# 9 Educational technology (EdTech)

## Unbounded opportunities or just another brick in the wall?

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### 1 Introduction

Sweden is among the European countries with the best access to bandwidth and connectivity and has a high student-to-computer ratio (Wastiau et al., 2013). Ninety-three percent of Swedes between the ages of 16 and 85 have access to the Internet in their homes (SCB, 2017). Furthermore, Sweden is the home of a wide range of technology- and software-based companies (Teigland et al., 2018). Entering in third place, Sweden, together with Denmark and Finland, are the top three countries for advanced digital economies according to The Digital Economy and Society Index (European Commission, 2019). As such, the Nordic countries are well placed to avail themselves of new and emerging educational technologies. EdTech is an emerging concern in the broader European context, too, demonstrated not least by the establishment of the European Institute of Innovation & Technology (EIT) in 2008. In 2018, the European Commission launched a digital education action plan that acknowledges the importance of supporting the use of technologies in education (European Commission, 2018b).

Disruptive innovations have the potential to unlock and create new markets, or radically change the ways in which current markets operate, displacing established market-leading practices and products (Christensen, Raynor and McDonald, 2015). Common examples of such innovations include the personal computer, which disrupted the development of mainframe computers, rendering them almost obsolete. In a similar way, mobile phones have made fixed-line telephony almost a thing of the past. Educational technologies have the potential to cause disruptions in the educational sector with a view to providing key services for governance, services that provide new ways of interacting with educational material, but also through services providing new ways of certification, both in compulsory and higher education. While we acknowledge that some EdTech innovations have the potential to be somewhat disruptive, the traditional Christensen, Raynor and McDonald (2015) definition does not translate well to the scope of compulsory and higher education sectors. Disruption in the educational sector comes slowly for a number of reasons, for example, path dependency in public infrastructure, laws regulating public procurement of services, and also data regulation laws. This chapter presents a number of potentially disruptive or transformational

innovations and considers the conditions needed for EdTech to play a part in displacing and transforming current practices. In doing so, we consider the difference between digitization and digitalization and acknowledge the transformative nature digitalization of practice could potentially involve. Finally, we present and discuss three different EdTech-oriented themes, *artificial intelligence*, *digital exams*, and *global content providers*, which extend across the educational sectors, and comment on how they could have a transformative effect on educational practice.

### *1.1 EdTech as the grand narrative of modernity*

EdTech is often sold as offering unbounded possibilities and a grand narrative of modernity. A positively oriented EdTech discourse is one that comes with the promise to replace a rigid education system with fast-moving technological developments, where insights into technology will have fundamental effects on how people learn. This juxtaposition of new and modern with old and antiquated is often touted from within the EdTech industry itself and should perhaps therefore be treated with skepticism by policy-makers and educators. For example, in AOL's TechCrunch magazine, one could recently read:

> For the past 150 years or so, most learning models – especially regarding children – have barely changed: A teacher or lecturer stands at the front of the classroom explaining ideas or introducing facts while students sit and listen with the learning materials being mostly physical textbooks or printouts. Now, however, digital technologies are starting to transform today's classrooms. More students are using computers or tablets, and teachers are increasingly using screens to illustrate aspects of their lessons. Physical textbooks are being replaced by online, interactive services that are more up-to-date and in-depth, which allows learners to explore and learn at their own pace. This is important because of two contributing factors. First, students are born with digital DNA.
>
> (Bainbridge, 2016, paras.10–12)

Other notions, such as digital nomads and digital natives, are projected in the media landscape, further enhancing the apparent and almost existential shift that is occurring through the advancement of technology-enhanced education. Advances driven by EdTech are, in reality, much more modest, where we, at times and at best, can identify some more or less strong correlations between learning in the classroom and the use of EdTech (Linderoth, 2016). Still, the grand narrative of disruptive EdTech is one that returns at regular intervals; in the early 2000s, flipped classroom instruction was going to have a profound impact on the classroom; 2012 was the year of the massive open online course (MOOC), when MOOCs were predicted to have an irreversible impact on how education was offered; and currently, we are in the midst of a hype of expectations with reference to how AI, big data, and learning analytics will affect how we teach and

learn. Only recently, a Swedish EdTech company claimed to be able to utilize AI to closely personalize content to the needs of each student. This promise is made at a time when access to user learning patterns is poorly documented, when public access to learner data is becoming increasingly restricted, for example, because of the new General Data Protection Regulation (GDPR). To confound matters even more, when user data are documented, they are rarely shared and aggregated or put to use in conventional learning contexts to systematically develop teaching (EU GDPR Portal, 2019; European Commission, 2018a).

## 2 An overview of EdTech in the school setting

In Swedish schools, teachers and students have access to and use digital resources on a daily basis in the classroom. Common arguments from the municipalities for implementing new technologies include such notions that education needs to keep up to date with the technological developments in society, and the argument that one can draw advantages from the possibilities to improve the pupils' performance is also often invoked (Tallvid, 2010; Hylén, 2013; Grönlund, 2014). However, it is difficult to establish a clear relationship between increased access to new technologies, leading to their increased use, and improved performance and grades (Lei, 2010). For example, if we consider the results from the International Program for Student Assessment (PISA) from 2012, in countries that use technology on a daily basis, students' results declined between 2000 and 2012 (OECD, 2015). One reason for the decline in students' achievement could be the lack of adequate teaching methods when using technologies in the classroom (OECD, 2015). In other words, previous research can identify some specific advances in learning, but it is difficult to identify causal relationships and "a general fix" for education using EdTech. As such, EdTech does not offer a panacea to student learning and achievement, but there are still many good reasons to use it. EdTech might not facilitate and in itself make learning and teaching more efficient. However, technologies can affect the way teaching, learning, and assessment are perceived and conducted in schools and universities (Åkerfeldt, 2014a). For example, the possibility to store, retrieve, edit, and collaborate when writing a text challenges the notion of writing if we compare writing with using pen and paper only (Åkerfeldt, 2014b). Writing using different technologies has increased in schools and higher education, and a recent investigation identified Google Docs as one of the most-used EdTech tools in the classroom in the United States today alongside YouTube and Google Drive (Molnar, 2017).

