Digital Expectations and Experiences in Education

Eyvind Elstad (Ed.)

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INTRODUCTION

For more than three decades, researchers, policy makers and educationalists have all harboured great expectations towards the use of technology in schools. This belief has received a hard knock after an OECD 2015-report has shown that computers do not improve pupil results: Investing heavily in school computers and classroom technology does not improve pupils' performance, and frequent use of computers in schools is more likely to be associated with lower results. Educational technology has raised false expectations. The prevailing view of educational technology has shifted. Nevertheless, hardly anyone wishes for a situation in which pupils do not use technology in the service of learning: education is supposed to prepare for the future, and it is evident that technology is one of the answers to the challenges of the future. Many school professionals, however, feel uncertain how schools should tackle challenges relating to the distractions that hamper in-depth learning, easy cut-and-paste solutions and online offensiveness that occur while pupils are at school. The initiative to provide a tablet or PC for each pupil is continuing despite a lack of evidence that it is beneficial to learning. School professionals and policy makers are seeking answers to the question of how schools ought to relate to challenges created by the use of technology in the school. The book is an attempt to raise questions and start a debate. The book presents new research relevant to a better understanding of the challenges and opportunities inherent in educational technology and strategies are discussed in relation to handling these challenges. Rather than presenting ready solutions, the book attempts to provoke debate and to contribute to a firmer grasp on reality. The articles in this volume offer an up-to-date discussion. In tackling the critical issues created by technology, this book provides an important resource for student teachers, teachers, education scholars and those interested in a critical examination of digital expectations and experiences in school education. The authors do not present a common front on the complex question of the proper use of information and communication technology in the school but instead present a diversity of arguments and viewpoints.

A main justification of this book is a turn of ICT appreciation: educational technology has raised false hopes. Computers do not improve pupil results: PISA results show no appreciable improvements in pupils' attainment in reading literacy, mathematics literacy and science literacy in countries that have invested heavily in ICT for education (OECD, 2015). This OECD study shows that there is no single country in which the internet is used frequently at school by a majority of students and

where students' performance improved (2015). Frequent use of computers in schools is more likely to be associated with lower results! Pupils who use ICT moderately at school have better learning results than pupils who use ICT very frequently (and of course better than pupils who use ICT rarely). The top-performing countries in digital reading and navigation skills are very cautious about using technology in their classrooms. What are the consequenes of this study? This book is an attempt to explicate, illustrate, and critically examine the digital expectations and experiences.

The demise of traditional schooling has often been predicted based on the assumption that media-related developments will explode it apart and revolutionise thinking about education. The 21st-century student has experienced the shift from the world of writing and the book to the world of images and the screen. Political expectations for the modernisation of schooling through the use of information and communication technology and the allocation of funds in accordance with politically created agendas have led to perceived pressure on school staff to employ information and communication technology as a teaching aid. Many schools are consumed by a race in which they haphazardly adopt the latest technological gadgets, but many teachers do not understand how to incorporate these devices into existing instructional methods.

Books dealing with the use of information and communication technology (sometimes abbreviated ICT) in the school have been published over the years. Is there any need for a new book on this phenomenon? The articles in this volume offer an up-to-date discussion on the challenges of technology use in school education. In tackling the critical issues created by technology, this book provides an important resource for student teachers, teachers, education scholars and those interested in a critical examination of digital expectations and experiences

This book publishes results from a new research project funded by the Norwegian Research Council[1] entitled Learning in the 21st century: Capitalising on students' digital strengths; compensating for desired capabilities. This research project produces research and knowledge relevant to student teachers, teachers, school leaders, researchers and other individuals with an interest in the use of information and communication technology in school. The book is thus aimed at the academic world and the teaching field and at policy-makers and other socially minded individuals.

Dissenting Opinions on Technology Use in Schools

From time to time, heated debates regarding the use of information and communication technology in the school arise among parents, politicians and educators. This is as it should be in a democracy. Powerful commercial interests promote the idea of I-pads or tablets for all pupils and smart boards in all classrooms. Most people have strong views on information and communication technology, and many feel qualified to express these views. The purpose of this collection of articles is to present research relevant to understanding of and debates on information and communication technology in the school. I have asked leading educational researchers to shed light

on different aspects of this topic. The authors do not present a common front on the complex question of the proper use of information and communication technology in the school but instead present a wide diversity of arguments and viewpoints. Authors are responsible only for the content of their own chapter, but all the articles are based on the academic principles of objectivity, restraint and investigative factuality. It is my belief that these qualities will improve the debate regarding the educational technology in schools.

Differing opinions regarding the use of information and communication technology in the school abound: should it be introduced in small steps or great leaps? Does increased use of information and communication technology, in fact, lead to educational improvements? What implications does the use of technology within and outside the school have for the in-depth learning necessary to understand the material in core academic subjects? Are all forms of educational renewal based on information and communication technology beneficial? These are a few amongst many questions. Those who work in the school system—teachers and school leaders—have differences of opinion on these and many other issues. There also appear to be generational gaps in teachers' views of using information and communication technology in teaching (Elstad, 2006). Generational differences, however, stand as only one of several different contributory factors. More knowledge of teachers' attitudes towards the potential use of information and communication technology in the school is needed.

It is tempting to believe that research can determine once and for all whether information and communication technology promotes better learning. Sadly, this is not the case as that general question is dependent on a large number of factors. By asking more specific questions, though, research can provide some insights into how information and communication technology can either serve as tools for better and smarter learning or stifle learning. Normative questions about the nature of future schooling depend on what values that, at the most fundamental level, we wish to promote. In considering this kind of question, researchers are on equal footing with other citizens in determining what constitutes a good school. It is my hope, however, that the interested reader will find in this book a better foundation for understanding the potential uses and pitfalls of using information and communication technology in the school.

NOTE

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PART I

EDUCATIONAL TECHNOLOGY BEYOND LEARNING

EYVIND ELSTAD

1. EDUCATIONAL TECHNOLOGY – EXPECTATIONS AND EXPERIENCES

An Introductory Overview

THE PURPOSE

In this chapter, I provide a general introduction that, I hope, will help the reader see the more particular contributions in a broader perspective. The purpose of this chapter is to provide an overview of the core topics and issues addressed in the book and to reflect more deeply on digital expectations and experiences in schools.

