7 Reading, Writing, Technology, and Embodiment

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The insights emerging from embodied (or 4E) cognition (Newen, et al., 2018) hold considerable promise for education, but thus far have had little impact. The widespread implementation of digital technologies in classrooms presents a timely occasion to remedy this situation. The increasing abstraction entailed in the transition from pen and paper to keyboards, and from reading in print books to reading on screens, warrants supplementing extant perspectives on learning and technologies as they are currently represented in curricula and educational policy documents. This chapter helps educators to rethink and redefine the role and meaning of technology in education broadly speaking, and describes how the use of digital technologies in the acquisition of basic skills like reading and writing specifically impacts learning from an embodied perspective. Drawing on examples from Nordic school contexts, we illustrate how 4E cognition can be pursued to benefit the learning experience in our digital age.

For us, as human beings, the skills of reading and writing are not innate—meaning, there is no genetic blueprint for reading or writing (Wolf et al., 2012). Whereas children normally develop the ability to speak and communicate by means of language socialization, both reading and writing require systematic training over an extended period of time to develop. Helping children learn to read and write is one of the major tasks of basic education. A recent study using functional magnetic resonance imaging found that both reading and writing are multisensory experiences (Smith et al., 2018). Yet the ongoing digitalization poses new challenges for researchers and schools concerned with students' literacy skills. As advances in technology in classroom applications become more mainstream, the way in which children engage in reading and writing is changing. Therefore, we argue that the theory of embodied cognition (4E) should be acknowledged when considering the strengths and weaknesses of various technologies in supporting different aspects of reading (e.g., low-level processes such as letter-sound correspondences, and high-level processes such as inference-based comprehension skills) and writing.

Literacy, Technology, and 4E Cognition

Reading and writing are not simply abstract phenomena of verbal expression and meaning-making but are tightly intertwined with applied technology. For example, whether it is a slate, pen and paper, or some digital device, both low and high forms of technology are always an integral part of the reading and writing processes and outcomes. Any technology employed to various reading and writing activities has affordances—that is, any technology, medium, or device offers a range of possibilities of interaction and meaning-making. These affordances depend on the materiality and the technical features of the device. For instance, the affordances of a print book make it available for browsing in a different way than an e-book, whereas the affordances of a digital text enable the reader to search for the location of specific words by using the search function.

At the same time offering possibilities and constraints on our interaction with the device, affordances necessarily affect the perceptual, cognitive, and sensorimotor engagement with whatever is being written or read (Gibson, 1979). The role and function ascribed to the technology is therefore contingent upon whatever view of learning is prominent at any time. The current transition from reading with traditional reading technologies, such as the codex, to reading with contemporary electronic devices illustrates how the act of reading is intimately connected with and intricately dependent on the entire human being. Therefore, the current discourse that pushes for digital technology regarding reading (i.e., hypertext, etc.) and writing has significant implications for relevant embodied pedagogical and reform policies (Mangen & Velay, 2010).

The emerging view of embodied cognition, commonly called 4E cognition, is embodied, embedded, extended, and enactive (Newen, et al., 2018). This view has been gaining considerable traction across several disciplines over the past couple of decades (Carney, 2020). As a corollary, any academic skill (e.g., reading and writing) is always contingent upon the body, the tools and technologies used, and the environment in which the activity takes place. For example, an instrument or technology is experienced as an extension of the mind, as is seeing through eyeglasses or contact lenses, talking on a cell phone, or walking with a cane (Clark & Chalmers, 1998).

As a result, such a view of cognition has important and potentially wide-ranging implications for education, curriculum, and policy (Fincher-Kiefer, 2019; Glenberg, 2008; Kiefer & Trumpp, 2012). Nevertheless, there are few indications that research findings from 4E cognition have found their way to classrooms, resulting in a misalignment between research and practice.

Digitalization and the Nordic Model of Education

Although digital technologies were adopted early in classrooms in Finland and Norway—two exponents of the widely acclaimed Nordic model of education—the resultant discourse on learning, reading, writing, and technology has been fundamentally at odds with findings from empirical research on 4E cognition. As an example, we will examine the Finnish National Core Curriculum and the justification of what was termed the "digital leap" (Saari & Säntti, 2018), and suggest alternative ways to frame the discussion of educational technologies in light of insights from 4E cognition.