Previous research on technology and education suggests that the most successful tools, when it comes to implementation of software and digital systems, are those that have been developed to align with teachers' established teaching methods (Kennewell, 2017), but in reality this is perhaps is not always the case. For example, one example of a digital tool that has been widely adopted in the United Kingdom during the beginning of the 21st century is the interactive whiteboard (IWB). The implementation of the IWB was not based on research; instead, the initiative was driven by policy-makers in the hope of modernizing educational

settings and introducing new and innovative teaching methods. Moss and Jewitt (2010) studied the implementation of IWBs, and their findings suggest that some of the teachers were using the IWB as a traditional blackboard. Many teachers did not use features, such as saving and sharing content created on the IWB, with learners. Moss and Jewitt (2010, p. 32) find that the "ways in which teachers use technology is strongly shaped by their existing pedagogic practice, the context of the school, and the demands of particular school subject areas and topics." Thus, the promise that IWBs would bring about a transformation of pedagogy and revitalize classroom teaching was far from being realized in the classroom.

## 3 Digitization and digitalization

The example of the IWB above acts as an introduction to a discussion on the difference between digitization and digitalization. Digitization, we postulate, is an evolutionary process of replacement, involving the creation of a digital version of analogue or physical artifacts. Examples include keyboards replacing pens and paper or computers replacing paper documents and physical books. Analogous to health care, when you transfer patient data to digital health cards, in education you can transfer student's performance data or admission data to digital "cards" or files. As a result of a move toward a digital society, companies are offering schools and municipalities the possibility to accommodate new digital solutions to old analogous problems. Such needs include the digital signing of certificates or offering digital exams, replacing practices that were previously performed on pen and paper, or offering software for a wide range of uses. These practices may not constitute a disruption of practice akin to the introduction of the mobile phone, but instead they may constitute a natural evolution of practice toward digitization, offering minor tweaks as opposed to radically changing the marketplace.

Conversely, we argue that the digitalization of education practice has a transformative nature. So, for example, when introducing digital technology in the classroom or incorporating digital tools in the classroom, there is a need to consider the basis for how educational and information technology can best service the learner and the teacher. Digitalization prompts questions such as: "What does the digital tool afford the teacher and the learner that the analogous version did not?" and "How can the digital tool enhance learning?" and so on. First, after answering these and other related questions, new digitally oriented pedagogies or new approaches can be developed that enhance learning.

### *3.1 EdTech as a tool for transforming teaching and learning*

Transforming teaching and learning does not come solely by introducing digital technology into education settings. The transformative process is made up of different layers, conceptual and practical, depending on how one views learning, teaching, and assessment. As the printed text moves to the screen with the possibilities to provide visual and auditory modes, these modalities, in turn, offer

specific ways of interacting with the learning material. The move from printed text to the screen has the potential to reshape content and therefore also the meaning of printed text. Jewitt (2002) shows in her study how the novel *Of Mice and Men* by Steinbeck was perceived by students both when represented as a printed text and on the screen. The findings suggest that the characters were conceptually reshaped differently by the students, depending on which media form was used for reading the novel. Furthermore, the characters' relations to each other and even the narrative in the novel communicated different meanings. "The electronic reorganization of the original text into the CD-ROM became fractured, the narrative was disrupted" (Jewitt, 2002, p. 20). The findings suggest that using technology to facilitate learning can involve a deeper transformation of how learners shape their meaning through different modes and media, which might have consequences for teachers' practice when using EdTech solutions in the classroom. However, as the IWB example above demonstrates, a practice-oriented transformation does not occur just because of the implementation of technology. So, how could EdTech have a disruptive or transformative effect in the context of teaching and learning, both in compulsory and higher education? That is the focus of the next section.

## 4 EdTech as a potential game changer: three examples

As mentioned above, technological advances continue to play a central part in most forms of education and have an impact on how people interact with subject content, through the introduction of digital tools and platforms offering students at different levels of education access to vast amounts of knowledge and access to peers across the globe. EdTech innovations also have the possibility to play a more disruptive or transformative role in how educators engage with their students and how students engage in their learning processes, but also how EdTech providers could play a key role in the nexus between teaching and learning. Below, we identify three different EdTech-driven themes and consider further how the different types of EdTech solutions might constitute a transformative change in practice for teachers and learners.

### *4.1 AI-enhanced learning solutions*

We are currently witnessing the emergence of a number of AI-oriented solutions with specific relevance to the educational sector, for example, recently the results of AI research have been translated into a tool used to identify and determine reading difficulties in children. In Stockholm's municipality, a large project has been started in which more than 15,000 students, spread across the municipality's primary schools, will carry out eye-screening tests to determine and identify students with reading disabilities. The test is currently offered at a low cost and is projected to be time effective, as it promises to take only two minutes for each student to complete. As early as 2016, four Stockholm schools were part of a study that tested the new AI tool developed with researchers from Karolinska

Institutet (KI) (Nilsson Benfatto et al., 2016). The new AI tool is not a diagnostic tool per se that can determine the cause of reading and writing difficulties; instead, the tool identifies the reading difficulties. Students read a short text on a computer screen while their eye movements are recorded by a camera. The eye movements are understood to represent cognitive processes in the brain, the results for each student are compared with a large database containing reference material, and the results are analyzed with the help of artificial intelligence (Nilsson Benfatto et al., 2016). The students who show deviating eye movements may have some form of reading or writing difficulties. Traditionally, testing could take half a day for each student, but the new tool promises to finish the test in two minutes per student. Once a student has been found to have problems with the help of the screening, special education interventions may be offered with support measures specific to each student's needs (Jällhage, 2017).