TECHNOLOGY-DRIVEN PROCESS OF CHANGE

A great technology-driven process of change is at work in today's world. Information and communication technology is transforming many day-to-day activities, even in the workplace. Technology is replacing manual labour and transforming the nature of work, and employees might lose the race against the machines. Work life has become more technologically intensive (Wajcman, 2008), and for those with know-how, the threshold to the world of technology has been lowered: it now takes only days for the technologically competent to master new computer programmes and new technological solutions (Cuban, 2009). Individuals who have a low level of education or did not complete secondary education have a greater chance of being left behind by technology-driven developments in the workplace than their more highly educated counterparts (Heckman, Stixrud, & Urzua, 2006).

We can reasonably maintain that schooling and higher education result in robustness and skill in dealing with change. The general formational effect of education provides the requisite cognitive qualities for understanding (*Bildung*) and dealing with social changes, including in the field of technology (Blankertz, 1969). The question of information and communication technology in school, therefore, touches upon the core tasks of education. This is the explicit theme of Chapter 2. Biesta argues that connecting the question of information and communication technology to that of school education raises questions about the aims of schooling, the content of schooling (the curriculum, in the restricted sense of the word) and the forms of schooling (pedagogy or didactics).

E. Elstad (Ed.), Digital Expectations and Experiences in Education, 3–28.

THE SCHOOL IN THE DIGITAL AGE

The quality of education has powerful economic effects, and economic growth is strongly affected by the skills of workers (Hanushek & Wössmann, 2010: 251). What people know matters. Education's most important tasks include lay the foundation for their future roles as employees (Hanushek, 1979; Todd & Wolpin, 2003), citizens (Lochner, 2011; Westheimer & Kahne, 2004) and users of digital technology. In addition to transmitting knowledge (Cuhna & Heckman, 2007), school acts as a sorting machine: firms infer worker's ability from their education (asymmetrical information), and students choose an education level to signal their ability to potential employers. Schools determine which individuals will advance to which studies in higher education (Burgess, McConnell, Propper, & Wilson, 2007), while education also indicates students' qualifications to potential employers (Spence, 1973). This arrangement is functional due to asymmetrical information: education acts as a signaling, or screening, device for unobservable ability. However, this process touches upon deeper issues of the values in education. Biesta emphasises that school education is orientated towards three purposes: qualifications, or engagement with knowledge, skills and dispositions; socialisation, or engagement with traditions and ways of being; and subjectification, or engagement with the question of the person as a subject of action and responsibility. These three purposes are explored further in Chapter 2.

It has been suggested that the way the school system is operated is the result of industrial society's need for instrumental skills[1] (symbolised by the three Rs, a widely used abbreviation for the basic elements of the primary school curriculum: reading, writing and arithmetic) and that the school system should be reformed to accommodate society's need for more specialised skills that require deeper insights to meet future unexpected challenges (Schleicher, 2015). The development of PISA tests reflects this endeavour. The OECD first administered the PISA in 2000 as an in-depth test of reading literacy skills (defined as understanding, using, reflecting on, and engaging with written texts), but the tests have evolved into an assessment of complex competencies: '(1) establishing and maintaining shared understanding; (2) taking appropriate actions to solve problems; and (3) establishing and maintaining team organisation' (Schleicher, 2015, p. 18). The demands on modern education systems are changing fast, and international assessments must evolve in response. For instance, a priority in the forthcoming PISA 2018 is the assessment of global competence, defined as 'the capability and disposition to act and interact appropriately and effectively, both individually and collaboratively, when participating in an interconnected, interdependent and diverse world' (Schleicher, 2015: 18). The PISA assesses four dimensions of global competence: (1) communication and relationship management; (2) knowledge of and interest in global developments, challenges and trends; (3) openness and flexibility; and (4) emotional strength and resilience. The PISA is designed to capture some of the broad cognitive, social and emotional

competencies emerging in a world of increasing migration and international exchange.

MASTERING TECHNOLOGY IN KNOWLEDGE- AND SERVICE-BASED ECONOMIES

In the knowledge- and service-based economies of Europe, businesses are becoming increasingly dependent on a highly qualified workforce, and European countries need to justify high salaries and generous welfare systems by achieving high productivity (Krugman, 1994; Audretsch & Welfens, 2013). The low productivity in many European countries, then, is a critical challenge. High skill levels are a key resource for sustainable, technology-intensive production, and the school system needs to lay a foundation for these skills. Mastering technology is a significant factor in employees' ability to govern the direction of their career and work life.

Social life outside the workplace is also undergoing change. An individual's social capital (Coleman, 1988; Putnam, 2001), manifested concretely in web friends and numbers of likes and dislikes, is increasingly significant in individuals' self-worth, self-esteem and ability to take action and perceive opportunities to take control of their lives (Gerlitz & Helmond, 2013). At the moment, social capital is built through apps called Uber, Airbnb and so on; tomorrow, such innovations will be called something else (Gardner & Davies, 2013). An app is a computer program designed to run on smartphones and tablet computers. These devices are often sold with several apps bundled as pre-installed software (calendar, mapping program et cetera) and an app for buying music or other media. The user of an app can see how previous users rated a driver or a landlord, who, in turn, can see how other drivers and landlords have rated the passenger and the tenant. Consequently, the individual's ability to build social capital is important in a digitalised world (Ahn, 2012). These interactions are examples of the workings of the new globalised capitalism (Hill & Kumar, 2012) and its penetration into life both in today's society and in what we can glimpse of tomorrow's society. Mastering technology is an important factor in our ability to govern the direction of our lives as citizens.

