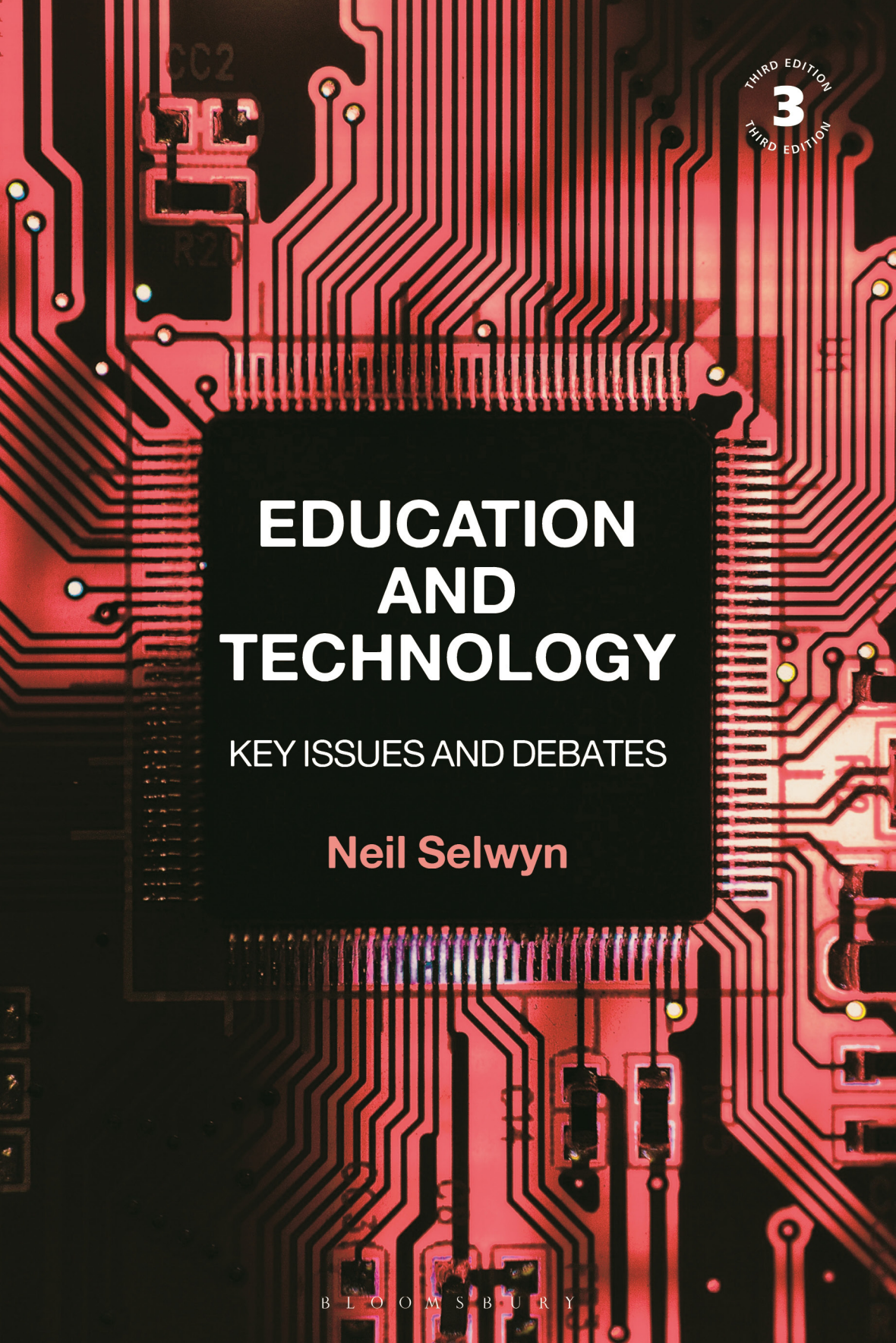
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KEY ISSUES AND DEBATES
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Education and Technology

Key Issues and Debates

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Neil Selwyn

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Preface to the Third Edition

This preface is being written in 2021 for the third edition of a book that was published originally in 2011. In terms of book publishing this feels like no time at all. Yet, when talking about digital technology and education, ten years ago can feel like a lifetime. The first edition of this book made mention of wikis, mp3 players, virtual worlds and other digital education phenomena that have long since faded from memory. Discussions about 'EdTech' during this time were driven by notable levels of optimism, with people enthused by ideas of 'user-generated content', the 'sharing economy' and the potential advantages of being hyper-connected and 'always on'.

As such, the first edition's call in 2011 to 'look beyond popular received wisdoms' was defiantly out of step from mainstream discussions of technology and education. I write this book with the aim of covering issues that had long been acknowledged by critical voices on the fringes of educational technology yet were certainly not major topics of mainstream conversation. As such, there was a transgressive thrill in giving these discussions the deceptively bland subtitle of 'Key Issues and Debates'. The first edition was a book that strove to prod the majority of its readers into thinking differently about technology and education.

A decade on, this third edition is released into very different circumstances. The past few years have seen an enduring 'tech-lash' – driven by widely held public suspicions of 'big tech' companies and their activities. As such, the high-tech optimism of the 2000s and 2010s has definitely faded. Instead, the 2020s is turning out to be a decade when populations around the world ask serious questions about the implications of their technology consumption. Doubts are being raised about privacy, surveillance, the right to be forgotten and the very real threats of online misinformation and other forms of digital malevolence. As such, the 'bigger picture' stance of the previous two editions of this book now seems rather obvious and tame. We now live in times when most people are well aware that digital technologies are fraught with difficulty and danger.

In educational terms, the topic of digital technology has also taken on an increasingly serious and unsettling nature. The role of digital education was

thrust to the forefront of public consciousness by the abrupt Covid-19 school shutdowns and the rapid switchover to 'remote learning' at the beginning of the 2020s. As a result, the prospect of fully online education is now being taken seriously by institutions and authorities that previously would have dismissed such change. Suddenly, digital education is seen as a means of remaining viable in times of economic uncertainly and continued global instability. At the same time, some educators, students, parents and employers are raising valid concerns over the ways in which education is pivoting over to digital modes of provision. These conversations are often not about technology per se, but relate instead to wider concerns over the values that we want our contemporary education systems to embody.

All told, the 2020s feel like very different times to be writing a book like this. It is therefore important that those of us who felt sceptical about the evangelism and hype surrounding educational technology during the 2010s retain an equally wary eye during the 2020s on any doomster-ism and nostalgic rejection of all-things-digital. Digital technology is not a completely 'bad thing', any more than it ever was a completely 'good thing'. Our discussions around this topic need to be sophisticated and self-aware.

At this point, I am reminded of Evgeny Morozov's subtle observation that any critique of technology needs to be approached along the same lines as literary criticism. As is the case with literature, Morozov reasons, we should critique technology because we ultimately believe it to be important enough to merit critique. So, while you might passionately dislike (or distrust) the forms of educational technology that currently prevail at the moment, this does not mean that you are completely opposed to any use of technology in education at all.

In this spirit, one of the key questions underpinning this third edition is, 'How might things be otherwise?' What alternate forms of technology use in education might be more desirable and/or more beneficial than those currently on offer? What needs to happen in order for these technologies to be designed, developed and taken up? What alternate education futures might we hope for? Of course, there is plenty to be pessimistic about, and many of the ways that digital technologies are being deployed in education remain deeply problematic and somewhat dangerous. Nevertheless, we need to retain residual hope that things might be better than they currently are.