Long the envy of the world, Finland used to have the best student achievement scores in the world. Finland's performance on the Programme for International Student Assessment (PISA), which measures academic achievement of fifteen-year-olds in seventy-three countries, was an outlier, ranking at the top or near top on assessments of reading, mathematics, and science (Välijärvi, 2002). In 2012, however, Finland's performance in PISA dropped quite significantly (Finnish Government, 2013), and the drop was in part attributed to an increasing use of digital technologies in school (Heim, 2016).

The National Core Curriculum is the foundation of local curricula. The same conflict is equally clear in the most recent version of the core curriculum (2014). Analyses of this version show the prominence of a *certain kind* of technology—namely, the implementation of information and communication technology (ICTs). An exploration of Norwegian curricula and policy documents before and after ICT have yielded the same impression: Haugsbakk and Nordkvelle (2007) observed how older technologies such as textbooks or audiovisual equipment are hardly mentioned, whereas references to ICT are abundant. Moreover, there are "surprisingly few concrete descriptions of how ICT could or should be employed" (p. 9). The authors argue that ICT is included primarily in an instrumentalist manner, emphasizing the "usefulness" and "significance" of using ICT. Considering its meager research basis and the significant bias of *digital* at the expense of any other type of technology, it is indeed worth asking about the decision processes behind privileging digital technologies for "future" or "innovative" learning.[1]

In response, Pasi Sahlberg, a Finnish professor of educational policy, has pointed to research showing that frequent use of digital technologies with young children is a cause for concern. Sahlberg added that screen time and cell phones were dominating students' lives and should be banned in primary school and monitored in secondary. He further added that screen time and the inconvenient consequences—psychological, social, and physical—have affected students' learning in schools, especially for reading, mathematics, and science, all which require concentration, attention, and perseverance to perform well.[2]

The rationale for implementing digital technologies in education is often rooted in an assumption that they make learning more engaging, motivating, and fun. Rarely, however, are such assumptions substantiated by reference to empirical research. For example, over the past three decades in Norway, Torgersen (2012) found no empirical evidence in educational policy documents and curricula to support ICT in relation to improved learning outcomes. Nevertheless, Norwegian educational curricula continue to emphasize the importance of using digital technologies in education across disciplines. Handwriting with pen on paper is being replaced by keyboarding, and digital study materials (e-books) are emphasized at the expense of print textbooks.

Several scholars have pointed to the lack of evidence in support of learning outcomes for the use of ICT in education. Most recently, Balslev (2020) examined a large corpus of white papers and politically commissioned evaluation reports on ICT in education over four decades (1983–2015). These sources display an abiding conviction that education and pedagogy can and should be improved by developing strategies that place digital technology at the center of learning. The research evidence of a positive effect of digital technologies on various aspects of learning, however, has been scarce (for reviews and meta-analyses, see, e.g., Bulman & Fairlie 2016; Tamim et al., 2011). In fact, the OECD report *Students, Computers and Learning* (2015) presented a number of findings that seem to undermine many prevalent assumptions regarding the application of ICT and learning: data have demonstrated no appreciable improvements in student achievement in reading, mathematics, or science in the countries that have invested heavily in ICT for education (OECD, 2015, p. 3).

Most importantly, the large-scale study found that students who reported using computers frequently (in school and for leisure) performed worse compared with those who reported only a moderate use of computers (OECD, 2015). As summarized by Andreas Schleicher[3] in 2017, "In a nutshell today, digital technology does more damage than it actually does good" (see Balslev, 2020, p. 14). Pointing to the infusion of technology into classrooms should give pause, as other factors are important in its implementation. Looking at these research findings on learning effects, and the continued—even increasing—digitalization of education must motivate a closer look at the rationale and rhetoric underlying the implementation of ICT in classrooms and suggest alternative ways to frame the discussion of educational technologies in light of insights from 4E cognition.