The increased interaction between buyer and seller enabled by information and communication technology has parallels in the use of media by youth. Social networks created by means of digital technology play an ever-greater role in the accumulation of social capital and perhaps in the formation of self-image, self-esteem and mental development (Chen, 2013). This increasingly dominant role of technology, especially social networking sites, in the lives of young people (Shen, Liu, & Wang, 2013) is the theme of Petter Bae Brandtzæg's chapter (Chapter 8). Youth are active Internet users and spend much of their free time on social media and computer games (Hellström et al., 2012). Some studies have found that computer games can be used as effective, motivational learning environments (e.g. Papastergiou, 2009). A surprising finding is that out-of-school gaming helped boys in vocational

studies improve their English reading skills (Brevik, 2016). The once-sharp divide between school and leisure time is eroding. There remain several crucial questions: Will and how can the school as an institution relate to this comprehensive process of change known as the digital revolution (Vavik & Salomon, 2015)? How can the school build a bridge between the world of youth and the world of school to enable students to learn in a new digital age? What are the good examples of bridging? These questions are addressed in a twin book named *Educational technology and polycontextual bridging*.

A NEVER ENDING STORY: THE GULF BETWEEN THE WORLD OF YOUTH AND THE WORLD OF THE SCHOOL

A well-known quotation from Aristophanes (often misattributed to Socrates) complains:

> Our youth now love luxury. They have bad manners, contempt for authority; they show disrespect for their elders and love chatter in place of exercise; they no longer rise when elders enter the room; they contradict their parents, chatter before company; gobble up their food and tyrannise their teachers.

This quotation shows that the gulf between the interests of children or young people and the interests of the adult life for which school should prepare them existed 2500 years ago. Is the gulf between the world of youth and the world of the school as great in today's digitalised society, or has it become even greater?

PREPARING 21ST-CENTURY PUPILS FOR A GLOBAL SOCIETY

It must also be acknowledged that the diversity, complexity and rate of social change are growing quickly in the knowledge- and service-based economies of Europe. The school needs to lay a foundation on which pupils can build the knowledge, skills and attitudes needed in tomorrow's European society. In the 21st century, important skills are both subject specific and universal: the ability to learn, communicate, collaborate, participate, explore and create. These skills are often referred to with the term the 4 Cs: (1) critical thinking and problem solving; (2) communication; (3) collaboration; and (4) creativity and innovation (NEA, 2015). Subject-specific skills are necessary but insufficient by themselves. To this list of important skills, we could add the ability to persuade other people, to negotiate, to cooperate—tasks which demand both social and emotional skills. Deming (2015) has demonstrated the growing importance of social skills in the labour market: employment opportunities and wage increases in the United States are greatest in jobs that draw on social skills and reasoning ability. That replacement of manual labour by technology is presented as further evidence of the increasing importance of social skills: 'while computers perform cognitive tasks of rapidly increasing complexity, simple human interaction has proven difficult to automate' (Deming, 2015, p. 1).

It is proposed that incorporating the technological innovations of which young people are major users can contribute to the necessary transformation into a school system adapted for the future. Research shows that young people have digital capabilities; some researchers regard youth as digital natives, in contrast to teachers who are disrespectfully described as digital slow-coaches (Elstad, 2006) or digital immigrants (Prensky, 2000).

GENDERED DIFFERENCES IN PUPILS' ATTAINMENT

Hærnes, Markussen and Røed (2016) investigate developmental effects of commercial television exposure during childhood and found that higher exposure to commercial television reduces cognitive ability and high school graduation rates for young men, but not young women. The effects are largest for exposure during pre-school and elementary school age. This finding suggests that availability of non-educational media content is a factor in the widening educational gender gap. A plausible explanation is that television-watching crowds out reading more for boys than girls.

Fraillon, Ainley, Schulz, Friedman and Gebhardt (2014) conceptualise information and communication technology literacy in two major dimensions: (1) collecting and managing information; and (2) producing and exchanging information. Collecting and managing information consists of knowing about and understanding computer use and accessing, evaluating and managing information. Producing and exchanging information entails transforming, creating, sharing, and using information safely and securely. Throndsen and Hatlevik (Chapter 13) use this conceptualisation of ICT literacy to explore gender differences among Norwegian pupils and find clear trends: girls achieve higher levels of information and communication technology literacy than boys. This gendered difference is not surprising as globally, adolescent girls demonstrate better reading comprehension and literacy than adolescent boys (OECD, 2013). Boys, for their part, outperform girls in maths and science in nearly all countries. However, in Scandinavian countries, gender differences in science and maths are very small, and Swedish girls out-perform boys even in maths. Swedish schools encourage pupils to exhibit a high degree of self-determination, which reinforces independence, and girls generally have stronger self-discipline for school work than boys (Duckworth & Seligman, 2006). Therefore, the strong self-discipline of girls within this school system which heavily emphases autonomous decision making might explain why Sweden lies so far from the norm in the relative maths performance of boys and girls.

CAPITALISING ON STUDENTS' DIGITAL STRENGTHS AND COMPENSATING FOR DESIRED CAPABILITIES

A core challenge is how schools can make use of these digital strengths as part of efforts to improve education. Frequent use of information and communication

technology can create distractions amongst learners and lead both to off-task behaviour that hinders learning (Fried, 2008) and to the so-called butterfly defect, which refers to young people's tendency to jumping from place to place in their extra-curricular Internet use (Salomon & Almog, 1998). Wisdom, however, is not to be found by roller-skating in the library (Smedrud, 2015: 24): "Technology can amplify great teaching but great technology cannot replace poor teaching" (OECD, 2015: 4). Technological devices can be a distraction. Non-academic use of personal computers (PC) in the classroom often occurs as pupils keep several windows open and easily switch between them (Elstad, 2006). In a survey, 56.6% of pupils at an upper-secondary school reported that teachers do not know what they are doing with computers (Hatlevik et al., 2013). Many pupils are experienced at quickly clicking onto the academic window when a teacher is near (Blikstad-Balas, 2012). Chapter 4 addresses this topic. Research has shown that, when pupils are distracted from lessons and lose concentration (Beland & Murphy, 2015), learning decreases (Fried, 2008). This is a serious challenge, which is discussed in Chapters 4 and 5.