This is just one example of a transformative innovation on a relatively small scale, identifying specific problems in the educational context. The innovation has a potentially transformative effect on one category of teachers in the sense that special educators can devote their time to implementing measures instead of conducting the tests. The tool also means that testing can now be done at a scale with many students, addressing a second issue in the Swedish educational context, namely the lack of special-ed teachers.

Other examples of AI in the education context include using machine learning and neural network software to make predictions based on a participant's scores on diagnostic tests, where individual learning patterns can be identified and proposed. The Swedish company referred to above recently won a global AI competition, beating other AI platforms in predicting mistakes that language learners would make based on their previous errors, and was able to suggest unique learning trajectories for individual learners. These advancements in AI and learning pathway prediction offer some interesting insights into potential possibilities for EdTech in the future. At the same time, there is a significant difference between learning language via an app and the reality of a school environment that is socially and culturally situated and that follows conventional assumptions about meaning-making and methods of information delivery.

### *4.2 Digital exams*

There is a current and widespread emergence of digital exam vendors in the Swedish context. In their simplest form, digital exams constitute a form of digitization whereby conventional exams are migrated to digital spaces and tools (Llamas-Nistal et al., 2013). Digital exams offer a tool or a range of tools; for example, when students log on to a platform via a computer, the system can be configured so that it locks down other elements of the computer, meaning that the student can only focus on the digital exam. The research on digital exams is still nascent at the moment, but there is ongoing research into automatic correction of open-response tests. This field of research combines natural language processing and artificial intelligence techniques, but empirical results are still scarce. Digital exams

also afford teachers a legible reading experience, and as a bonus if connected to a single-sign-on system, the results can be registered digitally, thus reducing the time for teachers to document students' results. Computer-based assessment such as digital exams, multiple choice quizzes (MCQs), single best answer (SBA), and other online tests are commonly used to assess students' knowledge. Computer-based assessment can, for example, reduce the teacher's workload, as the students' answers can be corrected automatically (currently limited to the preresponse selection type of questions such as MCQs). Moreover, it is possible to randomize the questions, and it is also possible to increase reliability, as the exams can be taken and corrected anonymously. In an interview study with 33 university teachers, the teachers stated that online MCQs were used as they saved time and they felt a pressure to adopt more efficient forms of assessment, even though some teachers questioned whether this was good practice (Bennett et al., 2017). The use of video and simulations was also mentioned as a technology that could offer efficiency. Simulation was used to assess students' practical skills, for example, in paramedics when students worked with simulated patients. However, creating new forms of assessment was perceived as time consuming and challenging. Conversely, teachers wanted to discuss foremost students' achievement rather than starting directly to implement technologies in their assessment practices. In this sense, the pedagogy and technology were disconnected (Bennett et al., 2017).

In Sweden, the national tests for compulsory and secondary school will be digitized by the end of 2022. In doing so, the government argues that the tests will be delivered digitally, corrected fairly, and provide reliable data (Government Offices of Sweden, 2017). Through digitization, all students will be subject to the same test. Testing reliability, it is argued, can be obtained when the students' answers are anonymized and are corrected by another teacher than the one that has been teaching the student. Previous investigations show that teachers tend to be more generous in their assessment and grading if they teach the student than if they do not know the student (Begler and Bremberg, 2012).

The digitization and digitalization of exams offer entirely new opportunities that utilize digital exam systems, but in ways that require a transformative approach to teaching and learning. Another aspect of the digitalization of assessment practices is that it can potentially transform how assessment is carried out in schools. In contexts where technologies are used on a daily basis for teaching and learning, assessment practices are changing and moving toward assessment for learning (Erstad, 2008) instead of assessment of learning. Through the use of learning management systems, educators have the possibility to follow students' learning and knowledge progress over time. Teachers using technologies in their classroom claim that they can determine students' grades before the students have handed in the final assignment. The teachers feel that they have been informed through the digital systems about the students' learning process (Hernwall et al., 2018).

New ways of approaching exams in a digital fashion are needed today; for example, it is not uncommon for large student cohorts in medicine, law, and computer science to do pen-and-paper exams, as there are no exam facilities for digital

exams for large groups in many of Sweden's university cities (n = 300–500). The solution to this problem, however, is not to provide 500 computers or tablets to the students; instead, new ways of conceptualizing and practically implementing changes are needed that take advantage of digitization and use EdTech as a catalyst for digitalization. Here, EdTech can offer solutions; however, the question remains: Are schools and universities open and able to capitalize on the new opportunities?

### *4.3 EdTech as global content provider*

In this section, we identify EdTech as a content provider, that is to say, specific EdTech companies offer courses or content material. We acknowledge that there are a wide range of forms of content providers on the marketplace that provide service and target compulsory education as well as higher education, both in Sweden and globally. However, in this part of the chapter, we will focus specifically on MOOCs as an EdTech phenomenon. MOOCs are not a specific EdTech innovation per se; instead, they are an aggregation of different educational technologies cohosted on a platform. MOOCs often offer tools that are broadly accessible and commonplace already, such as video-recorded lectures, multiple-choice questions, and discussion forums. Other innovations used in MOOCs are 3D modeling and virtual patients. This chapter uses the MOOC phenomenon to illustrate different views on how EdTech could be used in the context of higher education to disrupt current practices, and gives comments on developments so far.