Heim (2016) writes that emerging research on how the internet affects the brain—and thereby learning—suggests three principal consequences: shallower information processing, increased distractibility and decreased concentration, and altered self-control mechanisms. This is a cautionary tale—the implementation of a disembodied technology into the curriculum has not rendered evidence-based improvements, and it begs the question: Why not? Understanding reading, writing, and comprehension according to the principles of 4E cognition requires a paradigm shift in education, starting with how disembodied "technology" is defined and implemented in schools.

Defining Technology

Technology is commonly understood as a means of using tools to enhance knowledge or skills to perform a task. A universal definition of the term, however, is hard to find. Rather, technology remains an ambiguous phenomenon, which can be approached from numerous perspectives (see Rooney, 1997). As such, regardless of the perspective, technology is seen first and foremost as an instrument. This has typically been the assumption when dealing with reading and writing technologies. Indeed, within current educational policy and curricula, reading and writing are viewed as acts of meaning-making, creative expression, and verbal communication that can occur in digital or analogue environments, by the use of pen on paper, or keyboard and multimedia resources. Yet, there is little regard for the different affordances that these technologies provide. Nor are the potential implications of the increasing abstraction entailed in the transition from codex/print book reading to screen reading or handwriting to keyboarding. Looking at such questions through the lens of 4E cognition, however, yields a very different impression.

All technologies have their own material affordances and sensorimotor contingencies, which frame and constrain our interaction with the device. For instance, a printed book affords browsing and dog-earing the paper pages, whereas a digital text affords searching for specified terms. The material affordances of the substrate of paper, combined with those of the pen(cil), provides the writer with different possibilities and constraints for writing and drawing when compared with a keyboard—whether mechanical or virtual. From the perspective of sensorimotor contingencies and embodiment, writing with one technology—such as a mechanical keyboard—is fundamentally different from writing with another—a ballpoint pen on paper.

As we will see later, there is empirical evidence that such “framing constraints” of different technologies affect core cognitive aspects of reading and writing—for instance, recall and comprehension. This crucial aspect of technology use for learning has received precious little attention in educational contexts, with disparate perspectives about the use of technology in the classroom (Richmond, & Jordan, 2018). In the policy documents and educational reforms, as well as in the theoretical discourses on learning that currently dominate the field of education, 4E cognition has been conspicuously absent (Ord & Nuttall, 2016).

Digital Technology

“Digital technology” is also an ambiguous core concept. Whether we read European Union policy papers on the future of education and learning, or on national curricula, high expectations about the opportunities of digital technology for learning abound. Upon closer scrutiny, we may indeed ask whence this focus specifically on digital technologies. “Digital” means conversion of information to digits—usually, ones and zeroes. In education, the terms digitization (originally, the process of conversion from analog to digital) and digitalization (the adoption of digital technology to some context) are used rather carelessly, and we frequently hear about “digital learning” (or e-learning or similar). Presumably, this refers to the application of some digital products in education contexts. Importantly, though, learning itself is far from digital because human information processing does not convert information to a binary system. Arguably, concepts like digital learning or e-learning are metaphorical expressions that can be claimed to be misleading (see Pirhonen, 2005).

Hence, the prominence of “digital” in today’s discourse on technologies in education is grossly misleading because the digitality of fashionable consumer products, such as the smartphone and the tablet, attempts to hide from us, the users. The progenitors of modern studies of human-computer interaction found the ideals of interaction with digital devices to be invisible (Norman, 1998), intuitive, and ubiquitous (Weiser, 1991). Indeed, interaction with smart technology was supposed to be so transparent that it would result in an illusion of reality—as if the user of the device was using the real thing, not its digital substitute. The digital nature of the hidden processes is usually only revealed in the error condition. When something goes wrong, a picture that looked real suddenly breaks down to small squares—we say that the picture pixelates. In educational applications, it is hard to imagine a scenario in which we wish the learner to notice that the underlying basic technology is digital in nature. The loose talk about digitalization of education thus appears to originate from marketing jargon rather than from analysis of educational needs and an understanding of how learning—including reading and writing—is a deeply embodied and multisensory process of interaction with technology.

