In the digital ecosystem that has arisen, everything revolves increasingly around collecting (users') data, which can then be used for commercial purposes. Education's free space thus becomes more and more intertwined with the commercial space. The big tech companies' revenue model affects our privacy and autonomy: we get very little, if any, insight into the data that is being collected and what it is being used for. Moreover, the companies benefit when pupils become acquainted with their products and, in the process, develop a preference for them in their later life. The interest of the pupil should be at the heart of the educational relationship, not his or her economic value.

As an individual user, it is virtually impossible to evade the tech companies' services. We are deliberately steered and influenced to spend ever more time on the platforms of the tech companies and release more data. On the basis of this data, we receive content that makes us stay on the platform even longer.

It is not clear to what extent the big tech companies collect data about pupils and what they do with it. Google, Microsoft and Apple say they comply with privacy legislation, but they have not yet signed the Dutch Privacyconvenant[29]. This means it cannot be ruled out that the American authorities have access to pupils' personal data, which is in breach of General Data Protection Regulation (GDPR). When schools refuse to offer an alternative to pupils (and their parents) who do not want to be exposed to this, it raises questions about the right to education. At the same time, it is not possible for individual schools to negotiate with tech companies.

Spare time

Digital resources in education mean that learning is becoming increasingly less tied to a specific time and place. Messages from the student monitoring system or from other pupils keep arriving late into the evening. Pupils do not want this, but they are afraid to miss out

[29] https://www.privacyconvenant.nl

on something, which causes stress and often a poor night's sleep. Many students feel that their education continues day and night and that there is no longer any *spare time* (6) to catch their breath. The fact that parents have direct access to the student monitoring system deprives pupils of the freedom to keep quiet about marks or incidents or to choose for themselves the moment for a chat about them.

Space to practise and fail

Digital practising is the 'fuel' for personalised education. It produces customised education and boosts learning achievements. A result of this is that a pupil is no longer able to practise freely without being observed, judged, and incorporated into a profile. Each exercise has thus become a test. Even trying something out on a scrap piece of paper, deleting it or throwing it into the bin is a thing of the past.

If pupils and students are being monitored from a young age, the magnanimity with which we allow them to *practise and fail* (7) is threatened. Mistakes and deficiencies from the past can jeopardise their chances for the future, especially if they do not know what trail they leave behind, let alone exert any influence over it. If you feel watched, you feel less free. The Rathenau Institute advocates the right not to be measured, analysed or influenced.

Being approached with an open outlook

Increasingly, digital teaching systems will use self-learning algorithms, which find relationships and rules based on collected data, and use these to formulate interpretations and conclusions. Algorithms have a semblance of objectivity, but in practice they do not always have a neutral, ***open outlook*** (8). For instance, the data on which the algorithm is based can contain mistakes and bias. In addition, the algorithm can view the relationship between the data (correlation) mistakenly for a cause-effect relationship (causality). To conclude, the user should have a good understanding of how the algorithm works in order to interpret and use its conclusions to best effect. It is important to continue to realise, meanwhile, that this kind of technology only reflects what can be measured. Not everything that can be measured is important, and not everything that is important can be measured.

The Kennisnet report A Matter of Values (in Dutch) can be downloaded here: https://www.kennisnet.nl/artikel/laat-waarden-zwaarder-wegen-bij-digitalisering

The report also contains guidance about how to conduct an ethical discussion in a structured way, including some engaging examples.

New learning resources for a new curriculum in Norway 2020 – Implementing a curriculum and developing new, digital learning solutions

By Ingvild Kogstad Brodal and
Åsfrid Hegdal, Norwegian Publishers Association

Background

Fagfornyelsen (*the school subjects reform*) is the name of the new curriculum that will be implemented in Norwegian schools in 2020–2022. The reform covers all basic education (years 1–13). Norwegian publishers and other developers of learning materials have been working on resources for the new curriculum for many years already. Competitive digital and paper-based learning materials have been prepared for all levels of education and all subjects. Teachers and schools can choose to use all-digital solutions, just printed resources or a combination of the two. A number of interdisciplinary and comprehensive learning environments have also been prepared, which give teachers new opportunities to tailor individually adapted programs to each student.

Process

Work on the new curriculum began with two expert studies in 2013 and 2014, which assessed the content of basic education against the social and professional skills predicted to be needed in the future — outlining principles for the "school of the future". These studies laid the foundation for a report to the Storting (Norwegian Parliament), which was the starting point for the new curriculum.

The school subjects reform has been created in collaboration between, among others, expert committees, representatives from the school sector and teachers' colleges, political leadership and the civil service in the Ministry of Education, the Norwegian Parliament and the Directorate of Education. All the new plans have been subject to public consultation, and many rounds of input.

Principles of the reform

Norwegian curricula have an overarching core, which applies to all basic education. In the new core that has been prepared for *The school subjects reform*, the **value basis** for the school is developed. In short, it establishes the school's role in building and sustaining human dignity, identity, and an inclusive and diverse community. The school system should contribute to students developing critical thinking and ethical awareness, creative joy, commitment and exploration, and respect for nature. It should also give students the opportunity to participate and experience what democracy means in practice.

The new curriculum has in-depth learning as a guideline. The school's values, as defined in the core, should characterize in-depth learning processes so that the pupils "develop good attitudes and judgment and the ability to reflect and critically think and to make ethical assessments."

