1 Developing an Understanding of the Impact of Digital Technologies on Teaching and Learning in an Ever-Changing Landscape

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Abstract

In this introduction chapter, we reflect on the contributions of research in the field of digital technologies in education during the last decade (2008–2018). The guiding questions leading these reflections are (1) what progress in understanding the role and impact of digital technologies in education has been made? and

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(2) what emerging themes can be observed that warrant further study? Overall, the progress made in the last decade is promising, and new research themes have emerged. This chapter highlights selected findings and issues that serve as exemplars for those addressed throughout the 2018 *handbook*, within the thematic strands that served as the blueprint for the reference work itself. Whenever possible, brief comparisons and contrasts are made to the evolutions over the past decade, since the first edition of the *handbook* was published.

Keywords
Information technology · Teaching and learning · Leadership · Curriculum · Emerging technologies · Assessment · Research methodologies

Introduction

"There is a wealth of research on information technology (IT) in primary and secondary education. Yet most of it is scattered and a synthesis of the research from a broad international perspective is needed" (Voogt and Knezek 2008, p. xxix). This was the main rationale for the *International Handbook of Information Technology in Primary and Secondary Education*, which was published in 2008. At the dawn of the publication of the second edition of the *International Handbook of Information Technology in Primary and Secondary Education*, we realize that most sections of the *handbook* have substantially changed since the first edition.

The design and impact of technology-supported learning environments focusing on the student learner remain a major focus of the second edition. This line of research studies how learners, learning processes, and learning environments and their interactions change in a digitalized world. An equally important theme deals with the uptake of IT in educational practice. Research topics about the uptake of IT in education are considered from several perspectives: the curriculum, the teacher, the school leadership, the assessment, and the educational policy, while taking into account interdependencies. Equity is an important theme within research on IT in education and therefore deserves specific attention. Finally, valuing existing and evolving research paradigms and methodologies is needed to contribute to a better understanding of how technologies impact teaching and learning.

Since the publication of the first edition of the *handbook,* various terms on the use of digital technologies in education have been used, such as eLearning and mLearning. For pragmatic reasons we will stick with the term information technology (IT) as we did in the first *handbook*. In some chapters authors use the term information and communication technology (ICT) instead of information technology, because it better reflects the discourse in the addressed context.

In this introduction chapter, we reflect on the contributions of research in the field of digital technologies in education during the last decade (2008–2018). The guiding questions leading these reflections are (1) what progress in understanding digital technologies in education has been made? and (2) what emerging themes can be observed that warrant further study?

Overall, the progress made in the last decade is promising, and new research themes have emerged. This chapter highlights selected findings and issues that serve as exemplars for those addressed throughout the 2018 *handbook*, within the thematic strands that served as the blueprint for the reference work itself. Whenever possible, brief comparisons and contrasts are made to the evolutions over the past decade, since the first edition of the *handbook* was published.

Technology and Learners

Compared to the first edition of the *handbook*, there has been a stronger emphasis on the influence of digital technologies on learners instead of learning processes and learning outcomes in this second edition. Overall access to digital technologies by students, at least in the economically more advanced countries, is no longer a major barrier. We recognize that the importance of emotions, motivation, creativity, grit, and other non-cognitive variables related to attitudes toward teaching and learning with digital technologies has increased. Likewise, recognition of the importance of understanding the process of acquiring different kinds of competencies needed to be productive in a modern society (e.g., communication, confidence, collaboration) related to IT in education – rather than simply focusing on the end-goal performance of a mastered IT skill – has become universal.

By using networking technologies to support students working in learning communities, it is critical that students develop knowledge creating capabilities and the skills for knowledge innovation. Online learning communities should be designed not just for information sharing but should support an effective and student-centered way of learning.

Over the past decade, the use of digital technologies and applications has continued to increase, particularly the use of social media. However, research in social media is beginning to recognize that to be successfully engaged in this participatory culture, the learners need to acquire a new form of literacy and deal with cultural and social issues. Also, there is increasing recognition that how social media can be effectively used in the formal school context should be rigorously researched.

Research now clearly shows that digital technologies can support students to engage collaboratively to become innovative and creative learners. These technologies can support the creation of new knowledge and the development of new skills (Ito et al. 2013; Scardamalia and Bereiter 2015). It is still the case, however, that many young people use new technologies only to consume information.