Another factor is self-regulation problems among students (Oreopoulos, 2007). Given that knowledge acquired at school is an important factor in securing employment, a key question is how information and communication technology could support better and smarter skills acquisition. Many countries suffer from high rates of pupils failing to complete their education (De Witte & Csillag, 2014). The most important factor determining whether pupils will drop out of school is the skills they bring from lower secondary school (Markussen, Frøseth, & Sandberg, 2011). Some drop-outs chose to enjoy computer gaming and social media rather than concentrating on their academics (Schargel & Smink, 2014). Getting a job without completing upper secondary school or sixth-form education is possible, but there is an increased risk of falling permanently outside the labour force (Wang & Fredricks, 2014). Therefore, it is important to understand how schools can influence pupils' ability to develop greater resilience and determination when they experience learning as boring (Henry, Knight, & Thornberry, 2012; Rumberger & Rotermund, 2012; Schargel & Smink, 2014). This topic is discussed in Chapter 4 and 5.

PROMOTION OF LEARNING BY INFORMATION AND COMMUNICATION TECHNOLOGIES

Information and communication technologies do not necessarily promote learning. Computers do not improve pupils' school results; indeed, frequent use of digital technology in schools is more likely to be associated with lower results. PISA results show no appreciable improvements in pupil attainment in reading, mathematics or science in the countries that had invested heavily in information and communication technology for education (OECD, 2015): Pupils who frequently use computers at school have poor learning outcomes.

Technologies re-shape the learning environment and influence learning processes in favourable and unfavourable ways. Although the typical objective of

technology is to improve productivity (Brynjolfsson & McAfee, 2012; Audretsch & Welfens, 2013), this is not the objective of education (Ertmer & Ottenbreit-Leftwich, 2010). No clear research-based evidence has supported that information and communication technology supports school learning of the material valued by society (that is to say, by the individuals within society who have the authority to decide the knowledge and skills regarded as most important). In other words, access to information and communication technology in school is by no means a comprehensive solution to the school's needs for modernisation (Cuban & Jandrić, 2015). Chapter 5, for instance, shows that major innovations can lead to loss of the teacher's operational authority within the classroom and result in frustrations, especially in the age of so-called teacher accountability which assigns the teacher clearly defined responsibility for what pupils learn (Christophersen, Elstad, & Turmo, 2010).

However, it is difficult to see how the school can meet future skills needs by neglecting information and communication technology as a school subject. In Poland and Slovenia, information and communication technology is a school subject. In Norway it is integrated into several school subjects (however, it was a mandatory subject from 1994 to 2005). The question of whether information and communication technology supports learning is dependent on the rationale for the activities in which the school directs pupils to engage (Ertmer & Ottenbreit-Leftwich, 2010; Freeman et al., 2014).

SCHOOL SYSTEMS' NEED FOR A BETTER RESPONSE TO A CHANGING WORLD

The key question is what use information and communication technology can have when the objective is to promote learning material crucial to meeting the challenges of the future. A central ambition of this book is to contribute to an improved understanding of these issues and challenges. The reader, therefore, will also find chapters discussing the rationale and premises for uses technology in school. Chapter 2 is devoted to this issue. The twin book named *Educational technology and polycontextual bridging* contains chapters discussing good ways to make use of young people's digital strengths within school teaching. Chapters in this book report how schools have tackled challenges building bridges between young people's digital strengths and school's educational mandate to teach academic material and social skills. However, the present book has thus a practical mission, in addition to discussing abstract issues. We are aware that the presence of information and communication technology in the school can easily distract pupils from the very acquisition of knowledge that the school should enable (Beland & Murphy, 2015). Therefore, the opportunities for the school to strengthen pupils' ability to lead themselves through a school day and leisure time filled with distracting temptations from expected learning activities (Chapter 4) are also discussed.

DREAMS OF A FULLY DIGITALISED SCHOOL

Technological advances make it possible for pupils to work on their own without a teacher physically present. Pupils can log into and work with educational programmes designed by experts. In this way, pupils can learn at their own pace without the digital delays that hinder the modernisation of teaching. Digitalised help facilities can meet any need for explanation, while digital cognitive tutors can supply individual follow-up. Today's dreams concerning the digital modernisation of the school bear traces of a number of innovations (Schofield, 2006). One example of this is follow-up aided by data mining and learning analytics (Siemens & Baker, 2012), which have received great investments from Norwegian educational authorities (Ministry of Education and Research, 2015). Data mining is a process used by enterprises to turn raw data into useful information, for instance, to look for patterns in large batches of data. Enterprises do so to learn more about their users, develop more effective feedback strategies (e.g. marketing), increase sales and decrease costs. This process could also provide pupils with individualised academic customised for their needs (in the same way that Amazon suggests new book purchases based on earlier purchases or digital traces left from Internet usage).

The vision of a digitalised school is strongly supported by commercial providers of digital support systems (Cuban, 2009). To some, a fully digitalised school seems a dystopia (Skagen, 2014), while for others, it is a beautiful, futuristic dream (Søby, 2013). What is certain is that examples exist of systems that near what can be described as a fully digitalised school (Erstad et al., 2001). Examples, as presented in Chapter 6, can also be found of schools that have made brave attempts to take the leap and become fully digitalised. But the leaders have changed their strategy along the way (Chapter 5). There are also examples of schools in which information and communication technology is relatively little used (Cuban, 2009), as illustrated in Chapter 6. There is a breadth of variety strategic approaches (Wastiau et al., 2014). The institution of the school has shown an astonishing ability to survive despite all the winds of change that have blown through other social institutions. The school has been touched by technological developments but not changed to the extent envisaged years ago by many researchers and policy makers, such as Seymour Papert, who predicted:

> There won't be schools in the future … I think the computer will blow up the school. That is, the school defined as something where there are classes, teachers running exams, people structured in groups by age, following a curriculum—all of that. (*Popular Computing*, October 1984, p. 11)

FOUR VISIONS

The debate on information and communication technology in schools features four visions of technology use. (See Figure 1 for the varieties of ideal types). Firstly, the issue of technology influences the teacher's vision of developing professionally

relevant digital skills to use technology in teaching (Petko, 2012; Beetham & Sharpe, 2013). The realisation of this vision depends on the teacher enabling teaching and learning in a technologically equipped learning environment and challenging pupils make productive and relevant use of information and communication technology. Better and smarter learning arise from the use of such skills. To turn this vision into reality, educational authorities in some countries have made major investments in improving teacher skills and greatly increased in the number of computers in schools (Hatlevik & Throndsen, 2015).