MOOCs are courses that are hosted on globally accessible platforms. Initially MOOCs were open to everyone who had access to a computer and an Internet connection, and a certificate of participation was offered to students who passed courses. However, as business models have developed, it has become increasingly common for MOOC vendors to differentiate between audiences, offering some content for free (without certification), certification of participation for a fee (ca. USD 50), and corporate-specific education at a higher fee (starting at, for example, around USD 200 per one-week course). MOOCs came to wide public attention in 2012 and brought the promise of being a new force in higher education, promising to revolutionize but also disrupt traditional higher education (Ross et al., 2014; Yuan and Powell, 2013; McGrath et al., 2017). However, even though MOOCs offer the promise of open education resources (De Freitas, Morgan and Gibson, 2015; Czerniewicz et al., 2017), the broad transformative and previously promised revolutionary effects on higher education learning have yet to materialize (Eisenberg and Fischer, 2014; Siemens, 2015; Stöhr et al., 2019).

Arguably MOOCs could be a disruptive force in a number of ways, for example, they could empower a change in the demographics of higher education, enabling nontraditional students to gain access to higher education. MOOCs could, given their massive outreach, bring about a change in the certification of higher education credit, they could afford universities new ways of addressing learners' needs, and they could also involve university teachers in new ways of practicing and teaching their subjects.

In the Swedish context, the response to MOOCs thus far has been moderate. Some of the larger universities, for example KI, the Royal Institute of Technology (KTH), and Chalmers University of Technology all provide MOOCs via the edx platform, and Lund University offers courses on the Coursera platform. The current courses are either offered as introduction courses or as highly specialized courses, often requiring a good pre-understanding and several years of previous study.

Data on MOOC participants suggest that while there is wide geographical diversity – for example, KI's course on urology had participants from 172 countries (Henningsohn et al., 2017) – most MOOC participants already had a college or university degree (Breslow, 2016). In other words, the MOOCs themselves are not disrupting the traditional pathways to higher education studies but instead seem to be attracting and offering continued education to well-educated professionals, providing opportunities for them to solidify or refresh their knowledge. At the same time, research suggests that lay people and students alike can benefit from MOOCs, (Henningsohn et al., 2017; Stöhr et al., 2019).

MOOCs, given their specific attention to online learning and mass participation, could also allow universities to provide mass education in basic introductory courses traditionally offered by universities. In doing so, it would be possible to allow many people to attend "MOOCified" versions of introductory courses in medicine, engineering, and law, just to name a few. Georgia Tech has MOOCified one of its master's programs (McKenzie, 2018). Some initial data suggest that:

- An enrollment of 6365 makes it the largest master's degree program in computer science in the United States.
- New categories of people are attending the program. The typical applicant to the online program is a 34-year-old midcareer American, while the typical applicant to the in-person degree is a 24-year-old recent graduate from India.
- Students admitted to the online program had slightly lower academic credentials than those admitted to the in-person program; online students performed slightly better in identical and blind-marked final assessments.
- Tuition to the MOOC program costs USD 6630, which is one-sixth of the cost of the in-person program.

MOOCs could also afford universities new ways of addressing learners' needs. Given the mass participation, MOOCs provide higher education institutions with large datasets that could be used to better optimize the learning of certain subjects using learning analytics to identify gaps in student learning for on-campus students. However, a quick look at the MOOC strategies of KI, KTH, and Chalmers reveals that none of the universities have active policies for exploring how learning occurs in MOOCs. Instead, the research done on MOOCs is conducted on the same competitive grounds as other research and is self financed. Given the high costs associated with developing MOOCs (a one-week MOOC costs between SEK 350,000–700,000 to produce), it is interesting that the universities do not employ learning analysts to understand how MOOCs can be translated into a

return on investment in terms of educational practice and financial responsibility. It is clear to us that MOOCs could break open the higher education sector, offering access to higher education to new categories of students. Such digital learning resources could also change the way in which we select students for advancement through higher education. MOOC introductory courses could be used as a way of providing students with access to continued studies. This could mitigate concerns raised by the Swedish National Agency for Education (2018) that secondary school grades are not always the best predictor for successful university studies. By allowing students to attend the same MOOC, then performance scores on the MOOC could act as better predictors of performance in higher education. However, Swedish universities have a well-defined and path-dependent infrastructure that is based on quasi-meritocratic grounds. A loosening up of this system could have far-reaching consequences that may be more or less desirable and predictable, such as, for example, disturbing merit-based approaches to university access.

## 5 EdTech as a disruptive force – looking ahead

So far, we have considered the difference between digitization and digitalization, and we introduced the idea of transformation as a key concept when considering the disruptive nature of EdTech. The chapter has also presented a number of different EdTech-oriented innovations that extend across the broader educational sector from preschool to higher education, and we have commented on how they may or may not constitute a transformative effect on educational practice. We endeavored to acknowledge a distinction between what may constitute disruptions of the education sector and what otherwise might be viewed as opportunities to transform, in more or less radical ways, educational and learning practices. Our focus on transformation of educational practice is driven by our experiences as practitioners and researchers in education.

In this final section, three strands are presented that will form a starting point for a discussion about the use of EdTech in education: 1) IT education strategies are needed on several levels; 2) challenges when new technologies face policy, laws, and regulations need to be addressed; and 3) collaboration between researchers, teachers, and EdTech ventures can lead to mutual benefit.

We emphasize a need for strategy as a key feature when considering the digitization and digitalization of the education sector. Consequently, and for the purposes of this chapter, we conducted a mini-survey of a few Swedish higher education institutions, asking two brief questions related to digital learning strategies. The two questions were directed to the central communications departments at the universities and do not provide an adequate examination of how the universities approach digitalization and learning, but the results may be of interest, nonetheless. The questions were:

- Do you have a strategy document for IT with a view on education practice within your university?
- Does your university have a chief digital officer?

The outcomes are listed in Table 9.1.

None of the universities consulted reported having a dedicated digital learning strategy at this point in time. In the cases where there are strategies, they are part of wider IT infrastructure strategies. The fact that some of Sweden's foremost universities do not have digital learning strategies is perhaps not surprising – after all, Sweden's first chief digital officer (CDO), Åsa Zetterberg, was only recently (2018) appointed – but it does suggest that EdTech may not really play a disruptive part in the near future, at least simply for the reason that strategies may be needed to drive financial investments and strategies are run by key people within the organization. Looking ahead, we see a need for municipalities and universities to have digital learning strategies that are aligned to data-sharing laws and that are user focused. In addition, they must also have a strategy for developing university teachers' digital competence.