With this focus on the learner, rather than simply the learning outcomes, there are also some alarming issues related to the use of technologies., Negative issues include privacy issues and the lack of attention to the overall well-being (psychological and emotional) of the learners. There are also health and safety issues due to the increase of cyberbullying.

Technology to Support the Learning Process

While the specific impact of digital technologies on students' learning is difficult to demonstrate, some recent meta-analyses of the literature show higher effect sizes for students' learning performance (cognitive, affective, and social skills) when student are learning with digital technologies than without digital technologies (▶ Chap. 75, "Meta-analyses of Large Scale Datasets: A Tool for Assessing the Impact of Information and Communication Technology in Education" by Liao and Lai). These meta-analyses include a broader variety of technologies (including games and mobile learning) than the earlier meta-analyses – and higher effect sizes were found. However, the mechanisms that account for these findings cannot easily be identified.

While technologies are constantly changing, the education field has been trying to choose those that will best support and enhance learning. Games, simulations, and immersive environments are able to provide a great deal of data that can be evaluated for learning but has only been harnessed for feedback in select environments. The next decade should see the large sets of data that are unobtrusively collected become useful for targeting learning needs in near real time.

Since the first edition of the *handbook*, mobile technologies have become ubiquitous. The education field has been working to find ways to harness the power of one-to-one learning with mobile devices. Over the past decade, the smartphone has become a pervasive device that is used by two-thirds of the world's population. Over the past 10 years, mobile devices have gone from supplemental to mainstream for twenty-first century learning in many classrooms.

Also in the last decade, we saw the emergence of new pedagogies such as flipped learning and the use of advanced digital technologies to support distance and flexible learning. There has been huge growth of virtual schools in the USA, but the growth in other countries was primarily in online learning, to support face-to-face learning. Since online learning has been widely practiced in schools, we see the beginning of a reconceptualization of distance learning, with a shift from being on the edge of the educational landscape to the center stage, and fast becoming mainstream, particularly in the USA (Naidu 2016). Supported by Open Education Resources and Massive Online Open Courses, in the last decade, open learning has advanced beyond higher education, into the primary and secondary sectors, and we see examples of learning environments being developed that facilitate open access to content with more open pedagogies. There is also recognition of the importance of designing flexible learning environments to support personalized learning.

There is modest advancement in pedagogy for how to support students to become innovative and creative. In terms of learning theories, social constructivism is still the dominant learning theory underpinning innovative use of technology-enhanced learning. Once considered promising, there has not been much development of connectivism in recent years.

Rapid advances in neuroscience research investigate how neural activities affect learning by using digital technologies such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). A new discipline called educational

neuroscience (Bowers 2016) has been developed aiming to gain a better understanding of how the biology of learning can be used to support classroom practice and specifically in designing technology-enhanced learning (Howard-Jones et al. 2015). The advance of educational neuroscience has been slow, and there are many misconceptions as to how neuroscience research can illuminate learning sciences research. For example, it is not clear how and why immersing in digital technologies may reorganize and restructure the brain to enhance learning (Prensky 2009). There has also been increasing popularity of computer-based brain training software. However, to date it is not clear how or in what way these computer-based training programs can help the learner (Kroeger et al. 2012). Research in educational neuroscience has not advanced to the stage where research findings can be readily translated into practice (Howard-Jones et al. 2015).

Connecting In and Out of School Learning

The notion that learning is a lifelong process which extends beyond schooling and the school curriculum highlights the importance of informal learning and personalization of the curriculum. In the last decade, teachers began to recognize the importance of personal learning experiences taking place in everyday life and the involvement of other actors (e.g., the family and the wider community) in supporting students' informal learning. It is now considered pertinent to align students' experiences in school with their day-to-day digital practices in order to support identity and agency building. However, how formal and informal learning can be effectively connected remains a key research issue.

The maker movement is fast growing as an informal learning environment outside the school context (Peppler and Bender 2013), supporting participants to work on collaborative projects of personal interest but having connections to formal knowledge. Cultural clashes (▶ Chap. 14, "Bridging Formal and Informal Learning Through Technology in the Twenty-First Century: Issues and Challenges" by Lewin and Charania) between formal and informal learning are still unresolved. Mobile technologies provide affordances of informal learning and the opportunities to connect informal learning with formal learning. However, there has been slow advancement of how this can be effectively done. For now, it appears that learners will continue to advance most rapidly through mobile learning in the informal realm (▶ Chap. 53, "Section introduction: Mobile learning" by Norris and Soloway).