	Factors influencing the operations and dynamics of the use of communication technology	
	Internal factors	External factors
Shared norms and objectives	Professional teaching competence	Efficient school administration
Conflicting norms	Democratic participation in school by pupils	School as a service enterprise embedded in markets dynamics

Figure 1. Stylised visions of the operations and dynamics of the use of information and communication technology in schools (adapted from Olsen, 2005, p. 8)

Secondly, the issue of technology affects pupils' vision of taking responsibility for their situation as learners and making independent decisions about when and how to use information and communication technology within and outside the school (Zimmerman, 1989). A divided view of the practicality of taking personal responsibility for one's choices amidst of a thicket of technological alternatives is apparent amongst some pupils. For instance, Norwegian pupil organisations protest that teachers may restrict the free use of mobile phones (Ertesvåg, 2015). Young people seek to gain influence and strengthen pupil rights' within the school system, including participating in the formal decision-making processes of the school (Osler & Starkey, 2005; Starkey, Akar, Jerome, & Osler, 2014). Democratic participation by students in the school's decision-making apparatus emerged as early as the 1970s, while the vision of pupil influence has been developed and extended in more recent times (Osler, 2010; Lundy & McEvoy, 2012).

Thirdly, the issue of technology in the school influences the vision for the effective administration of the school. Electronic platforms improve information and communication technology for all users (pupils, teachers, parents and school administrators) and can lead to efficient solutions which consume fewer resources. For instance, electronic books decrease the consumption of trees for paper production and simplify the logistics of teaching resources.

Fourthly, the advent of competition among schools necessitates that schools make themselves attractive to survive. Friedman (1962) advocated the introduction

of market mechanism into public school: the presence of competition raises overall productivity of schools' contribution to value added. However, the empirical results of Friedman's theory are mixed (e.g. Greene & Kang, 2004; Geller et al., 2006; Hsieh & Urquiola, 2006). There is no clarity on this topic. However, technology-based modernisation is regarded as a signal of quality in schools. This view puts pressure on schools to use the best available technology, especially technology attractive to decision makers. A hybrid form of the promotion of societal efficiency arises from the synergy of education administration and market competition: technological diffusion in the school sector may cultivate employee skills necessary for enterprises to reap the benefits of information and communication technology for economic growth.

These four stylised visions presented in Figure 1 may be at odds with each other; therefore, their intentions need to be balanced. To this end, we need to consider a perceptual combination of conceptual perspectives and weigh their contributions against each other. Good learning demands academic commitment and effort on the part of pupils, who nevertheless might believe that the teacher needs to deliver inspiring teaching for pupils to attain good results (Elstad, 2006). A tension exists between pupils' desire to be guided through a progression of demands leading to the desired qualification (Lundgren, 1999) and teachers' emphasis on problem-solving tasks which require the pupil to exert effort to attain a deep understanding of the subject in a mindful transfer of learning (Perkins & Salomon, 2012). Knowledge-thirsty pupils do exist—for instance, those who wonder why insects are usually smaller than mammals—but such thirst for knowledge is by no means a universal feature of youth in our culture. It is the task of the school to persuade pupils to think deeply about the questions which civilisation has tasked the school with addressing (Perkins, 2008). The entertainment industry makes only a limited contribution to this goal. In-depth learning can be regarded as of crucial importance for 21st-century European countries. In-depth learning based on problem solving can frustrate a struggling pupil, and completion of their education will require self-discipline and perseverance. In short, the principles of the most effective teaching might be at odds with pupils' desire for full self-determination in schooling.

EDUCATIONAL TECHNOLOGY AND THEORETICAL PERSPECTIVES

The school of educational theories on educational technology and its use in school has distinct traditions, including perspectives used as theoretical lenses in this book. To aid understanding, the five theoretical perspectives are outlined in this chapter: (1) the behaviourist view, (2) the cognitive view, (3) the time discounting perspective and its' egonomics, (4) game theory as a theoretical lens, and (5) the socio-cultural view of learning. The perspectives called (1), (2), and (5) are well known, however, time discounting theory and game theory can fill up blanks in the theoretical landscape of educational technology. In this book, I use these perspectives

to discuss how educational technology may influence learners' academic work and teachers' work.

Behaviourist View of Knowing and Educational Technology

Before the most recent elaboration of the behaviourist view, a mechanical teaching machine was being developed. Such machines rely on a design which interprets behaviour as responses to stimuli in a situation where the machine introduces a task. An early attempt to use technology in line with behaviouristic principles was made in 1926. Sidney Pressey constructed a self-scoring teaching machine based on multiple-choice questions, such as 'Using Ohm's Law if E = 12 and I = 4: R = ? Options A: R = 8, B: R = 16, C: R = 3, D: R = 48' (Lumsdaine, 1960). The pupil quite simply had to press a button to select option A, B, C or D and received immediate feedback on whether the chosen alternative was correct. This mechanical format, however, proved to be cumbersome and impractical, so Pressey's machine never made a breakthrough in the school.

However, the idea of teaching machine was re-ignited in 1958 when Skinner (1958, 1983) advocated for the development teaching machines which could allow pupils to be active users and receive immediate reinforcement from the machine's response. Skinner (1958) asserted that learned behaviour should be shaped in small steps, which are explicitly reinforced. Learning could be improved by well-defined, target-based learning schemes and programmed instruction, also called behavioural objectives. School tasks could be broken down into simple components treated as prerequisites for more complex tasks to lead to the accumulation of skills (Gagne, Wager, Golas, Keller, & Russell, 2005). This is the *behaviourist view of knowing* (Greeno et al., 1996). Precise knowledge of what the learner is to learn enables designing technological aids (called programmed instruction, computer-assisted instruction and intelligent computer-assisted instruction) that meet the purpose. Programmed instruction is a sequence of frames consisting of learning material: a question is displayed, the pupil actively responds, and feedback or reinforcement is delivered immediately. Skinner (1958) argued that method could minimise the use of prompts and allow pupils to work at their own pace. The teacher could benefit from more free up time to help those who need it most. However, the small-step approach is often experienced as boring.