We identify that laws regulating public procurement of services and also data regulation laws constitute major obstacles to EdTech ventures, and we argue that strategies along a number of lines are needed. Laws regulating the public procurement of services may also act as obstacles, at least initially, to the development of the new, previously unthought-of services. The public procurement act regulates the way in which public bodies, universities, and municipalities conduct procurement and stipulates that a public procurement contest must be organized that is open to all and arranged by a contracting authority with the aim of acquiring a plan or design selected by a jury. Other restrictions entail no one contractor being treated more favorably during the procurement process. Such a process makes sense from the viewpoint of authorities' legal obligations via-à-vis the law. Still, we wonder if this may in some ways act as an obstacle to the development of specific new innovations in the public sector. The implementation of the new data-protecting regulations (GDPR) also means that vendors may be more restricted when collecting data from learners in the context of the EdTech industry. This

*Table 9.1* Survey of digital learning strategies at a selection of Swedish universities

| *University* | *Do you have a strategy document for IT with a view on education practice within your university?* | *Does your university have a chief digital officer?* |
|---|---|---|
| Stockholm University | No | No |
| Karolinska Institutet | No | No |
| KTH, The Royal Institute of Technology | No response within time frame | No response, but KTH has a digitalization officer |
| Lund University | There is no overall digital learning strategy, but Lund University has an IT strategy | No |
| Umeå University | No response within time frame | No response within time frame |

presents a major challenge, not least for the development of personalized learning solutions and also for researchers and practitioners in the educational field.

We believe that there is a lack of experience and knowledge about how researchers can collaborate with EdTech ventures. However, there are attempts to bridge this gap between research and ventures. For example, universities in Sweden have created software in order to encourage researchers to think about how they could commercialize their research and create new innovations with companies, or how they could start their own business. Researchers are paired with a business mentor who supports the researcher for one year to think more in terms of commercialization of their research findings. One challenge that the participants in the program faced was that the academic organization did not have the appropriate "know-how" about business models, laws, intellectual property, copyright, and so on.

In conclusion, we acknowledge that EdTech has a prominent place in the Swedish educational context, and we identify many middle-way transformative outcomes that use EdTech to drive a change in practice; such examples include flipping the classroom and other blended learning techniques. We have shown how open-source software circumvents the procurement law, enabling students to access and learn code and coding. "Scratch" is an example of an open-source web-based application, where the user through block-based programming can create, for example, stories and games. However, we also acknowledge that these advances do not come quickly, nor are they adopted radically or systematically, but occur more sporadically. Furthermore, closer partnerships with end users are needed to promote mutual benefit.

In this chapter, we did not address corporate learning, where companies and global corporations may have a more direct decision-making process and whereby they could potentially have a very strong financial drive toward implementing AI in their corporate educational programs. Similarly, we have not discussed how other forms of continued professional development could be enhanced by educational technology.

Finally, we should consider the value that teachers and educators provide to students' learning experience, and offer a word of caution. Teachers and educators offer unique experiences to students at all levels of the education system, and offer critical voices that act as a counterbalance to many taken-for-granted ideas. They also act as creators of knowledge, by breaking knowledge down into intelligible bits and pieces that are shared, critiqued, and used to build further knowledge in our society. Are we willing to embrace the full effects of educational technology? If so, then what is the role for educators? Will they be reduced to curators of content created by artificial intelligent systems in Silicon Valley? We believe there is an inherent value that educators are cocreators of intellectual output and on-demand solutions that enhance their own teaching efforts and the efforts of the students they meet and engage with.

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# 10 Education at the intersection

## A practitioner's view of the effect of digital transformation on public education

*Stephen Mahaley*

### 1 Introduction

The objective of this chapter is to explore the ongoing evolution of public education in the United States, with a particular focus on the risks and rewards of digital transformation. There are a number of dimensions of public education that merit review: funding, access, content, methods, teacher qualifications, and infrastructure, to name a few. Arguably there are no institutions, formal or informal, that are immune to the effects of widespread technological innovation – from the dawn of the Internet through the rapid proliferation of digital connections in the early 2000s, to today's deeply ethical considerations of the potential impact artificial intelligence, gene editing, robotics and automation, and data sharing and analytics, among other manifestations.

Education will be argued as a core and abiding component of viable democratic economies and societies, and the current range of digital transformations (and related policies) stand to either bolster the public good that quality education can create, or further damage and divide public education in ways that exacerbate existing disparities. I will be examining public education in the United States only, with references to global comparative data where applicable and available. It is my hope that the reader gain some useful information from this chapter and ask questions about the state of digital influence on this particular public good and what she or he can do to direct investments, programming, policies, and conversations in ways to support it.

### 2 Material

#### *2.1 A brief history of public education in the United States*

At the turn of the 20th century, the United States was poised at the edge of an educational crisis: the industrial revolution was in full swing, yet there were not nearly enough workers who had basic skills to run machines and participate in the booming assembly-line industries expanding across the country. The federal government established the Department of Education, and each state in the union was given some budget and latitude to levy its own taxes for public education, and to

interpret and implement federal education guidelines. Over the years, states determined their own methods of funding public schools – either through management at the state level (with funding through state taxation), through localized counties or districts (with funding largely based on property taxes), or some combination of both.