So, this third edition has been (re)written in a spirit of 'pessimism of the intellect, optimism of the will'. Some sections of the book remain largely intact from 2011. For example, there are a few central discussions that I

deliberately wrote eleven years ago to give the first edition a decent shelf life. There are also a couple of chapters (those exploring the history of 'predigital' technologies in the classroom, and twentieth-century learning theories) whose subject matter should remain relatively evergreen for years to come.

On the other hand, there are many sections in this third edition that are necessarily new. The first edition only contained a couple of sentences regarding artificial intelligence – now we have a full chapter. Very few people in 2011 were discussing the sustainability of educational technology in light of the burgeoning climate crisis – these issues now seem to be of fast-growing importance. There are many other additions, improvements and refinements to this new edition that I hope bolster the book's original underpinning argument that we need to think very carefully indeed about the relationships between digital technology and educational contexts.

All told, this new edition of the book is very much preoccupied with the uncertain futures that the 2020s hold, while retaining the thrust of its predecessors. If you are looking for a quick 'elevator pitch' to get into a suitable frame of mind for the next 75,000 words, then perhaps this tweet from a couple of years ago is a good place to start. Dan Krutka from the University of North Texas managed to construct a very neat summary of the second edition in the following 229 characters:

> BOOK REVIEW: @Neil_Selwyn's Education & Technology weaves thru history & debates with the general point that #edtech is contested, ideological, & on its own, doesn't 'improve' ed. Instead of asking, what works? We can ask, what is/should education be for? And start there.

Given the increasing popular appetite for 'bite-size' content, it is tempting to just use Dan's tweet as the third edition. Yet, we should not be turning our backs on the idea of books just yet. There is clearly still value in long-form writing (and reading) as a way of thoroughly working through the issues surrounding education and technology. Indeed, if one thing seems certain, it is that the topic of education and technology is becoming even more contested, ideologically driven and messy than ever. These are important conversations to keep developing throughout the 2020s and beyond.

Neil Selwyn, Melbourne, June 2021

How to Use This Book

There are a number of ways that readers might like to engage with this book. In a traditional manner, the eight chapters have been written to present an unfolding iterative argument and therefore develop a growing understanding of key issues and debates. In this sense, readers are encouraged to pick the book up and read sequentially through each chapter. Opening chapters start with basic definitions and frameworks, leading to a set of examples that build key arguments, and, finally, leading to a number of important conclusions and further avenues of discussion.

That said, each chapter is also designed to be read on a stand-alone basis. Each chapter concludes with a few **key questions** that prompt readers to think further about the issues that have been raised in that particular section. We also have a **glossary of short definitions** of key terms and phrases that might be unfamiliar at first. Finally, we have a couple of **key heuristics** that are used throughout the book to guide readers' thinking. Chapter 1 introduces the distinction between seeing technology in terms of (i) **artefacts and devices**; (ii) **activities and practices** and (iii) **context**. These are definitely important distinctions to become familiar with. As such, Chapter 2 develops **a model of six broad levels of 'context'** to take into consideration when thinking about the ways in which technology interacts with education. Again, this is an important set of distinctions to reflect upon throughout each chapter and apply to your own wider experiences and reading.

1

What Do We Mean by 'Education' and 'Technology'?

Chapter Outline

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Introduction

The use of technology – and in particular the use of digital technology – is an integral aspect of education. Yet, making sense of education and technology is not a straightforward task. The digitisation of society over the past couple of decades has been fast moving and extensive. We live in a 'digital age' where technology products and practices can quickly become fundamental parts of everyday life. For example, many people now consider it impossible to be without their smartphone at all times. The most popular social media platforms are now accessed by billions (rather than millions) of users each day. We are accustomed to turning to technology for immediate solutions to mundane problems. These days, people will simply 'Google the answer' to

a misremembered fact, 'ask Alexa' for a forgotten name or swipe and tap a screen to order a taxi or arrange a date; whatever predicament one might be in, it is likely that 'there's an app for that'.

It is understandable, therefore, that most aspects of education are beginning to be reimagined in a technological light. For instance, digital technologies lie at the heart of how people communicate, consume information and organise their lives. These shifts clearly have implications for how learning takes place, how knowledge is created and how people expect to be taught. At the same time, digital systems and networks are integral to the management and operation of modern institutions. This has obvious consequences for schools, universities and other sites of education provision. As such, anyone interested in contemporary education needs to be mindful of the complex relationships that have developed between education and technology. These are aspects of education that demand sustained analysis and critical thought. This is *not* simply a background feature or narrow technical concern.

Unfortunately, education and technology is something that people rarely give serious thought to. This is not to say that intelligent or thoughtful things are never said about education and technology. Yet most people see little need to scrutinise what has become a familiar feature of the education landscape. The majority of people working in education see digital technologies as a common-sense element of their job and, for the most part, something that is simply 'got on with'. This book does not share such complacency. Digital technology is certainly an embedded aspect of contemporary education, but is surely something that requires sustained and honest appraisal. More than ever, the issues and tensions that have grown up around education and technology merit our close attention.

Any discussion of education and technology needs to be wide-ranging and broad-minded. In particular, our principal focus should not be on technological devices, tools and applications per se, but the practices and activities that surround them, the meanings that people attach to them, and the social relations and social structures that these technologies are linked to. At this early stage of the book, such concepts might seem a little imprecise and unclear. This opening chapter lays some foundations for subsequent exploration of these issues.

First, then, it is helpful to get a good sense of exactly what is at stake when we talk about specifically *educational* technology. In addition, it is useful to properly consider what 'technology' is and how technologies interact with a

complex domain of social life such as education. Going back to basic definitions and questions such as these is an important initial step in developing a detached, critical stance – drawing our attention towards crucial questions that can otherwise be easily overlooked in the excitement that surrounds any new digital innovation. Beneath any 'new' technology being implemented in education is a range of long-established concerns and challenges. In this sense, we need to first pay due attention to a couple of fundamental questions of definition; that is, what exactly do we mean by the terms 'education' and 'technology'?

What Is Education?

Perhaps the best way to develop a full understanding of 'education' is to start by defining another term altogether: 'learning'. Despite being a concept central to education, many educational commentators are surprisingly vague in their basic definitions of 'learning'. With this ambiguity in mind, the description offered by Ivan Illich (1971, p.11) is perhaps as good as any, contending that 'to learn means to acquire a new skill or insight'. In these terms, the process of 'learning' can refer to an individual's acquisition of new skills, or perhaps new forms of knowledge and understanding. These different aspects of learning are also reflected in Benjamin Bloom's (1956) well-known 'taxonomy of educational objectives'. Here Bloom asserted that all learning can be described in terms of three overlapping domains: the psychomotor domain (manual and physical skills – i.e. 'doing'); the affective domain (emotions and attitudes – i.e. 'feeling') and the cognitive domain (intellectual capability and knowledge – i.e. 'thinking').