During the 1960s, more functional technology was tested, and since then, interest in teaching machines has flourished. The development of educational computer programmes based on behaviouristic principles has contributed to this growth, which has accelerated since the breakthrough of computer technology into society in the 2000s. This type of technology has become widespread in nursery schools and schools (Vangsnes et al., 2012). In nursery school, letter and word recognition is taught through educational programmes designed to meet children's expectations for decoration and audible rewards. Extensive experiments with games and i-Pads based on the behaviouristic perspective are being conducted in schools and nursery

schools (Zidianakis et al., 2012). However, drill and practice devices also remain popular (Connolly et al., 2012).

The core of this learning-environment design is that a technological device typically presents a question to be answered. The learner responds by doing a task. The technology then provides immediate feedback about whether the answer was correct. The simplest feedback method is merely to indicate whether the selected answer was correct or incorrect. The learner can quickly change the answer (in line with behaviouristic design principles). Alternatively, the technology can present a total of correct and incorrect answers and provide feedback concerning how many and which answers were correct. Countless computer programmes have been designed to make an encouraging sound when the learner selects a correct answer and a less pleasant sound when the learner answers incorrectly. Computer-assisted instruction, which relies on the Skinnerian model of instruction and other behavioural models of instruction (e.g. performing a tutorial role that tests student comprehension), is a further development of simplistic teaching machines (Steinberg, 1984). Other methods in this area that have flourished include: computer-assisted learning, computer-based learning, human-computer interaction, computer-supported collaborative learning, computer-mediated communication, computer-mediated discourse, computer-supported cooperative work and technology-enhanced learning. These methods are designed to offer well-organised information and training through a prescribed course of study (Greeno et al., 1996). Clear goals, feedback and reinforcement are key components of the behaviouristic learning environment, and computer systems provide training opportunities.

Cognitive View of Knowing and Educational Technology

The *cognitive view* emphasises processes that promote conceptual understanding, problem solving and reasoning. The learning environment should encourage pupils' to construct understandings of concepts and mental models through reasoning in activities (Greeno et al., 1996). Applied to teaching machines, the cognitive view of knowing stresses the importance of deep-level information processing for building mental models. For example, technology designed based on cognitive principles which emphasises didactic explanations of learning materials—a so-called intelligent computer tutor—was developed in the 1990s.The components of an intelligent computer tutor are an expert module, a pupil module and an instructional module, which are embedded in a learning environment. Advanced forms of feedback might involve the learner receiving either correction throughout the learning process, or explanation regarding why answers are incorrect or a combination of both). Research shows that errors made by pupils are not coincidental but are based on systematic misunderstandings and incorrect reasoning, analogous conclusions, heuristics and cognitive biases (White, 1993).

Computer programme designers have sought ways to counter these misunderstandings. Some scholars, however, argue that designers of learning

environments should instead build on these misconceptions and view them as potential learning resources (Smith et al., 1994; Larkin, 2012). Learning with understanding is the most important objective, and pupils' ability to understand phenomena which depend on mental representations draws heavily on their preconceptions. Further, technology can help in learning technical material by providing understanding impossible to observe or experience in everyday life (for instance, a Newtonian world without friction). The learning effect, though, depends on how the learner actually uses the digital representation to gain a better understanding or mental model of a complex phenomenon. Some computer programmes support learning via manipulatives, or features invisible to the human eyes, but these programmes have not yet experienced a breakthrough in schools (Zacharia & de Jong, 2014).

We can consider the example of a cognitive learning environment from the field of mathematics which relies on digital devices. The study of mathematics is based on axioms, which makes it possible to identify breaches of the rules of mathematics. For instance, 40% of students in first-level economics course (Sydsæter, 2003, p. 29) used incorrect analogous reasoning that if $(AB)^t = A^tB^t$ is correct, then 2^{a+b} must be $2^a + 2^b$. Some students also deduced that 2^{ab} must be 2^a2^b (Matz, 1982). These linearity errors are not random errors but the logical continuation of procedural rules learned in mathematics (Matz, 1982). When selecting an analogous solution as an alternative answer in an intelligent computer tutor, the learner receives electronic feedback that explains why the chosen answer was incorrect.[2] Koedinger and Anderson (1998) colleagues developed a tutoring system for high-school algebra and geometry. Pupils can read explanations showing, for instance, that setting figures into an algebraic formula demonstrates that the temptingly simple analogous solution is incorrect. Such feedback can help the learner understand why an answer is incorrect and correct a misunderstanding. Of course, the teacher could also correct misunderstandings, but teachers have limited time to follow up with each pupil at a school. Digitalised aids that help explain academic misunderstandings thus can contribute to greater efficiency in the school's teaching. Kluge's chapter in the twin book *Educational Technology and Polycontextual Bridging* is devoted to learning algebra with games.

Flipped classrooms are another approach which relies on digital devices (Thompson, 2011; Tucker, 2012). For instance, the online Khan Academy offers a set of structured educational materials for math. Through this series of free, short, teacher-created videos and interactive lessons, instruction that earlier used to occur in class can be accessed at home. This opportunity for online instruction at home can reinforce classroom lessons and free class time for other activities (Murphy, 2014; Ruipérez-Valiente et al., 2015; Zellner, 2015). Pupils have the opportunity to see in the home what they missed by watching videos or solving exercises.