Times were tumultuous, given the racially divided country, stemming from a century or more of subjugation of African Americans. *Brown v. Board of Education*, a landmark ruling of the US Supreme Court decided in 1954, called for all states to integrate their schools, and while the legal intent was there at the federal level, many states were slow to implement the guidance (taking more than a decade), leaving a legacy of great disparity in the funding of schools, largely based on the populations they serve. In many cases, school districts were formed around zones of wealth and districts organized around neighborhood schools, such as in the state of Connecticut. Combine that with the fact that the largest portion of public school funding in Connecticut comes from local property taxes, and we see large disparities in levels of funding for local schools, with poor students attending dilapidated schools (CT School Finance, 2018). For more on the Connecticut example, see Thomas and Kara's 2017 report (Thomas and Kara, 2017).

The importance of the *Brown v. Board* ruling and the realities of state-level funding policies should be held in consideration as we think further below about the implications for equal funding and access to modern educational tools. As Chief Justice Warren stated in the ruling in 1954:

> We conclude that in the field of public education the doctrine of 'separate but equal' has no place. Separate educational facilities are inherently unequal.
>
> (United States Courts, 2018, para.15)

As we will see below, these funding disparities have a direct effect on how digital transformation is evolving in this sector.

Public education in the United States has been undergoing a digital transformation for decades, and that transformation, since the advent of the Internet, has accelerated with a host of new technologies available. The Internet, born out of early sharing of research data between US governmental agencies and academic institutions, was a key turning point for education, affecting everyone involved – from teachers, to students, to content producers, to school building designers, and of course to governance and financial managers.

As a former public school teacher, I began my teaching career in the 1980s using the same technologies that I had had experience with as a student decades before: overhead projectors, filmstrip projectors, the occasional vinyl record or tape, and of course plenty of mimeographed copies to go with well-worn textbooks and chalkboards. This was the state of learning technology at start of the 1990s, and it looked like it could stay that way forever – until the expansion of personal computers.

In the mid-90s, I was there to open the first boxes of hardware that arrived at my public elementary school. Owing to thin budgets, I volunteered my time

to learn all about databases, email servers, networking protocols, HTML, and hardware installation. This was a radical time, as everyone – parents, teachers, administrators, and students – wandered into the web to figure out what it was and what it could mean. After having corralled a group of parent volunteers together to run a "Net Day" at our school in which we ran wires to the classrooms and connected as many computers as possible, it became clear that the "soft side" of this transformation needed just as much care and attention. The teachers needed help understanding what this new world would mean and how to integrate the rapidly growing toolset into their instructional practices, evaluation methods, and curriculum design.

And now, as the 21st century has begun, the pace of technological innovation has accelerated from the boom at the end of the 20th, placing traditional educational practices and structures in the crosshairs of potential innovation. Examples of this innovation include rising student access to digital learning resources (DLR) and the incorporation of those tools and resources into the educational experience. Access, however, does not necessarily equate to increased performance, and the United States may be falling behind. According to the National Center for Education Statistics' (NCES) 2017 report, US teenagers, solving problems in a technology-rich environment, performed at a lower level than the OECD average (Hussar and Bailey, 2014).

Certainly multiple factors (income levels, access to resources, parental educational levels, etc.) have come into play. In 2015, only 62 percent of households had Internet access in the state of Mississippi (Hussar and Bailey, 2014). If there is an expectation that students access online tools, content, and experiences, equal access to the Internet will need to be resolved. This history of digital transformation, coupled with federal and local policy-making, has placed public education squarely in the intersection. Will there be equitable and democratic access to high-quality public education, powered by technologies? Let's take a closer look at how these factors are playing out today.

### *2.2 The current state of digitalization of education*

Over the past ten years, the open Internet and the proliferation of digital tools have not delivered the degree of democratization of education that we once predicted. Some great examples of this democratization do exist, to be sure: Salman Khan and his Academy (www.khanacademy.org), the genesis and proliferation of massively open online courses, the wide use of live webinar platforms, open-source learning management systems (e.g., Moodle), and myriad digital learning experience and content authoring tools. During this time we've seen educational business models evolve, including the purely digital "freemium" models for online coursework as well as an expansion of for-profit colleges and universities (e.g., University of Phoenix as a prime example). Based on NCES data, we can expect today a total of 27 to 28 million students enrolled in post-secondary schools in the United States (NCES, 2019). This is indeed a large market to be served.

What has failed to keep up, however, are smart regulations that ensure that infrastructure is equally available across school systems and that options are available for the many students who do not have reliable (or any) Internet or computer access outside of school. Nowhere is this more pronounced, perhaps, than at the K–12[1] level, where the United States has seen a significant relaxation of regulations regarding the number and structures of charter and private schools. While these schools promote the benefits of "choice" in schools, those choices are rarely available to the populations who arguably most need them – namely the underserved, lower middle class, and poor communities. Charter and private schools are typically exempt from providing transportation, meals, or special services for children with exceptional needs, and the result is a further widening of the gap between those who have choice and access to well-funded schools and those who do not.

What is more, the data on performance do not typically bear out the promises: in a 2016 study of school performance in Louisiana, charter and private schools, on average, underperformed their public school counterparts (Mills et al., 2017). Additionally, there are widely varying governance structures and standards: many private or charter schools do not require their teaching staff to have any formal education or qualifications in instruction or child development. Frequently there is little to no recourse for parents if their students are underserved; these students eventually find their way back into the public school stream.

This is not to say that all charter or private schools fail to provide quality education. This is, however, to bring focus on a critical piece of the overall landscape to consider as we look at digital transformation and examine the arguments for school choice that present deeper funding challenges for public schools (Walker, 2016). With potentially more limited funding reaching public schools, and greater concentrations of wealth in fewer school districts, there is a growing concern for equal access to the latest that digital tools and methodologies can offer.

We have also seen a lack of accountability and standards with regard to the quality of many privatized, online education providers, often leaving students with incomplete educations and a significant pile of debt. Examples of failed for-profit universities abound, and the number of current and former students struggling with a mountain of student loans to repay is staggering. Forbes, the Brookings Institution, and others have reported on the perversion of higher education toward revenues and shareholder returns, resulting in what is now 1.3 trillion dollars of debt owed by students – many (35–47 percent, depending on source) of whom will default (Simon, 2018). Public and for-profit universities have been offering increasing numbers of distance education courses and garnering a growing share of student participation – totaling nearly 30 percent of all students in 2015 (Seaman and Seaman, 2017). The digital wave may have brought new possibilities for access to education, but in too many cases educational outcomes have been limited due to mounting debt.