The core defines five basic skills: reading, writing, arithmetic, oral skills and digital skills. In teaching, these basic skills must be seen in connection both with each other and across subjects.

In addition, there are **three interdisciplinary subjects:** Public health and life skills, democracy and citizenship, and sustainable development. These are based on current societal challenges that require students to see the connections across subjects.

The curricula for the individual subjects have also been given a new structure in *The school subjects reform*. Key values and the relevance of the subject are defined in addition to core elements, and lines are drawn for the interdisciplinary themes and basic skills. Then competence goals and an assessment guide are defined. The competence goals and the curriculum are open and relatively overarching, and thus give a lot of freedom to the teacher. An example of a competence goal is "the student should be able to listen to and talk about fiction and non-fiction". Individual authors or works are not mentioned.

Digital and printed learning materials are developed in parallel, with new textbooks to cover all subjects for all educational stages. New digital resources are developed to cover the full curriculum, and schools buy licenses that give teachers and pupils access to all learning material in digital format.

Resource pages:
https://www.regjeringen.no/en/dep/kd/id586/
https://www.udir.no/in-english/
https://skolen.cdu.no
https://aunivers.lokus.no
https://www.gyldendal.no/grunnskole/skolestudio/
https://www.kf.no/laremidler/grunnleggende-lesing/

Core elements, Norwegian, 1–13[30]

Oral skills involve:

- being able to interact with others through listening, telling and talking;
- being able to use rhetorical skills and express oneself appropriately in various spontaneous and prepared communication situations;
- being able to plan and perform different types of oral presentations adapted to the audience.

The development of oral skills in Norwegian goes from early interaction in play and academic activities to using oral language in an increasingly precise and nuanced way in various Norwegian academic conversations and presentations.

Writing skills involve:

- being able to express oneself in a wide range of fictional and factual genres;
- developing personal written expressions and mastering writing strategies, spelling and text structure;
- developing and structuring thoughts and a method of learning.

The development of writing skills in Norwegian goes from basic writing training to planning, designing and processing texts in different genres and when adapted to purpose, medium and audience. Writing in Norwegian means expressing oneself with an ever-increasing linguistic certainty in both main- and second languages. (Norwegian has 3 official languages, bokmål, nynorsk and sami. All pupils must learn their main language, but also read and achieve a level of understanding in a one of these other languages.)

Reading skills involve:

- reading both on paper and digitally;
- being able to read and reflect on fiction and non-fiction;
- mastering reading strategies (reading slow or fast, browsing or deep reading etc.) adapted to the level of reading;
- being able to critically evaluate texts;
- reading compound texts that may contain writing, pictures, drawings, numbers and other forms of expression.

The development of reading skills in Norwegian goes from basic decoding to reading, interpreting and reflecting on texts in different genres, for different purposes and of different length and complexity.

[30] Udir.no, Core skills, Norwegian, https://www.udir.no/lk20/nor01-06/om-faget/grunnleggende-ferdigheter, accessed 3.9.2020

Digital skills involve:

- finding, evaluating and using digital sources in text;
- using digital resources creatively to create complex texts;
- developing critical and ethical awareness when presenting oneself and others digitally.

The development of digital skills goes from planning and creating simple composite texts to developing and editing composite texts based on knowledge of how different forms of expression work together. The development should also show an increasing degree of independence and judgment in the choice and use of digital sources.

About the authors

Miha Kovač is a former publisher and professor of publishing studies at University of Ljubljana. His main research interests are book statistics, book markets and the role of books as a media in contemporary societies.

Adriaan van der Weel is professor of Modern Dutch Book History at the University of Leiden and lecturer in Book and Digital Media Studies. His research interests are in the field of Book Studies, concentrating on the digitisation of textual transmission, publishing studies, scholarly communication and reading.

Natalia Kucirkova is Professor of Reading and Children's Development at the University of Stavanger, Norway and The Open University, UK.

Trude Hoel is Associate professor at the National Centre for Reading Education and Research at the University of Stavanger, Norway. Her research interests concern children's stories in various modalities, facilitation of language and reading activities and reading and implications of digitalization.

Hildegunn Støle is associate professor at the National Centre for Reading Education and Reading Research at the University of Stavanger in Norway. She used to be a teacher of English and Norwegian in upper secondary school. As a reading researcher, she is specialising in large-scale reading surveys among children and the effects of digitisation on reading comprehension.

Theresa Schilhab is Associate Professor, Future Technologies, Culture and Learning, Danish School of Education, University of Aarhus, Denmark.

Gitte Balling is Associate Professor in the Department of Information Studies, University of Copenhagen, Denmark.

Anežka Kuzmičová is a postdoctoral research fellow in the Department of Culture and Aesthetics, Stockholm University (Sweden).

Michael van Wetering is a strategic innovation advisor with ICT & ICT infrastructure at Kennisnet and an expert in the field of innovative ICT developments and ICT infrastructure in the schools.

Lisa van Ginneken, GEU, Netherlands. GEU is the trade association for providers of learning materials, tests and educational services in the Netherlands.

Ingvild Kogstad Brodal is political adviser in Norwegian Publishers Association

Åsfrid Hegdal, special adviser, Norwegian Publishers Association, IPA State of Publishing reports

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Current research into the effectiveness of learning materials

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