One recurring area of debate among educationalists is whether learning should be seen as a product or as a process. Many of the theories of learning that were developed during the first decades of the twentieth century tended to conceptualise learning as an end product or outcome – most often as a distinct change in behaviour. This view of learning is expressed, for example, in the 'behaviourist' conception of learning as a relatively permanent change in behaviour as a result of an individual's experiences. This notion of learning-as-product continues to be a common-sense way of understanding learning. Many students (and some educators) continue to see learning as consisting largely of 'gaining knowledge' and 'the filling of empty vessels' –

ideas that Carl Bereiter (2002) describes as 'folk' theories of learning. These concepts were reflected in Roger Säljö's (1979) investigations over forty years ago where he questioned large numbers of adult learners about what they perceived themselves doing when engaging with education. The view of learning-as-product was certainly apparent in the first three types of responses that Säljö identified:

- Learning as a quantitative increase in knowledge, that is, learning as acquiring information or 'knowing a lot';
- Learning as memorising, that is, learning as storing information that can be reproduced;
- Learning as acquiring facts, skills and methods that can be retained and used as necessary.

By contrast, the fourth and fifth categories of responses arising from Säljö's research seem to point towards a different notion of learning. In this sense, some people also described their learning as an ongoing process rather than a finite product:

- Learning as making sense or abstracting meaning, that is, learning that involves relating parts of the subject matter to each other and to the real world;
- Learning as interpreting and understanding reality in a different way, that is, learning that involves comprehending the world by reinterpreting knowledge.

The latter descriptions of learning as an ongoing process raise the idea of an individual learner who is building upon their previous experiences, and perhaps then changing their behaviour as a result. As we shall see in Chapter 4, this is certainly a view of learning that many twenty-first-century educationalists and psychologists would concur with. As Jerome Bruner (1996, p.146) put it, learning 'is not simply a technical business of well-managed information processing'. Instead, learning might also be seen to involve individuals having to make sense of who they are, and thereby develop an understanding of the world in which they live. From this perspective, learning can be seen as a continuing process of 'participation' rather than a discrete instance of 'acquisition' (Sfard 1998).

In this respect, we should acknowledge that learning can sometimes be an unconscious and unplanned process that individuals are unaware is taking place. Alan Rogers referred to this type of learning as an ongoing process of 'task-conscious' or 'acquisition' learning that takes place all the time. As

Rogers (2003, p.18) argued, learning along these lines is 'concrete, immediate and confined to a specific activity; it is not concerned with general principles'. For example, much of the learning arising from parenting or running a household could be said to fit this description. While some commentators have referred to this kind of learning as unconscious or implicit, Rogers (2003) suggests that it might be better to speak of people as having a consciousness of the task. In other words, while the individual may not be conscious that they are learning, they are usually aware of the specific task in hand.

Of course, when asked to describe 'learning', most people would think of forms of activity that are rather more organised and planned. In this sense learning is often a process that individuals are engaged consciously in. Rogers (2003) labelled this as 'learning-conscious' – that is, learning that is facilitated in some way by someone else rather than the incidental accumulation of experience described earlier. This implies that people are aware fully that the task they are engaged in involves some form of learning. As Rogers (2003, p.27) put it, usually this process involves 'formalised' guided episodes of learning – in other words, 'learning itself is the task … learning [is made] more conscious in order to enhance it'.

In these terms, then, the processes and practices of 'education' are obviously related to Rogers' 'learning-conscious' descriptions of learning. When most people talk about 'education', they are referring to the institutionally supported provision of formalised learning – that is, learning that is structured and often assessed and credentialised. Formal education is perhaps the easiest form of education to identify, and by far the most discussed in the academic literature. A wide range of institutionally provided educational opportunities exist – most obviously the compulsory forms of school-based learning for children and young people. Similar forms of continuous post-compulsory education also exist through colleges, universities and various types of distance education. Formal education can also be found outside of settings such as schools and universities. For instance, 'adult education' and 'community education' institutions offer a range of full-time and part-time opportunities to engage in classes and courses. Work-based training also represents a major source of adult formal education – including health and safety training, work-related evening classes, as well as more complex forms of professional development. These latter forms are increasingly relevant to the broad concept of 'lifelong learning' – that is, the notion that education encompasses not only the compulsory phases of schooling but also education and training throughout the life course.

In contrast to these examples of formal education, Rogers' notion of task-conscious learning relates mainly to what could be termed 'informal education'. In one sense, informal education can be seen simply as the 'learning experiences of everyday life' (Scribner and Cole 1973, p.553). This is learning that usually has no curriculum, assessment or formal 'teacher'. In contrast to the types of formal education just described, informal education 'is not typically classroom based or highly structured, and control of learning rests primarily in the hands of the learner' (Marsick and Watkins 1990, p.12). One common form of informal education is work-based 'learning on the job', as well as the diversity of learning arising from general interests, pursuits and hobbies outside of the workplace.

As a whole, then, the term 'education' can be best understood as the conditions and arrangements where learning takes place. Yet, in reaching this definition we should recognise that education is not simply a technical matter of facilitating an individual's learning. Indeed, thinking about education and technology primarily in terms of 'learning' narrows our attention towards specific processes and activities centred on the individual 'learner' rather than the broader aims and purposes of 'education'. Instead, Gert Biesta (2015) suggests that there are three broader functions of 'education' that need to be acknowledged alongside matters of 'learning'. First are matters of qualification – that is, giving people the knowledge, skills and dispositions that allow them to 'do something' (whether this is training for employment or the 'life skills' needed to function in society). Second is what can be termed a 'socialisation' function – what Biesta (2015, p.19) describes as 'insert[ing] individuals into existing ways of doing and being' such as particular social, cultural and political 'orders'. Third is what can be termed a 'subjectification' function – giving individuals a sense of who they are, encouraging the ability to act autonomously, and think independently and critically.

These broad societal and cultural functions remind us that much of what takes place in educational settings might have little (or nothing) to do with learning per se. Often the most significant aspects of education lie beyond the immediate instance of an individual engaging directly in the process of learning. Instead, it is important to also consider what can be termed the social 'milieu' of education. This can include the organisational cultures and micro-politics of educational institutions such as schools, colleges and universities. Similarly, how an individual engages with education can be often linked closely with the concerns of institutions such as the family, the workplace and wider community. In turn, these contexts are themselves set

within a range of even wider social milieu – not least commercial marketplaces, nation states and global economies. While perhaps not immediately apparent to anyone in a classroom setting, it would be foolhardy to attempt to make sense of education without some consideration of all these wider influences.

It seems appropriate that this book pays close attention to the aspects of education and technology that lie above and beyond the context of the individual and their immediate learning situation. In Chapter 2, we will attempt to map out these different factors and concerns. This will include acknowledging the linkages between educational systems and the various 'macro'-level elements such as global economics, labour markets and political and cultural institutions. Similarly, we need to approach the act of learning as being entwined with many other stratifications of social life such as family background, socio-economic circumstances, gender, race, (dis) ability and social class. As such, our discussions of education and technology move deliberately beyond making sense of the 'technical' aspects of learning and, instead, develop a 'social science' perspective on how education comes together with technology.

What Is Technology?

Making this distinction between the 'technical' and 'social' aspects of education carries over into how we can approach the notion of 'technology'. Unlike learning, there is fairly clear agreement on the definition of 'technology'. In basic terms, technology is understood as the process by which humans modify nature to meet their needs and wants. Jon Agar (2020, p.381) offers the definition that technology is 'a designed, material means to an end'. The notion of technology being 'designed' is illustrated by the distinction between sheltering under an umbrella to keep dry, as compared to sheltering under a tree. An umbrella is a technology in the sense of being a designed material means to keep dry. A tree can also be a material form of shelter, but it is not a technology that has been designed to keep people dry.