While we in the United States continue to struggle with these issues of affordability and access, there are still great examples of digital innovation that illustrate the right blend of educational design and technology integration. There are better

and better learning apps that provide not just another boring channel for pushing content, but that connect content to context. The University of Adelaide's Allan Carrington has integrated the SAMR model (substitution, augmentation, modification, and redefinition) along with Bloom's Taxonomy to identify over 125 apps that can be used on the iPad for instructional purposes (Carrington, 2016). For example, there are apps that deliver content based on geolocation or through the use of beacons, giving learners relevant information, questions, and tools for a particular place in the world – be that in an art gallery or during onboarding at a new office job.

We have also seen the early growth of virtual and augmented reality tools in teaching, learning, and performance support applications. Apps, on tablets or phones, now incorporate augmented reality tools – just point the camera at an object, a map, or a photo and a contextual overlay appears. Surgeons have used augmented and virtual reality views of a patient's heart muscle to identify particular approaches to correcting a blocked artery – in the operating theatre (Zhang, 2018). There are many, many applications of augmented reality – through headsets or handheld devices – that provide learners and workers real-time guidance during particular procedures, be that in the automotive garage or on an oil rig out at sea. Students at Georgia Tech University enrolled in Professor Ashok Goel's Interactive Computing course have their online questions fielded by Jill Watson, an artificial intelligence engine that functions as a virtual teaching assistant (Maderer, 2017). And this has been going on since 2015.

These immersive experiences are but one aspect of positive impact of digital transformation today. There is also the improving use of online platforms, powered with data analytics, that allows for greater insights into student performance, engagement, and smart suggestions for further, personalized, study paths. We have seen the disaggregation of some services to allow for interoperability – with many thanks to standardization on using xAPI technology to create links between content warehouses, LMS activities, and online learning events. Systems are now linking up, and learning can (with the right hardware and access) happen just about anywhere.

Today's reality for digital transformation in education is part of a larger context, of course. Here in the United States, there is an ongoing debate about net neutrality. Recent actions by some of the service providers have sought to split up service levels of Internet access, providing more opportunities for these companies to charge for their services. If you have a large dataset or rich streaming media experience you want to access, that could require greater levels of payment. As we think about the benefits of immersive education (gaming, virtual reality, live streaming, etc.) and the role of public education as a potentially equalizing force in our democracy, these debates over net neutrality[2] will hopefully result in fair access for all students, irrespective of their income (Hitlin, Olmstead and Toor, 2017).

### *2.3 Considerations for the future*

Projected enrolment in 2022 in public elementary and secondary schools in the United States is expected to be at 53 million students (Hussar and Bailey, 2014),

according to the National Center for Education Statistics (US). This is just around the corner. What will children and high-schoolers' experience be? How will digital transformation show up for them?

Will campuses be ready? According to a 2018 article by EDUCAUSE President and CEO John O'Brien (2018, para.6):

> digital transformation is affecting the entire higher education enterprise, of course. Yet evidence from EDUCAUSE research shows that comprehensive approaches to digital transformation are not evenly distributed. Around one-third of institutions . . . show clear signs of campus-wide digital strategy either already in place (3%) or exerting a 'major influence' (28%) on their emerging IT strategy.

Looking into the future is, of course, a guessing game. Disparities in access have been outlined above, and other trends that are disrupting our "today" may be themselves disrupted and supplanted by others in quick order. We can, however, take the directionality of the previous storylines and some data from current economic projections and extrapolate on a few points.

First, let us consider the "why" of education in the future. Many are arguing now that the combination of artificial intelligence (pulling big data from an Internet of Things) and robotics will revolutionize many industries, destroying long-held jobs (and career paths), creating new ones, and therefore spawning an entire wave of new learning and development requirements. The Pew Research Center's report (Rainie and Anderson, 2017, para.5) summarizes current expectations nicely, and points out that:

> A central question about the future, then, is whether formal and informal learning structures will evolve to meet the changing needs of people who wish to fulfil the workplace expectations of the future.

With artificial intelligence managing the paperwork and assessing the best cases and points of law from thousands of sources in hours rather than weeks, many legal jobs stand to disappear. With routinized work such as welcoming guests at hotels, processing paperwork at doctors' offices, and performing quality controls on assembly lines in the AI crosshairs, many more jobs are at risk.

From an educator's perspective, I think there are big opportunities here, as well as risks. First, let us consider the pedagogy of technology and how that will shift as some tasks are automated with smart systems and perhaps even some forms of robotics. Artificial intelligence will continue to evolve to power such smart learning systems and to provide increased predictive tools for high degrees of personalization in the learner's experience. To some extent, "curricula" will become detached from standard process, and an individual will, with these enhanced systems, be able to demonstrate success at his or her own pace. And with different methodologies available based on their preferences, the learning experience of "courses" will be much more individualized. Granted, there will always be a need to understand processes and procedures in a standardized fashion (thinking

about medical training, for example), but for many other topics, content, and skill development areas, the future will be highly differentiated thanks to these new technologies.

And as jobs themselves become more specialized, so too will the role of those smart recommendation engines be for the ongoing learning and development of individuals in many different fields. Consider radiology: there are already nearly a dozen subspecialties in this field, each with its own evolving set of technologies, procedures, and protocols. It is not far-fetched to imagine much of this work being performed by machines, with interpretation of results informed by an AI entity that quickly compares vast data sources to the very specific profile of the patient in question to produce a potentially greater accuracy in assessments. The jobs of the future may well be in the specialization of AI and data analytics for radiology, along with innovation in technologies that perform the various tests. Will this mean fewer lab coats? More data engineers?