Programmes such as Geogebra, Kikora and Dragonbox can raise a decision-making problem to a higher analytical level. Technology, in this instance, can be said to represent a person plus (Perkins, 1993).[3] Pupils, for instance, can use Geogebra to

interpret curvilinear functions which illustrate typical company productivity without using a derivation to analyse the function (Hohenwarter et al., 2009). An explanation of the direction of productivity might be understandable, but schoolchildren usually lack the fundamental mathematical knowledge necessary to follow this strictly logical-sequential subject of study (for example, to understand calculus). A quadratic function is any function with the form $y = ax^2 + bx + c$. The numbers a, b and c are the coefficients of the equation; a is the quadratic coefficient, b is the linear coefficient, and c is the constant. The graph of a quadratic function has a general shape called a parabola. The location and size of the parabola depend on the values of a, b, and c. For instance, the shape of the parabola resembles a U when $a > 0$ and reverses when $a < 0$. In addition, the pupil can explore how the size of b and c influences the location and size of the parabola as the graph is moved to the right or left, up or down. Using Geogebra can help build an understanding of how a, b and c influence the graph of the parabola.

In studying an academic subject, such as mathematics, the learner's goal is understanding. It is important both to cultivate understanding and to comprehend the basic rules governing mathematics. Other aids, such as Photo-Math app, do not necessarily help learning (Hamadneh, 2015). The key question is how the technology is used. When an equation is scanned from a textbook or screen, Photo-Math shows the various stages in solving the equation, as well as the correct answer. When using Photo-Math, the pupil might not need to employ thought at all when solving mathematical equations and so might not learn anything useful about solving equations. The same might be occurring when learning a foreign language by using a translation programme, such as Google Translate. In such cases, the use of technological aids may be a disservice, although it can have benefits, not the least, increasing motivation for a subject (Godwin-Jones, 2011).

A learning environment designed to improve pupils' understanding adheres to cognitive principles, while a design intended to reinforce an association between stimulus and response is based on behaviouristic principles. There, however, is not sharp division but a continuum between learning through tasks that demand deep thought and understanding and through material divided into small areas taught by individual training and (Gagne et al., 2005). In other words, the distinction between behaviouristic and cognitive design principles is not always clear-cut (Curzon, 2003). It is easier to design meaningful teaching machines with feedback mechanisms for subjects that have a firm logical and sequential structure (e.g. mathematics) than in more loosely structured subjects (e.g. history). Using a teaching machine for history could easily lead to pupils attempting to simply learn facts rather engage in a deep-level learning approach. Therefore, it is not evident that multiple-choice-based teaching machines are a good approach for a subject such as history. Some technology, though, does appear to promote learning in subjects with a loose knowledge framework. For example, the programme EssayCritic provides feedback on texts which pupil load into the programme. The programme gives students a list of topics already are included in the text and suggestions for missing topics (Cheung et al., 2007).

We can conclude that it is easy to design learning systems that promote learning factual knowledge, but designing learning systems that facilitate in-depth learning is more demanding, although not impossible (Perkins, 2013). There is a large selection of quiz-like tasks teaching factual knowledge but far less educational material designed to develop in-depth understanding.

Time Discounting and Egonomics

George Ainslie (2001) analyses dynamics of multiple selves as a bargaining process: conflicting reward-seeking processes may arise spontaneously to get incompatible goals available at different times. Humans bargain the processes with each other, and claim that this bargaining can create ego functions like willpower from the bottom up. This view is extensively outlined in Chapter 4. Time discounting is a way of directly comparing present and future rewards (or punishments). Our decisions require us to weigh consequences that are distributed over time. Practically all human beings face 'choice-situations' in which they must to choose between immediate and delayed rewards. When humans have choices between something they can achieve at different points in time, the relative valuation of the choices is discounted according to expected delays until realisation. The subjective value of a delayed reward is inversely related to the postponement of the delay (Ainslie, 2001), a hyperbolic pattern that has been observed in extensive research on human decisions since individuals have a tendency to attach more importance to rewards in the near future than to rewards in the distant future (myopia). The volitional processes according the valuation of rewards and punishments are here seen as inner bargaining processes in which any plan we make at one moment must be sold to ourselves at future moments. A new kind of challenge arises with the free access to Internet in the classroom; the students use computers partly for academic work, and partly for off-task behaviour. Volitional strategy is therefore the conscious faculty by which a person may impose some overriding value on extrinsic temptations (Ainslie, 2001). In Chapter 4 the authors try to identify and describe the most prominent of these strategies called egonomics.

How should schools arrange things so that pupils can manage school demands on their own? How can schools design components of a self-discipline program so students with volitional problems succeed better? To do so, schools must design institutional features that support volition to work, i.e. that influence the students to be more sophisticated about their own volitional strategies. Teachers and principals are planners of institutional arrangements and need to be sophisticated about their design choices. By including volitional issues as a purpose for well-designed instructional interventions, pupils' use of volitional strategies can be increased.

Paternalistic constraining of pupils' digital off-task behaviour corresponds to the notion of the guardian, the person who knows what is good for the learner. How can designers for learning choose among paternalistic options? When a teacher imposes external limitations on the students' behaviour, the locus of control is outside the

learner. It is possible, however, to enhance autonomy and self-determination through paternalistic policies. Libertarian paternalism is a foundation for rethinking the question of institutional design; it preserves freedom of choice, but accepts that the school is moving students in a direction that will promote their future achievements.

Game Theory as a Theoretical Lens

In Chapter 5 I use the observational lens of game theory through which to study interactions in the classroom with a view to seeing how ICT affordances may influence behaviour. One way of analytically approaching the systemic nature of life in the classroom is to view the parties to the interaction as intentional players. Game theory is an analytical theory that defines instrumental, rational players as having a consciousness of each other's consciousness inasmuch as each participant achieves a result which depends partly on his or her own actions and partly on the actions of others. Game theory can clarify how the players respond to structural changes, and how the outcome in the form of patterns of interaction is explained by the logical structure of the problems confronting the players. Central to game theoretical analysis is an understanding of the situation and the construction of a situation-logical model and logical derivatives of the model.