Teachers

We recognize that using digital technologies to foster twenty-first century skills such as critical analysis of information and collaboration with peers is often more important than using digital technologies to help students memorize facts. We have moved from standardized paper and pencil tests for teachers to show performance, in recognition that how much teacher knows must be equally important with how well they can

foster student learning. Instruments to measure teacher development can best be described as a battery of developmental appraisals rather than a single test.

There are issues of what teachers need to learn about digital technologies and the application of IT in supporting learning in the twenty-first century, since most teachers continue to use IT primarily to support content delivery rather than to engage students in creative activities. Recent research highlights the need for teachers to develop technological knowledge and technical skills, in addition to pedagogical and content knowledge.

However, research has shown that tacit qualities of the teacher (e.g., self-efficacy, positive attitudes, beliefs) are also important to develop, which are, beyond observed teaching performances and mastery of content knowledge or theories of teaching and learning. The instructional strategies teachers use in the classroom are evolving due to the influences and influx of digital technologies. In the case of technology integration, it is important to consider the level of confidence teachers have in the instructional use of technologies to enhance student learning.

How to support teachers in a technology-enhanced environment remains a key issue. This support involves a reconsideration of the role of the teacher, in terms of their agency, and their role in bridging formal and informal learning, with a growing importance of the latter. This is about empowering teachers to exercise agency. It has been suggested that a way of enhancing teacher agency is to engage them in collaborative pedagogical inquiry (▶ Chap. 25, "Information and Communication Technology and Education: Meaningful Change Through Teacher Agency" by Albion and Tondeur). Also, as one of the most important factors affecting student learning, there has been increasing recognition that research should be conducted to clarify the knowledge base of the teacher.

School Leadership

Teacher readiness for technology integration, although important, also depends on a school's readiness to support the use of digital technologies in teaching and learning (Petko et al. 2018). The role of school leadership therefore is important for fostering teachers' use of technology in daily teaching and learning processes.

We now know more about the benefits of a school-level perspective to technology integration, including leaders' roles in IT integration. Research has provided evidence that by adopting a distributed leadership perspective, the main functions of leading technology innovations, including developing vision, supporting integration, and ensuring the accountability of technology initiatives in terms of ownership and outcomes, can be framed.

The distributed leadership perspective and some key functions for IT leaders are still considered important to promote IT further in schools, but there is now a more fine-grained emphasis on practices – *how* leaders do their work. Research-based strategic interventions have been developed for leaders to coordinate actions across their schools so that multiple leaders' areas of expertise are used to facilitate and support teachers in using IT in classrooms. Thus, a shift can be observed from an

emphasis on instrumental actions of leaders from an accountability perspective, toward transformative and instructional leadership actions aiming to change the culture in schools regarding teachers' collaborative learning to fuel the design and enactment of IT in classrooms.

Curriculum and Assessment Challenges

In the first edition of the *handbook*, the focus of IT in the curriculum emphasized on the use of digital technologies to enhance the learning of traditional subjects as well as the use of digital technologies in cross-curricular themes. However in the last decade, we have witnessed a renewed discourse on the question of what should be taught in the twenty-first century society – which is the classical curriculum question (e.g., OECD 2018). Because of technological advancements and their implications for living, learning, and working, many countries and states worldwide are now redesigning their curricula. In the process of curriculum redesign, the need to pay attention to the knowledge, skills, attitudes, and values, often referred as the twenty-first century competencies, is recognized, as they are important in a global and digitalized society. Technology is seen as a driver of change as well as a tool to develop twenty-first century competencies. Emerging domains are important in the twenty-first century such as the development of new literacies, the notion of digital citizenship, and the importance of computational thinking as an integral part of digital literacy. These new domains are theoretically conceptualized and discussed in the *handbook*. However, empirical research evidence on these new domains is still scarce and further study is needed.