In a (pre)historic sense, the concept of technology refers to humans' ongoing use of tools and crafts to adapt and control their environment. Human use of technology is usually seen as originating over two million years ago with the conversion of natural resources into simple tools. This practice took place for reasons of survival and mastery of the environment

(e.g. the development of the spear), as well as for more affective purposes such as decoration and adornment (e.g. the development of cave painting). Seen along these lines, technology is a key feature that distinguishes humans from most other animals. As David Nye (2007, p.2) reasons, 'Animals are atechnical; they are content with the simple act of living. Humans by contrast continually redefine their necessities to include more'.

As Nye implies, technologies are not just utilised by people to sustain forms of life but also to enhance and improve existing forms of living. Early humans' development of a capacity to control fire greatly increased the availability of food sources. Pottery, textiles and mud architecture were also all significant technologies of their time. Similarly, the invention of the wheel around 4000 BC greatly helped people to move around and control their environment. In this sense of a technology that leads to significant improvement, the development of the wheel is certainly comparable to the development of the computer. Indeed, the notion of using technology as a means of improving previous arrangements lies at the heart of what we would see as more 'modern' technologies. For example, technological advances such as the printing press, the telephone and the internet all reduced physical barriers to communication and allowed people to interact on a worldwide basis. Even the development of technologies such as nuclear weaponry could be said to have followed this logic of making things better, albeit from a much more contested perspective.

These definitions all point to an understanding of 'technology' as something that is 'developed and applied so that we can do things not otherwise possible, or so that we can do them cheaper, faster and easier' (Volti 1992, p.4). Jon Agar (2020) also offers the distinction that all technologies have the essential property of 'intervening between scales'. For example, cars can help us move further (from 'body-scale' distances to 'road-scale' distances). Similarly, refrigerators expand the thermodynamic scales that we can make use of, and lightbulbs expand scales of luminosity. In this sense, contemporary digital technologies are especially notable in their capacity to work at very small *and* very large scales.

These ideas of 'doing things better' and 'intervening between scales' suggest that the term 'technology' refers to more than just material tools and artefacts that are designed and used to do something. This can be seen in the origins of contemporary uses of the word 'technology' in the ancient Greek word 'technología'. The first half of 'technología' relates to the Greek word 'techne', which can be variously translated as skill, art or craft. This itself reflects an earlier Indo-European prefix 'teks-' which refers to the process of

weaving or fabricating (as in 'textile'). The second half of 'technología' relates to the Greek suffix '-logía', which translates roughly as the understanding of something, or as a branch of knowledge. In this sense, the term 'technology' has always referred to the processes and practices of doing things, understanding things and developing knowledge. As Albert Teich (1997, p.1) reminds us, 'technology is more than just machines'.

Indeed, contemporary uses of the term 'technology' refer to far more than just machinery, devices and other 'non-human' material aspects of technology. By contrast, 'technology' is usually taken to also refer to the social contexts and social circumstances of the use of these machines, devices and artefacts (i.e. what can be termed the 'human' aspects of technology). Making sense of these human aspects of technology involves a number of important distinctions and definitions. For instance, Donald Mackenzie and Judy Wajcman (1985, p.3) suggest that technology can be seen in three ways:

- The physical objects themselves;
- The human activities that take place in conjunction with these physical objects;
- The human knowledge that surrounds these activities – that is, 'what people know as well as what they do'.

From this perspective, technologies are 'cultural' objects – part of bodies of knowledge shared between people and passed down from generation to generation (Goyder 1997). These latter aspects of 'technology' are implicit in the classic philosophical question: 'If an axe has had all its original parts replaced is it still the same axe?' (also known as 'The Ship of Theseus' paradox). While a totally reconstituted axe might be materially different, it can still look, feel and function almost identically. Moreover, the woodchopper who owns the axe will still be doing the same things with the axe, in the same contexts, under the same circumstances and with the same outcomes. As a technology, this axe certainly needs to be understood as more than the sum of its material parts.

This idea of technologies being more than just material artefacts is made clearer if we consider a contemporary technology such as the internet. While it is always important to pay due attention to matters of infrastructure, most people would agree that the internet is more than just the copper wires, fibre-optic cables, wireless connections, servers and processors that constitute the material networks that support the internet. Indeed, when people talk about the internet, they are far more commonly referring to the activities that they engage in online, the cultures and values that can be said

to surround these social activities, and the knowledge that results from these activities. In this sense, it is much more useful to describe the internet in terms of its 'social content' rather than its technical form (Wessels 2010).

One of the most straightforward ways to conceptualise the social and the technical aspects of technology is offered by Lievrouw and Livingstone's (2002) description of three distinct, interconnected aspects of what 'technology' is:

- **Artefacts and devices**: the technology itself and how it is designed and made;
- **Activities and practices**: what people do with technologies (including issues of human interaction, organising, identity, techniques and competencies);
- **Context**: social arrangements and organisational forms that surround the use of technologies (including institutions, social structures, cultures and beliefs).

We shall return to these different aspects of technology throughout this book. As well as encapsulating neatly the human *and* non-human aspects of technology, these three categories introduce the idea that technologies are not merely 'neutral' tools that people can use freely in any ways that they wish. Instead, technologies are an important part of the conditions of social life, often 'providing structure for human activity' (Winner 1986, p.6).

Of course, this idea of technology providing structure and setting conditions for human activity can be imagined in purely beneficial terms. We have already discussed how technologies have been developed and used to enhance the quality of life from the invention of the spear and the wheel onwards. Many commentators share the common expectation that present-day digital technologies continue to play similar roles in the distinct improvement of society. Indeed, some people go further than this, and argue that present-day digital technologies have significant potential for transformative change, not least in enhancing the capacity of individuals to act independently and to make their own free choices. Throughout the ages, emerging technologies have always provoked hope, optimism and enthusiasm for better things to come.

Yet, as we shall discuss throughout this book, it is important to adopt a balanced perspective on the potential benefits and presumed transformations of technology. In particular, any technology must also be considered in terms of limits and constraints that it imposes, as well as opportunities that it may offer for individual action and agency. Even what may appear to be

the most 'transformatory' technology can end up limiting the choices and opportunities available to some individuals. In particular, acknowledging the ways in which digital technology is connected with pre-existing organised structures of human activity can help us develop more detailed understandings of why different digital technologies are used (and not used) in education in the ways that they are. It is therefore important to acknowledge that digital technologies do not always change things in education for the better. Digital technologies do not always allow people to work more efficiently, or support people in doing what they want. Instead, digital technologies can often have unexpected, unwanted and unintended consequences, especially when used in education. Digital technologies are often linked to many other issues far beyond immediate concerns of the individual learner or classroom.