Whereas paradigms of learning have undergone significant revolutions in the last few decades, the structure and underlying conception of learning entailed in educational applications—implemented with digital devices in particular—has remained astonishingly stable (Saari, 2019). For instance, distance learning applications still often rely on video conferencing, in which the focus is on the talking head of a teacher, or exercises whose structure resembles the structure of so-called programmed learning from the 1960s and 1970s. In general, it can be argued that if the focus of the design of educational applications is on technical issues, the applications hardly reflect the contemporary theoretical development of teaching and learning. Most importantly for the present context, the understanding of "learning" on which such applications are founded remains entirely disembodied and uninformed by recent insights from the domain of 4E cognition. Instead, and perhaps especially in the Nordic educational context, policies, pedagogy, and curricula remain strongly influenced by sociocultural and social constructivist approaches to learning (see, e.g., Balslev, 2020; Mangen & Schilhab, 2012). In such perspectives, the role of the body—and embodiment—is squarely defined in social, cultural, discursive, or ideological terms.

Writing on a keyboard has by now become the primary mode of writing for most people, including for students in schools. This is particularly the case in the Nordic countries, where digital technologies are abundant in education starting in elementary school (e.g., Elstad, 2016). Likewise, we now increasingly read by engaging with texts displayed on screens, and we navigate by swiping and tapping rather than by interacting with the substrate of paper. Digital technologies introduce a level of abstraction, in which texts—written and read—become immaterial and intangible.

Pen and paper are technologies that were created for reading and writing. Their user interface and functionality serve the writing and reading of human language. They have their limitations and shortcomings, just as with any other technology. Computers, in turn, were brought into education from offices and an industrial context. In industry, ICT-enhanced productivity has been praised as a revolution (Rifkin, 2013). The success of one technology in one context, however, does not guarantee its success in a completely different context. Seymour Papert (1980) suggests that the setting in which tools from industry were introduced into schools was simply declared, rather than designed, as "educational technology." With respect to writing, when computers with keyboards were introduced in offices, they replaced typewriters to enable faster and more efficient writing. It was therefore appropriate to imitate the typewriter's user interface and use the existing skills of office workers. For instance, the QWERTY style arrangement of a computer keyboard is inherited from the mechanical typewriters, in which it was appropriate for technical reasons (i.e., the personal computer as we know it is a result of its history in industry and mechanical engineering).

Reading as Human-Technology Interaction

When we read and write, we engage with technologies that have distinct user interfaces, affordances, and sensorimotor contingencies. Digitalization reveals the fundamentally embodied nature of reading and writing, beyond what has been covered in the research on discourse processing and language comprehension (e.g., Glenberg & Kaschak, 2002; Zwaan, 2014; for an overview of much of this research, see Fincher-Kiefer, 2019). When we read, and especially when we read longer texts, we typically hold the text—whether on an iPad, a Kindle, or in print—in our hands. When reading for study, moreover, we often hold a pen or pencil in our hands and annotate, write in the margins, or use the pen to follow the lines and help sustain focus. Empirical research on medium preference in study reading has found a persistent print preference (Baron, 2015, 2021; Mizrachi & Salaz, 2020; Rose, 2011): Students report that they like holding the text in their hands; they miss the feel of paper when reading on screens, and they have a feeling that they focus better with paper than when reading from a screen.

Recent research inspired by 4E cognition may explain the contribution of haptics and kinesthetics to cognition during reading and writing. The role of our hands, and the close connections between fine-motor movement, perception, attention, and cognition, can hardly be overstated (for excellent overviews, see Wilson, 1999; Tallis, 2003). As a corollary, learning may be contingent on the ways in which various technologies—paper and pens, keyboards and touch screens—cater to our embodied and multisensory engagement with the devices and implements. Concurrent evidence from a range of studies in neuropsychology and cognitive science serves to underscore the key role of 4E cognition in the acquisition of basic skills such as reading and writing.