While curriculum deals with what needs to be learned, assessment is about what has been learned. Technology-based assessment is a dynamic field that has been advancing rapidly with growth set to accelerate with emerging opportunities for automatic data collection as well as increased possibilities of communication and interaction mediated by IT. In order to continue moving forward in a constructive manner for education, assessment discourse needs to involve designers, teachers, and learners working together to support twenty-first century curricula and pedagogies. This shared vision among stakeholders allows that data can be collected and represented to enable learners and teachers to identify achievements, collate evidence of achievements, diagnose needs – both cognitive and affective – and decide on suitable pedagogical approaches for enabling the next steps in learning.

IT Policies

Moonen (2008) concluded in the first edition of the *handbook*, in his review of IT policies of different regions of the world, that in the developed regions the emphasis had shifted from a concern about the IT infrastructure to the incorporation of IT into the teaching and learning process. As a result IT policies in education

were no longer explicit but had become implicit in the educational policy in many countries. However, a decade later the opposite seems to be true. Many countries are now renewing their IT policies in education. Current policy developments result in the inclusion of a computing (computer science) curriculum in schools (Fluck et al. 2016). However, in practice, there is little evidence to show that digital technologies have been used in a creative way globally.

Eickelmann (▶ Chap. 81, "Cross-National Policies on Information and Communication Technology in Primary and Secondary Schools: An International Perspective") observes that in the last decade while variability of IT policies across regions was the norm, some commonalities as follows could be identified:

- Developing ICT infrastructures that reflect pedagogical aims, especially the fostering of one-to-one and BYOD ("bring your own device") concepts, often in combination with personalized learning
- Focusing on access, equity, and participation
- Reaching all students and improving teacher training
- Bridging and linking formal and informal learning
- Integrating the aims of (subject-specific) learning with ICT with more general education goals such as creating a skilled workforce for the twenty-first century
- Introducing new topics (e.g., computational thinking) and modernizing curricula
- Pointing to new potentials such as those afforded by new forms of online learning and online assessment as well as to risks and more critical issues like data privacy

These common aspects in IT policy show that the high expectations at the turn of the century that IT would transform education seem to have now changed toward the more realistic opportunities IT may offer to solve some prominent challenges in the digital society. For IT in primary and secondary education, the challenge is to transfer the plans and core ideas of IT policies into practice, because realization of developing school systems in the digital age is still pending and not automatically assured by simply having policies. Having a vision and shared aims captured in IT policies is indispensable and especially valuable when they do not only outline goals but also give direction on how goals can be translated into practice and how supportive conditions can be facilitated.

The focus on access, equity, and participation is a common concern of IT policies globally. The evolving nature of digital equity is a complex topic, and depending on the point of view, there is both an increase and a decrease in digital equity. Regarding digital equity for learning with technology, there have been attempts to close the gap or bridge the divide regarding gender, race, social class, learning disabilities, etc. However, the focus is not on the amount of access that students have but on technology as a potential agent for social inclusion and strategies in moving toward digital equity for classroom teachers.

Research

From a superficial point of view, the time consuming and slow research process often do not seem to align with the rapid development of technologies and their potential for teaching and learning. However, research that helps to understand why specific technologies work and under which conditions might better predict the potential and issues of new technologies for improving student learning. For this reason we think it is important to review the history of educational IT research to better understand the issues at stake.

One important issue that remains essential in educational IT research is acknowledging the importance of context in which IT applications are used to foster teaching and learning. Unraveling the context is seen as a challenge for educational IT research. It requires researchers to think of research methods as being complementary to each other instead of hierarchical. Thus in addition to a clear theoretical basis guiding research on IT in education, deliberately making use of the diversity of research methods may help to better understand not only if specific technology interventions have impact but also why the outcome is realized. Even stronger than in the 2008 handbook, there is a call for further integration of research paradigms and of quantitative and qualitative research designs.

Since 2008, the technology landscape has tremendously changed. IT has now become a ubiquitous aspect of life. Many IT tools can be used for learning purposes, but they are typically not designed with student learning in mind. In addition, technology potentially can create learning environments everywhere, including outside the traditional education systems. However, how best to make use of technology to foster student development (including their well-being) yet mitigating its threats is a challenge for the design and evaluation of IT tools which requires close collaboration of researchers with key stakeholders. Much progress in understanding the evolving role of digital technologies in education has been made, but much that is unknown still remains regarding the impact of digital technologies on teaching and learning in an ever-changing landscape.

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