The strengths of conceptualising contemporary technology in this way are illustrated if we consider one of the most familiar educational technologies of the past hundred years or so – the textbook. In one sense, describing a textbook (like the one that you are reading at the moment) as *artefact* refers to the material book itself – its pages and covers, ink and paper. There are, of course, some very important issues relating to textbooks as artefacts, not least their portability and durability, as well as the environmental issues related to printing paper-based books. Yet if we also consider the *activities* and *practices* of using textbooks, then a number of other issues come to the fore. For example, the activity of reading requires certain skills and literacies that can advantage some individuals but disadvantage others. The practice of using textbooks in a classroom can also imply certain modes of teaching and learning – often passive, didactic and instructional, but perhaps learner-driven and imaginative. Textbooks can be used as starting points for discursive forms of learning, or simply as an end in themselves. As Norm Friesen (2017) reasons, textbooks are designed to become meaningful in conjunction with specific forms of educational engagement – for example, large lectures and classes, or perhaps solitary note-taking, annotation and other self-study practices. Even when used in modern, sophisticated classroom contexts, some teachers may well choose to teach 'to the text'. In some classes textbooks might be the sole preserve of the teacher, in others they will be distributed to every student.

Focusing on the *context* of the textbook as an educational technology introduces a set of further issues. For example, the content of textbooks is an especially contentious area. Often textbook content will reflect the notion of an 'official curriculum'. In countries where there is no official state-authorised curriculum, the textbook can itself 'become' the de facto curriculum. Often

the content of a textbook will imbue certain judgements, assumptions, values and perspectives on what is otherwise presented as 'objective' information. Much has been written, for example, about the selective tradition of textbook content where some voices are silenced and other voices privileged. Concerns exist over the promotion of stereotypes and values, such as the presentation of race, class, gender and disability. These issues are reflected in long-running debates over the tendency of history textbooks to privilege the 'voices of the victorious' – usually the accounts of white, European males. Indeed, there have been long-running debates over the tendency for textbooks to portray male-centred versions of history (criticised by some commentators as only telling '*his*-story'). Attempts have therefore been made to produce alternative texts focusing on '*her*-story' – that is, historical accounts that are written from feminist perspectives, that emphasise the role of women and that are told from women's point of view.

The wider context of the textbook as an educational technology also includes the role of commercial companies in producing and selling the books. Like all aspects of educational technology, textbook production certainly remains a big business. A company such as Pearson Education sells (and increasingly rents) over $4 billion worth of digital textbooks and curriculum materials each year. From this perspective, the politics of textbook production and sales are understandably complicated. In the United States, for example, some state governments and large school districts have significant leverage over the editorial decisions of publishers concerning what is written (and what is not written) in their books. Groups who have sufficient purchasing power to influence publishers' decisions can dictate the inclusion of information on contentious topics such as the theory of evolution, climate change, slavery or the rights and wrongs of abortion. As Michael Apple (1991) has argued, the textbook should be seen as a social and political issue – a source of 'official knowledge', as well as a source of commodification and commercialisation of what takes place in the classroom.

From 'Analogue' to 'Digital' Technology

These different aspects of the textbook as technology illustrate the diverse ways that familiar and ordinary instances of technology use in education are

linked to a wide range of social issues and factors. This is especially the case with the types of technologies that this book is concerned primarily with – contemporary forms of digital technology. Next, then, we need to define what 'digital' is and consider the wider practices, contexts, issues and factors that 'the digital' might be linked to.

Digital aspects of contemporary life are so frequently talked about that it is easy to lose sight of the origins of the word. In basic terms, 'digital' simply refers to discontinuous data, based on the two distinct states of 'off' or 'on' (or 0 and 1), with no value in-between. Digital computers, for example, are capable only of distinguishing between these two values of 0 and 1, but are able to use binary codes to combine zeros and ones into large numbers and other practical forms of information. In order to understand the significance of digital data, it is important to understand its opposite – that is, analogue data. 'Analogue' refers to data that can be measured as a continuously varying value. The most commonly cited example of analogue data is the hands of a clock that move continuously around the clock face to provide an ongoing measurement of time. A digital clock, in comparison, is only capable of presenting a discontinuous series of numbers denoting time with a gap between each value (every one hundredth of a second, for example).

Alexander Galloway (2015) argues that the defining characteristic of 'digital' technologies therefore lies in their capacity to first split and divide things, and then to reassemble them (usually in forms that appear to be unaltered). The essence of digital technologies, therefore, could be said to lie in ones and twos (rather than zeros and ones) – specifically 'the one dividing into two' (Galloway 2015, n.p.). At first glance, the disassembled and reassembled nature of digital objects might appear unimportant. Yet these distinctions are crucial in explaining why digital technologies are often perceived to be 'different' (and many people would argue 'better') than what came before them.

The difference of digital technology is something that people often find difficult to put into words, yet usually relates to the fact that digital technologies essentially facilitate the simulation of the ways that real-life things look, sound and feel, while at the same time processing information at a scale, spend and complexity that was previously impossible. Many people are able to discern (if only faintly) the aesthetic differences of these digital simulations, while marvelling at their instantaneous nature. In particular, it is important to remember that from a physiological and psychological point of view, humans generally experience the world in analogue form. For example, vision is a response to the ever-changing

intensity and wavelengths of light. Similarly, sound is made when objects vibrate producing continually fluctuating pressure waves that can be picked up by our ears. Nevertheless, as the example of the digital clock suggests, most analogue events can be simulated through digital information. Thus, while they might not be able to fully explain why, many people would agree that there is a difference between hearing something in 'real life' and hearing a digital audio recording, or comparing a digital photograph with its old-fashioned chemical equivalent. While we might become inured to experiencing things in digital form, simulating the real world through billions of pixels is a qualitatively and quantitatively altered process that will often feel slightly 'different'.

Such aesthetic differences notwithstanding, it is understandable why most people consider digital technology to be an improvement on previous analogue ways of doing things. First, digital information is far easier to store and distribute electronically. Digital information is dense and compressible, meaning that a great deal of digital data can be stored in a small physical space. Moreover, digital data is easier to manipulate accurately than 'real-world' analogue data. The contrasting manipulability of analogue and digital information is illustrated by the lengths that one has to go to alter the appearance of a conventional photograph as opposed to a digital image on screen. Digital data is much more easily controlled, altered and stored. Digital processes are seen to be instantaneous and infinitely replicable. Perhaps most significantly, it is much cheaper to distribute and sell large amounts of digital data. Digital technologies have obvious logistical *and* commercial benefits.

All of these technical advantages have led to the idea of 'the digital' being associated with a number of wider qualities and characteristics – not least the general perception that digital technologies are more precise, more accurate and more efficient than analogue machines and methods. Digital technologies certainly allow processes and activities to take place on far greater scales than before, in considerably quicker and more replicable ways. Crucially, digital technologies and digital practices are seen to give more control and flexibility to the individuals that use them. Digital technologies are therefore associated with significantly enhanced and improved ways of doing things. As far as many people are concerned, digital technologies have ushered in a new and transformed era of living – the so-called digital age.

As such, the need to continue making distinctions between the 'digital' and 'non-digital' is now increasingly questioned. Indeed, labelling something as 'digital' in the 2020s might come across as somewhat old-fashioned. It

could be argued that we are now living in times where digital technologies, systems and processes are barely noticeable and simply part of the contemporary social milieu. As Nathan Jurgenson (2011) contended at the beginning of the 2010s, perhaps it is time to move on from the 'digital dualism' of distinguishing between digital and analogue, online and offline, real world and virtual work, and so on. A decade later, many academic accounts are keen to frame contemporary society as an entanglement of the physical and the digital, people and machines, code and cognition. Many people are therefore now happy to accept that we have reached a point where talking about digital technology is redundant. Surely everything now has 'digital' aspects in one way or another?