In game theoretical analysis, changes in the institutional framework surrounding the interaction between rational parties are isolated: 'Its method consists in analysing the social situation of acting men sufficiently to explain the action in terms of the situation, without any further help from psychology' (Popper, 1976: 102). In Chapter 5, the analysis is based on hermeneutic insight into case material (interviews and classroom observations) from a school. The construction of a game theoretical model on the basis of the case material is a rational reconstruction of how institutional features are embodied in the basic logic of systems and can influence the actions of rational players (Elstad, 2002). The behaviours are thus explained by the incentive structures inherent in the institutional framework, i.e., I assume that among the player characteristics presumed by this analysis, accountability failures may emerge as a rational response to the institutional framework. The game theoretical analysis method must be said to be an example of parsimonious explanation (Occam's razor). On the basis of a very simple model, an attempt is made to explain as much as possible with as little as possible.

An important step in the game theoretical analysis consists of constructing game theoretical models that capture core elements in the interactions between teacher and students in the existing institutional frameworks. The content of the models is believed to consist of reasonable assumptions about all aspects of interaction in the classroom. I use the rules of logic in order to derive consequences from theses assumptions. Model analysis provides the basis for logical deductions, understood in the following as patterns of interaction what are called equilibrium when each player has made his choice. These model results must then be put back into an educational context and interpreted. The game theoretical analysis framework is

useful in revealing dilemmas and trade-offs in the intersection of curriculum and pedagogy. One of the dilemmas is related to the teacher's control, i.e. aspects of the interaction situations that capture tensions with regard to the locus and extent of control in classroom situations, and the effects on the content of schooling. The rational reconstruction constructs 'a theory of intended or unintended institutional consequences of purposive action' (Popper, 1976: 104), how situation structures may affect interaction patterns in the classroom, the content of schooling.

Sociocultural View of Knowing and Educational Technology

During the 1990s, sociocultural theories of school and learning were popular amongst Nordic educational researchers and gained particular currency in the Nordic education professions (Säljö, 2013). The sociocultural or situative perspective (Greeno, 2011), derived in part from the concepts of Vygotsky (1997), highlights the role of social interaction in learning through collaborative activities. Sociocultural theory is founded on a theoretical basis developed by Vygotsky and applied to the didactic use of information and communication technology (Mercer & Howe, 2012). This sociocultural framework is used as an analytical lens in several chapters in the twin book *Educational technology and polycontextual bridging*.

The social practices of inquiry and sense-making have been successfully applied in schools. Computer-supported intentional learning environments (CSILE) are a design experiment relying on the sociocultural perspective of knowing (Scardamalia, 2002). CSILE are designed to make knowledge processes accessible to all and to foster the creation and continual improvement of public artefacts and community knowledge. They provide a community space for carrying out collaborative academic work (Rahikainen et al., 2013). Most of the chapters in the twin book *Educational technology and polycontextual bridging* present examples of social practices of inquiry and sense-making in schools.

Proponents of the sociocultural view of knowing emphasise authentic tasks in the school (Andersson & Andersson, 2005). Many adherents of the theory urge allowing learners a freedom of action while working with tasks in the school; it is not certain that the school and teachers should have the power to define what is important to learn (Van Lier, 2008). This perspective stresses the social aspects of the learning process, including pupil collaboration and social interaction (Greeno, 2011). Pupils can even interact in a global classroom and create new knowledge (Higgins, Wolf, & Torres, 2013). Information and communication technology opens up for such possibilities. Assessments of teachers' practice of their profession often employ metaphors, such as scaffolding and coaching, to describe desirable qualities (Brown, Collins, & Duguid, 1989). Some proponents of this view point to the old apprenticeship concept as an ideal model of teacher – pupil interaction. The cognitive apprentice ideal is based on a gradual approach to learning. Scaffolding and coaching are used in the early phases, but as the learner masters more of the subject, the scaffolding can be dismantled (Jin & Corbett, 2011). Here, too, information and

communication technology provides digital aids that can function as scaffolding. The radical ontological idea that knowledge is built into artefacts (Säljö, 2013) points towards the conclusion that the learner's use of artefacts should be tested in school exams, supporting the view that the pupils should be allowed to use all aids, including information and communication technology, during exams (Prøitz, 2010).

LEARNING IN THE 21ST CENTURY

The purpose of this chapter was to provide a general introductory text that, I hope, helps the reader see the individual contributions in this book in a broader perspective. The authors' chapters show that educational technologies do not necessarily promote learning but certainly re-shape the learning environment and influence learning processes in favourable and unfavourable ways.

This book contributes to a critical examination of educational technology, its' expectations and experiences. The expectations are great. European school systems were built for economies and societies that no longer exist and must respond better to a changing world. As European industries increasingly lose ground as an employment mechanism, the school systems still reflect their origins as a means to meet industrial society's need for instrumental skills. In contrast, creativity, cross-disciplinary problem solving, performative skills, blended and cross-arena learning and working patterns, including crowd collaboration, are important skills for the 21st century. Future areas of employment growth in European societies will be found more in highly skilled areas, such as niche products, than in industrial mass production of goods, where European countries lose out in competition with the low-cost economies of developing countries. Research provides evidence for a deep learning approach (Marton & Säljö, 1976; Struyven, Dochy, Janssens, & Gielen, 2006). Carrying out a deep learning approach, however, requires sacrifices and dedication, which can easily be lost in the battle against easy solutions. Future employees and employers then should invest in skills development, which demands a basis of technical skills to which schools should contribute. Tomorrow's pupils will increasingly compete in a transnational or global society and so must be proficient communicators, collaborators, critical thinkers and creators (the 4 Cs, NEA, 2015)—skills important for the 21st century.

NOTES

1 In the late 18th and early 19th century, the role of schools in preparing children to work in the manufacturing industry was centered around the three Rs (reading, writing, and arithmetic). However, Sir William Curtis (1795) included reading and writing, arithmetic and reckoning and wrighting and wroughting in the 3 Rs (Stevens, 2008).

2 An example of feedback is the following: Insert a = 1 and b = 3 into 2^{a+b} and $2^a + 2^b$, and check the answers. If we do so, $2^{1+3} = 2^4$, which is 16. However, $2^1 + 2^3 = 10$; therefore, 2^{a+b} is not $2^a + 2^b$.

3 A person-solo is the person without resources in his or her surround while the surroundings in the classroom form the persons plus (their surround).

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