When reading, we do not merely engage visually with the text on the paper or screens. Part of the experiential—attentional, perceptual, multisensory, embodied—process is also the texture and materiality of the substrate on which the text is displayed. The material affordances of this substrate form an essential part of the embodied engagement with the text during reading, and define the nature of our haptic and kinesthetic interaction with the text. The text on paper is physically contiguous with its medium/substrate, whereas this contiguity between the substrate and the medium is split up in a digital device. Hence, when we hold a book, we "hold the material substance of the only text it can be," whereas when we hold an iPad or an e-reader, we hold "a virtual library, an archive, a media access tool, and so the device seems immaterial, abstractly functional" (Mc Laughlin, 2015, p. 177). Moreover, books are fundamentally multisensory objects in ways that screens are not (Spence, 2020).

Writing as Human-Technology Interaction

Analogously to reading, writing is not merely an "inner," perceptual, and cognitive process of text production and edition. Nor is it merely a sociocultural practice, or an act of creative or personal expression. It is all of this and more. Most importantly, writing always implies the use of some technology both in terms of the act of writing something and in terms of the (visible; tangible) result of one's writing—whether the lines and traces are on paper or the virtual text is on a screen. Insights from embodied cognition reveal how the embodied engagement with the technology used for writing is closely entwined with cognitive and experiential aspects of the result—the text. "Our knowledge about letter shapes is not solely visual . . . we also know how to write them" (Longcamp et al., 2003, p. 1492).

Learning to write has, until fairly recently, entailed meticulous fine-motor training to automatize the optimal trajectories of lines, curves, and dots that make up each single letter in the alphabet. With the introduction of digital technologies and keyboards, this part of beginning writing instruction has, in many schools, changed dramatically. Given the fundamental motor differences between writing by hand and by keyboard, it is not surprising to find evidence of the role of sensorimotor contingencies of writing devices (pen[cil] vs. keyboard) on aspects such as recognition and memory (for an overview of much of this research, see Mangen & Balsvik, 2016).

Handwriting entails setting up and, with practice, automatizing a specific motor program for each letter (the direction of strokes, lines, and curves is not accidental), and to create the perceptuomotor links that emerge through the creation of each letter. The movements entailed in writing a letter by hand completely define the shape of only that particular letter. When writing by hand, the information derived from producing, for example, the letter "g" (or "G") leaves a motor trace that supports subsequent visual recognition of the letter (including variants of it). By contrast, writing the same letter by typing it on a keyboard entails a pointing and tapping movement that, motorically, is close to identical to that entailed in producing the letters that are located next to "G" on the keyboard. In contrast, the "motor trace" of keyboarding consists in the proficient incorporation of the spatial distribution of letters across the keyboard (see Mangen & Velay, 2010).

A number of studies have evidenced the ways in which this feedback supports aspects of visual recognition, recall, and categorization of letters, both in children and adults (e.g., Longcamp et al., 2005; Longcamp et al., 2008; Mayer et al., 2020). A few studies have found similar results—that is, better recall after having written by hand than by keyboard—on a word level (e.g., Mangen et al., 2015) and on the level of short stories (Frangou et al., 2018). Hence, if curricula were premised on insights from 4E cognition, we might have seen a more nuanced approach to the implementation of digital technologies for reading and writing in education.

Discussion and Conclusions

Investments in education have been vital for the Nordic countries in the pursuit of welfare. Here, education is considered to be the nucleus capable of producing national identities, citizenry, and citizen ideals that distribute equal rights and opportunities among the entire population (Ydesen & Buchardt, 2021). The recent trends in policy-making, however, yield an impression that in certain countries—like Finland—the educational system as the bellwether of society has lost its status and become a mere instrument of supporting industry.

Available technology is the unavoidable precondition to the organization of education. The current COVID-19 pandemic made this point very clear: when the schools were temporarily closed as a precaution, the usual technological facilities, like school buildings and the technology inside them, were not available. The teachers had to reorganize everything in a couple of days' time, only counting on the technology that they assumed their pupils had access to. Suddenly technology was at the very center of discussions about schooling.

Reading and writing are both fundamentally technical skills—there is no reading or writing without an appropriate technology. Thus, what kind of processes are actually activated during reading and writing largely depends on technology. For instance, whether writing with a fountain pen or typing with a computer keyboard, we say that we are writing, even though the processes are quite different due to different technologies.