Like many critically minded accounts, this book continues to talk about 'digital' technology in order to remind us of important issues of difference and disadvantage. In short, it is important to continue to deliberately emphasise 'digital' technology as a reminder that any idea of society being seamlessly digital is highly problematic. Indeed, we continue to see huge disparities in people's access to digital technologies. There are also entrenched differences in people's experiences of digital technologies – especially the extent to which different social groups are advantaged and empowered by the digital technologies in their lives. All told, continuing to talk about 'digital technology' and 'digital education' reminds us that the digital is not a topic that we can afford to stop thinking critically about. Instead, there is a heightened need to continue highlighting the flaws, glitches, gaps and breakdowns in the societal conditions that persist long after the initial hype from the 1990s and 2000s over 'cyberspace' and 'new media' has faded away (see Jandrić et al. 2019).

Making Sense of Digital Technologies in Education

We will return to these specific distinctions and arguments throughout the book. For the time being, we can conclude this chapter with some broader definitions and questions. As already discussed, this book is concerned primarily with digital technologies rather than 'pre-digital' technologies such as the textbook or pen. In this sense, much of what we shall go on to discuss relates to what might have been previously referred to as 'information and communications technology', 'computerised technology' and other variations

on the 'information technology' label. In a technical sense, all of these terms refer to computer-based systems – particularly software applications and computerised devices – that can be used to produce, manipulate, store, communicate and disseminate data. Put simply, then, the umbrella term of 'digital technology' refers to a range of different aspects of contemporary technology use in education, including:

- Computerised devices with an ability to access, modify, store and share data – for example, smartphones, laptops, tablets and desktop computers.
- Other electronic devices with an ability to create, transmit and view data – for example, digital cameras, wearable technologies (such as smartwatches, activity trackers) and sensors embedded into everyday objects and settings.
- Display technologies capable of displaying digital data – for example, projectors, smart boards, holograms, 3D displays and optical head-mounted displays.
- Systems software that controls and operates computer hardware, as well as supporting the running of applications software – for example, operating systems and user interfaces.
- Applications software that helps users perform an activity – for example, word processors, spreadsheets, search engines, games and computer-assisted design.
- Simulation software – for example, xR (cross-reality) technologies such as virtual reality, mediated reality and augmented reality.
- Data processing tools and techniques – for example, data mining, analytics and algorithms.
- Artificial intelligence (AI)–based tools and systems – for example, intelligent systems, recommender systems and chatbots.
- Physical robotics – autonomous 'social robots' and 'companion' robots, tele-operated and controllable machines – for example, drones and telepresence robots.
- Additive manufacturing technologies capable of processing digital data in physical form – for example, 3D printing.

This list is by no means exhaustive, yet these examples highlight a number of characteristics of digital technology use that have emerged into education settings over the past thirty years. One of the defining features of these forms of technology is that they draw upon what can be termed as a 'networking' logic. This is apparent, for example, in the networked connections that the

internet and mobile telephony support between people, objects, organisations and information regardless of space, place or time. As Kevin Kelly (1995, p.201) noted over twenty-five years ago, 'the central act of the coming era is to connect everything to everything … all matter, big and small, will be linked into vast webs of networks at many levels'. While not as equitable or all-encompassing as Kelly anticipated, the subsequent integration of networked technologies into many aspects of everyday life has prompted subsequent claims of a 'culture of connectivity' being a defining feature of contemporary society. This connectivity can be seen both in terms of the 'connectedness of human users' *and* the recent 'automated connectivity of platforms' through flows of data and complex algorithms (van Dijck 2015, p.2). Developments such as these are generally understood as having profound effects on everyday life. As Stig Hjarvard (2020, p.259) contends, 'The advent of a new and global digital infrastructure has both challenged existing organizational forms and helped build new and more network-oriented forms of collective association.'

Another defining feature of these digital technologies is that they are increasingly social in nature, as evident in the continued popularity of 'social media'. Of course, it can be argued that the idea of 'social media' is not new. As Linder and Barnard (2020) remind us, 'all media are social' inasmuch as they foster communication. What distinguishes recent digital technologies is their capacity to support forms of 'mass socialisation'. In this sense, the full potential of many of the digital technologies just listed relies on the collective efforts of their users. Many of the most popular online services and applications rely on content that is authored, curated, critiqued and reconfigured by a mass of users. In this way, much online technology use is based upon an interactive and participatory ethos – as Danah Boyd (2015, p.1) puts it, supporting contexts for mass interaction that 'help people connect and collaborate, socialize, and coordinate'.

As will be discussed throughout subsequent chapters, many of these technologies also fit with a distinct logic of 'platformatisation'. This is certainly evident in the ways that schools and universities are now often reliant on large software systems and platforms – such as 'learning management systems' which are used to act as intermediaries between students, their teachers and the broader official institution. These systems are used to host access to resources, as a site for communication and social exchange, to support monitoring of attendance and engagement of work, as well as uploading and grading of assignments. These platforms are integral to the long-term organisation and planning of a school or university, as well

as a key determinant of day-to-day decisions within every classroom. As such, the adoption of these systems in schools and universities reflects the rise of the 'platform' as the dominant infrastructural and economic model of many aspects of everyday life in the 2020s (Helmond 2015). Indeed, it is argued that we now live in a 'platform society' where all areas of public and private life are permeated by platforms (van Dijck et al. 2018). One can certainly see a dominance of platforms in sectors of society such as news and journalism, retailing, hospitality and transportation. In this sense, education is following a well-worn trend. As will be discussed in later chapters, we need to give careful thought to how 'platform logics' increasingly shape the nature of what is done in education – from the types of work and interactions that students and teachers engage in, through to the ways in which educational processes are controlled by 'outside' interests.

One further defining feature of many of these digital technologies is the generation and processing of data. For example, vast amounts of data are generated, stored and shared through the use of many of the digital technologies listed earlier. This data is becoming an important part of how digital technologies now operate. Computational tools are being developed to facilitate the processing of 'big data' where vast data sets are joined together and analysed through large-scale and complex calculations based around the use of algorithms, analytics and data mining. These mass applications of data carry the promise of what David Beer (2019, p.22) has termed the digital 'data gaze' – that is, the promise of inherently 'speedy, accessible, revealing, panoramic, prophetic and smart' ways of knowing and acting through the comprehensive analysis of data. Such ideas build upon established computational theories in fields such as data science and computer science that seek to harness the power of mathematical modelling, statistical analysis, feedback and algorithms. For example, as shall be explored in later chapters, the application of such techniques to modelling learning and other educational processes is currently the focus of considerable interest.

All of these trends look set to continue into the near future, reflecting the ongoing development of digital technology. Take, for example, the increasing capacity of digital technology to store and process data. Over the past few years even the most casual technology users have witnessed their use of data storage progress from talk of 'megabytes' and 'gigabytes' to 'terabytes' and 'petabytes' of information (or, if you prefer, from millions of bytes to many trillions of bytes). This expanding capacity for storage and connectivity means that the built-in capabilities of technologies has become less important

than their ability to connect to more powerful devices and systems elsewhere. Such advances will continue to be accompanied by the 'ubiquitous' placement of digital technologies throughout the environment. The advance of flexi-screen technology, for example, now allows miniature and disposable devices to be embedded in everyday objects such as clothing and paper. This embedding of digital technologies into social settings is sometimes referred to as the 'Internet of Things', where internet-connected sensors and data generation devices are integrated into everyday physical objects, machines and appliances, humans and other living entities.