From the side of learning administration and credentialing, there is likely to be a shift to the use of artificially intelligent systems that recommend courses and modules based on preparatory testing and/or learner habits and expressed interests. This will be a more widespread application of what we are currently experiencing as "recommendation engines." I can easily imagine these recommendation engines having a presence like Amazon's Alexa or Apple's Siri, speaking and interacting with the learner to further personalize the experience.

This shift is going to happen either by design or by default. As individuals gain access to greater resources online, tracking of completion of various coursework and qualifications may no longer reside in formal institutions, but in individually held, publicly recognized repositories. This is where blockchain technology and learning record management will become services that individuals and institutions depend on and subscribe to, and that provide continuity of verified learning from academics and expert systems, from formal educational processes through ongoing, employment-based and job-specific development. The learner will control her credentials and "own" them – we may actually see the waning of the diploma as the ultimate credential and the waxing of the badged portfolio of learning and work experience, secured and verified through blockchain-powered services.

We may see an expansion of individual contractor teaching staff, who depend on these independent systems to track their own reviews, ratings, and qualifications, and who rely on more technologies to deliver live and recorded learning lessons, experiences, and coaching. We already have services such as Teachable and Thinkific that are turn-key solutions for individual instructors and educational service providers. Other content and teaching aggregation services such as Gooru and Khan Academy will likely expand and diversify, offering more and more vetted, well-designed content and services to individuals and institutions of learning.

And even if not an individual contractor, the classroom of this future may be a much more blended environment, including more distributed students real time, in a highly interactive, collaborative, and data-rich setting. Virtual and augmented reality technologies will become commonplace as tools for connecting and interacting. New display technologies; expanding distribution of high-speed

networks; and better, smaller, faster cameras could revolutionize "being there" – as virtual field trips place students in the moment, creating new immersive learning experiences.

Another potential future shows the rise of platforms such as LinkedIn as career managers. What we already have seen is the purchase of Lynda.com by LinkedIn, and the service is following the "freemium" approach to offer paid assistance in being the Match.com of careers. I can see additional potential here, as LinkedIn or other platforms continue to acquire content, knowledge, education, and career management services. Marrying this idea with the aforementioned need for independent and validated housing of learning records, I can easily imagine LinkedIn (or something similar) becoming the one-stop shop for learning from grade school through late-stage careers.

From a topical level, science, technology, engineering, and mathematics (STEM) has been the focus for the early part of the 21st century, owing to the growing need for students and workers with skills in these areas to become the authors of computer code, developers of apps and hardware, and managers of data. With the expansion and eventual standardization of artificial intelligence communication (much like xAPI in recent years), systems will become self maintaining, and many of those jobs that required hard technical skills will begin to go away.

I foresee a time when a return to human sciences occurs, especially as the operational side of human existence becomes more automated and deeper philosophical and ethical questions emerge. We are already seeing the beginning of this with the move to extend general data protection regulations to preserve individuals' privacy and agency over data shared across networks and devices. Deep and shared understanding of human factors, ethics, history, social constructs, and so on will be in great demand as technologies expand in reach and potentially threaten our ability to understand and empathize with others, leading to what Sherry Turkle (2011) describes as a situation of being "alone, together."

Public policy will need to evolve in sync with new technologies, bearing in mind the greater good and supporting not just a nation-state level of health and well-being, but also a global and integrated perspective that reflects the interconnectedness of economies, access to core services, digital trade flows, and of course education and skill development. Internet service providers may continue to challenge net neutrality, and if they win, we may be in for a further bifurcated world of haves and have-nots, and this will have a direct impact on the quality and availability of education. We may also see advanced applications of bio-hacking, embedding technologies that are designed to monitor, send, and receive data connected to learning and performance. This will open up its own set of concerns as we think about health factors, data privacy, and related issues.

And while all this is going on, learning science will advance, and organizations will further increase their focus on connecting learning to performance, spawning an increase in the number of digital tools available to bridge the knowledge to application gap. We have already seen the development of learning platforms designed to create this bridge. Those platforms, in the future, will be augmented

with all manner of data capture and reporting mechanisms, owing to the Internet of Things and the eventual shakeout of standards for interoperability. And, while content and platforms will expand to meet a growing opportunity for online, ubiquitous learning and development, a premium will be placed on the creation of immersive learning experiences. What we postulated as a possible future in our work in virtual worlds ten years ago will become a vivid reality, accessible through lightweight, multisensory virtual reality gear. We can easily imagine a version of Ernest Cline's (2011) Ludus from *Ready Player One* – a virtual galaxy of three-dimensional locations where simulations of all forms are developed and experienced.

## 3 Conclusion

Education as a public good sits squarely in the intersection of digital innovation and economic and social policy. We cannot consider the design, development, and implementation of new technologies in educational settings without also considering factors relating to equal access and quality assurance. The current ongoing debate and legislation related to privatization of education is critically important to this: The World Economic Forum has stated that education is a human right (Brende, 2015), and if we are to meet the needs of the millions of learners globally, young and old, we will need to advocate for policies that ensure access for all to the many benefits of digital transformation.

## Conflict of interest

To the writer's knowledge, there are no conflicts of interest of the writer with regard to any of the subject matter above. It is solely of the writer's views and interpretations of source materials and direct experience. At the time of this work, the writer was employed by Align Technology, but was not under any compensatory contract with any of the data sources mentioned.

## Notes

1 K–12 = kindergarten to 12th grade. That is, primary and secondary free education for publicly supported school from kindergarten all the way up to 12th grade.
2 This is a highly politicized debate in the United States, and the attempts to garner public comment on the issue were stymied by hacking. Fifty-seven percent of comments submitted to the Federal Communications Commission, through online forms, were made from duplicate or temporary email addresses.

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