Pedagogy, as central as it should be, is finally not a discrete object of development. Pedagogy can only be developed in terms of applied philosophy and available technology. Although education in Nordic countries is supposed to be research based, it is interesting that according to our analysis the usage of certain kind of technological products (ICT) lacks empirical evidence of its appropriateness.

In order to understand the push of digital consumer products into schools, we need to recognize that as soon as technological products are introduced, politicians will propose they be applied in education. The problem is that these persons apply their own, colloquial conception of learning and teaching. For instance, conditioning as the theoretical basis of learning was effectively discarded at least four decades ago, yet the bulk of learning applications on the web still appear to repeat behavioristic models with their structure, immediate feedback, and rewards.

After decades of intensive piloting, application, and research of digital educational technology, we still lack credible indication of the superiority of digital devices in education (e.g., Balslev, 2020; Cuban, 2001; Selwyn, 2014). Given the cost of all these efforts and the lack of evidence of their benefits in education, we conclude that educational objectives have not been the driving force of the computerizing of schools. It appears that certain patterns of failure are repeated when introducing technology in the school context (see Balslev, 2020; Cuban, 1986; Winner, 2009). Moreover, it can be argued that these patterns concern our cultures in general, not only education. For instance, the concern about the education equity crisis referred to as the "digital divide" (EdTrust, 2020) has been one argument for the introduction of digital devices in schools.

An expert in multimedia processing and learning, Richard E. Mayer (2009), pointed to the driving force—and the cause of the subsequent failure—of so-called educational technologies being the assumed power of the technology rather than an interest in promoting human cognition.

Summary

Because technologies are inevitably present in practically all learning processes, technological choices are crucial in the development of educational policies and practice. From the point of view of 4E cognition, this implies that the technological aspects of learning environments should be exposed to criteria that are based on the assumptions of cognition as embodied, embedded, extended, and enacted. Attention needs to be paid to the different affordances that these "technological instruments" provide. This approach challenges us to develop educational technology, which provides opportunities to create and manipulate physical, tangible objects and encourage the learners to throw themselves into that creative process we call learning.

In this chapter, we addressed some important and hitherto neglected issues concerning digital reading, with special emphasis on the vital role of our bodies, and in particular our fingers and hands. Reading is a multisensory activity, entailing perceptual, cognitive, and motor interactions with whatever is being read. With digital technology, reading manifests itself as being extensively multisensory—both in more explicit and more complex ways than ever before. The different affordances of paper and screen as substrates for reading and writing illustrate the core of the 4E thesis: how 4E opens a perspective very different from the Cartesian dualism in the analysis of reading and writing processes.

To be prepared for the next wave of educational technology, efforts in the implementation of 4E cognition to school practices could be the awaited counterweight to the pressures from outside the educational context. Well-informed teachers should be able to make objective-driven choices among technologies rather than blindly pursuing a modern look in their classrooms—or just opposing everything new (see technophobia, Brosnan, 1998).

Notes

1. In the case of Finland, one clue could be the composition of an expert group of the educational use of ICT, nominated by the government (Finnish National Board of Education, 2010). The group consisted of twenty-three members. The chair of the group was the then director of the National Board of Education. The other twenty-two members represented the National Board of Education (one member), the Ministry of Education (one), municipal organizations (two), universities (three), the Finnish Funding Organization for Technology and Innovation (one), the Information Society Development Center (one), the Trade Union of Education in Finland (one), and—most interestingly—enterprises (eleven). In other words, half the members participated to promote their businesses. In popular media, the work of the group was reported as an expert view of what our educational system requires at the moment. It was not surprising that the central recommendation was a huge investment in ICT by schools (e.g., Liiten, 2010).

2. Should schools ban smart phones or teach self control? School News Australia, May 30, 2018; https://www.school-news.com.au/news/should-schools-ban-smart-phones-or-teach-self-control/

3. Schleicher is Division Head and coordinator of the OECD Programme for International Student Assessment (PISA) and the OECD Indicators of Education Systems programme (INES).

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