All these advances suggest that day-to-day life for many people around the world will increasingly be arranged around interactive, individualised digital technologies in the same way that many people's lives throughout much of the twentieth century were shaped around mass broadcast technologies of the television, telegraph and radio. We will return to the future educational implications (and limitations) of these technological developments in Chapter 8. Suffice to say, while it may be relatively straightforward to foresee the technical form and function of digital artefacts over the next few years, gaining a sense of the associated social practices, activities and wider contexts of use is far more difficult, if not impossible.

Conclusions

At first glance it might appear that this chapter has little immediate relevance to the key issues, concerns and debates surrounding technology use in education. Indeed, while we have talked much of 'education' and of 'technology', there has deliberately been little consideration of how the two concepts come together. Instead, this chapter has taken the necessary step of disengaging ourselves from our own personal experiences of the digital age and, instead, beginning to think dispassionately about the role of technology in society. Often social scientists refer to this process as 'making the familiar strange' – an awkward but necessary initial stage of any objective analysis.

This chapter has also attempted to take a step back from the day-to-day minutiae of technology use in education, and instead develop a solid basis for reconsidering and re-evaluating the topic of educational technology. First, we have made a case for a broad and societally aware definition of what 'education' is – covering a wide range of issues above and beyond formal learning in a classroom. Similarly, we have made a case for

developing more precise understandings of what technology is. This should allow us to avoid the limitations that often befall discussion of education and technology. As Martin Oliver (2016, p.35) observes, this is a topic of discussion that often:

> makes many claims about technology's effects, but rarely asks what technology is. This is a dangerous oversight; it leaves us with inadequate accounts of the role of technology, and we risk simply cataloguing a series of outcomes without really understanding what is happening or why.

At this early stage in the book, it seems sensible to conclude that our subsequent discussions of education and technology need to cover much more than the material technologies and tools that are used in educational settings. Moreover, we clearly need to move beyond seeing digital technologies simply as neutral tools that are used in benign ways within educational contexts. Like all other technologies, educational technology is linked intrinsically with social, cultural, economic and political aspects of society. In particular, this chapter has highlighted the benefits of approaching educational uses of technology in terms of practice and context. In other words, educational technology is less a matter of devices and applications, and more a matter of what is 'done' with these devices and applications – that is what can be referred to in terms of practices and meanings. From this perspective, it is worth returning to Lievrouw and Livingstone's (2002) framework and restating our interest in the use of technology in education along the following expanded lines:

- **Artefacts and devices**: digital technologies themselves and how they are designed and made before they reach educational settings;
- **Activities and practices**: what people then do with digital technologies in educational settings and/or for educational purposes (including issues of human interaction, organising, identity, techniques and competencies);
- **Context**: the social arrangements and organisational forms that surround the use of digital technologies in educational settings and/or for educational purposes (including institutions, social structures and cultures).

It will be useful to keep these distinctions in mind throughout the remainder of this book. Before moving on to Chapter 2, it might also be worthwhile to begin to consider the different types of questions about education and technology that these distinctions raise. Take, for instance,

the following questions that media critic Neil Postman (1997) proposed should be asked of any new technology in society. While Postman was primarily concerned with the increased use of computers and the internet during the 1990s, his questions hold up remarkably well for the technologies of the 2020s:

- What is the problem to which a technology claims to be a solution?
- Whose problem is it?
- What new problems will be created by solving the old one?
- Which people and what institutions will be most harmed by this new technology?
- What changes in language are being promoted by these new technologies?
- What shifts in economic and political power are likely to result from this new technology?
- What alternative uses might be made of a technology?

Postman's points of contention are also reflected in a set of more recent questions posed by Tressie McMillan Cottom. These echo Postman's interest in moving beyond any initial interest in the potential of new technology, and turning our attention towards finding out exactly what can (and what cannot) be done with that technology. Most importantly, Cottom encourages us to also progress onto more important questions of what *should* be done with this technology. As Cottom (2019, p.24) reasons, this then leads to a set of more complex final questions:

> Who is the 'we'? What resources, power, and legitimacy do 'we' have to do what should be done? When we think about what we should do as opposed to what we can do, we get into questions about ethics, fairness, and justice and their intersection with learning technologies.

Both these authors point to a range of issues, ideas and approaches that should be taken forward into the remainder of this book. For example, Cottom and Postman each alert us to the importance of thinking of alternatives and how to do things differently. Moreover, both sets of questions also highlight the uncertain and contestable nature of technology change, as well as suggesting that technologies are not neutral, but rather promote certain values, interests and agendas over others. These questions also alert us to diverse ongoing interactions between technology and society, economics, politics and culture. Moreover, these questions foreground the likelihood that any intended outcomes of technology use will be accompanied by unintended

(or perhaps simply unacknowledged) consequences of technology use. Yet, perhaps the most important areas of critique that Cottom and Postman both invoke are that of use and usefulness. Why do we actually need to be using digital technologies in education? How exactly is the use of digital technologies impacting and changing education? Is this even a sensible way to think about the relationship between education and digital technology? All of these questions will now be explored in Chapter 2.

Further Questions to Consider

- What instances of digital technology use in education can you think of that are *not* concerned primarily with learning and/or teaching? What issues and processes do these technologies address? How is the use of digital technology reinforcing or altering these issues and processes?
- How do the issues raised in our discussion of the paper-based textbook relate to the relatively 'new' technology of the digital textbook? What additional issues does the digital textbook introduce? What existing issues remain, or are even amplified in the shift from using paper textbooks to digital textbooks in education? Remember to think about the activities, practices and wider contexts of digital textbook use, alongside the actual artefacts (hardware and software).
- Digital technologies are often celebrated in terms of their speed, size and storage capacity. To what extent are the perceived advantages of digital technologies related to matters of quantity rather than quality? What limitations or even disadvantages can be associated with the 'digitisation' of educational practices and processes? What aspects of education might not be easily simulated in digital form?

Further Reading

Further discussions of the nature of education and learning can be found in the following books:

Biesta, G. (2020). *Educational research: an unorthodox introduction*. Bloomsbury

Matheson, D. [ed.] (2014). *An introduction to the study of education*. [4th edition] David Fulton.

Eric Schatzberg and David Nye are well-known social historians of technology. In these books, they develop wide-ranging and informative overviews of key theories and ideas about technology:

Schatzberg, E. (2018). *Technology: critical history of a concept*. University of Chicago Press.
Nye, D. (2007). *Technology matters: questions to live with*. MIT Press.

Many authors have written about digital technology and the nature of 'the digital'. Both these books provide accessible accounts of the nature of digital media from a social science perspective:

Lingren, S. (2018). *Digital media and society*. Sage.
Siapera, E. (2018). *Understanding new media* (second edition). Sage.

2

Making Sense of Technology and Educational Change

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Introduction

Despite a notable cooling-off of societal excitement and enthusiasm for all things 'high-tech' over the past ten years, many people would probably still go along with the assumption that digital technology is a largely beneficial part of contemporary education. This mirrors the general sense that digital technologies are leading to widespread transformations in most areas of society. Relating back to Jon Agar's (2020) definition of technology 'intervening between scales', digital technology development is widely seen to have heralded a 'change of scale now affecting life on the planet. … The planet is being urbanized, equipped and reorganized' (Augé 2014, p.47). These shifts include new modes of employment and forms of digital labour, the increasing dominance of global markets based around the sale of technology and data, and the interests of transnational companies exceeding those of nations. As we saw in Chapter 1, many

accounts of the digital age are based on generally optimistic expectations of these developments and a general hope driven by the allure of 'the new'.

Many people are happy to presume that the increased use of digital technology in education will progress along broadly similar lines of reorganisation and transformation. Indeed, it is possible to point to evidence of digitally driven change across most areas of contemporary life. For example, digital technologies do appear to be hastening a 'flattening out' of hierarchies and the introduction of a 'networking logic' to the arrangement of many aspects of society. These changes do seem to be leading to the open (re)configurations of social relations and organisational structures. Put simply, large bureaucratic organisations that prospered during the twentieth century are believed to be losing much of their significance and power in the face of the fast-paced and fluid nature of 'digital' processes and procedures. In this sense, why should schools, universities and other educational institutions be any different?

Such transformations are not only taking place on a broad society-wide basis. Digital technologies are also seen to be introducing distinctly 'individualised' ways of doing things in everyday life. Growing numbers of processes and practices are now centred around the needs of individuals rather than the demands of large institutions and organisations. Some commentators contend that digital technologies are bringing people together in different ways that allow individuals to do things for themselves without the involvement of organisations and official institutions. For example, strong claims are now made regarding the role of digital technologies in enriching and enhancing people's personal connections (Ragnedda and Ruiu 2020). Elsewhere, optimistic claims are made about powerful forms of digitally supported global 'cosmopolitanism' based on international exchanges and intercultural affinities (Elkins 2019, Zuckerman 2013). There are various reasons to get excited about what appear to be fast-changing times.

Even if we discount the more idealistic aspects of such accounts, many people continue to hold essentially optimistic views of the ways in which digital technologies are changing key aspects of our lives – not least in terms of education and learning. Indeed, the central concerns of education and learning (e.g. the production and dissemination of knowledge, interactions with others) could be said to be interlinked closely with some of the main functions and processes of digital technologies. Surely, then, the increased

use of digital technology throughout education is a largely welcome development.

These apparent affinities and overlaps have led many people to consider education an area that is ripe for technology-based change and improvement. Yet such assumptions are not straightforward. We need to think much more carefully about the types of educational changes that tend to be associated with digital technologies, and why the actual consequences of technology use often end up being more inconsistent and unpredictable than expected. This raises the need for more socially nuanced approaches to understanding the relationships between education and technology. In this chapter, we expand on some important issues introduced in Chapter 1 that can guide our discussions in subsequent chapters – notably, issues of contexts, politics and values. There is a lot of ground to cover here. So first off, we can start by mapping some basic beliefs and assumptions – how and why do people believe that education changing in this era of digital technology?

Popular Expectations of Digitally Driven Changes in Education

Digital change in education is usually anticipated along a number of different lines. First is the idea that digital technology has clear potential to change various aspects of education for the better. In other words, there are 'internal' imperatives for the increased use of digital technology within educational settings. Second is the belief that the rise of digital technology elsewhere in society necessitates corresponding changes in education. In other words, the general digitisation of society prompts 'external' imperatives for education to 'catch-up' and make increased use of digital technology. Third is the sense that technology heralds an inevitable 'disruption' to the educational status quo.

Some of the most immediate rationales and reasons for the increased prominence of digital technology in education relate to basic ambitions to improve education – what was just referred to as 'internal' issues and pressures. In particular, many academics and practitioners believe technology to be capable of improving the core processes of education. For example, it is argued that digital technologies allow learning to take place

within collaborative and supportive social contexts, as well as increasing individuals' control over the nature and form of learning processes. Digital technologies are welcomed as invaluable tools for teachers – supporting classroom processes and providing access to resources and professional development around the world. Looking beyond the benefits for individual students and teachers, other 'internal' educational advantages of digital technologies are seen to include improved organisational effectiveness of educational institutions – instilling business-like efficiencies in how schools and universities operate, as well as improving key 'outcomes' such as examination results, retention rates and students' progression on to higher levels of study.

Another significant organisational benefit of digital technology is seen to be the more efficient delivery of education. In particular, one of the most obvious advantages is the use of digital technology for 'breaking boundaries' and allowing schools and universities to operate beyond 'the four walls of the classroom' (Campbell 2015, p.108). In this way digital technologies are popularly seen as widening access to education, supporting a diverse provision of educational opportunities from which individuals can choose. Such changes are seen to allow greater numbers of people to participate in a wider range of learning than was previously possible. In particular, the increased choice associated with technology-based education is believed to increase inclusion of social groups who might otherwise find it difficult to engage in education. The distribution of educational opportunities via technology, it is suggested, can help overcome barriers that otherwise deter people from taking part. Digital technologies may do this by making learning provision more flexible, reducing costs, making learning more accessible, offering reliable and accessible information, and allowing people to learn on an 'Any Place, Any Pace' basis. These shifts are seen to support more democratic forms of educational access. As former UK prime minister Gordon Brown (writing with the founder of the 'edX' MOOC Anant Agarwal) argues,

> With the power of technology, we can reduce current economic disparities and become the first generation in history to have made universal, lifelong education a reality. (Brown and Agarwal 2019, n.p.)

Of course, the push for digital technology in education also stems from a range of interests and agendas outside of the education profession – not least policymakers, the IT industry, employers, education reformers and parents. One of the most immediate 'external' imperatives for the educational use

of digital technology is seen to be the straightforward priority of 'keeping up' with the rest of the modern world. As we discussed in Chapter 1, the increasing complexity of technology development has been accompanied by a corresponding growth in the use of digital technologies across most areas of life. Yet many people feel that educators and educational institutions are noticeably 'behind the times' in comparison to technology adoption in other sectors of society. This creates an imperative for educators to respond to technological advances – as Rose Luckin (2019, p.39) puts it: 'We do risk being left behind unless we respond … and accept EdTech as an inevitable and much-needed support to the progression of teaching and learning.'

Of course, the imperatives for education change are not just based around concerns of remaining 'up to date' with technology for its own sake. Many people would argue that education faces ongoing pressures to respond to the economic changes associated with digital technology, not least developing the knowledge and skills required in the post-industrial economy. Aside from issues of economic success and 'employability', the ability to use digital technology is also considered to be an essential life skill for individual citizens to be able to effectively participate in civic affairs and other community activities. In a more immediate sense, it is also argued that the use of digital technologies is now expected by current generations of young people who are now entering schools, colleges and universities (and who were born into an era of the internet and smartphones). All these pressures and demands have certainly prompted considerable efforts by politicians and policymakers to bolster the use of digital technology in education. Regardless of a country's social or economic circumstances, digital technology has played a key role in how people have talked about the improvement and modernisation of education systems over the past twenty years or so.

Many people presume that these internal and external imperatives will continue to encourage educators and educational institutions to steadily increase their use of digital technology. Yet, an alternate view is that traditional forms of education will not be transformed easily by digital technology. These arguments relate to a buzzword that resonated throughout discussions of education and technology during 2010s: 'disruption'. Indeed, the idea of 'disruption' continues to be a popular way to describe technology-led change in the 2020s – from high street retailing to the newspaper industry (see Daub 2020). For many people, the idea of digital disruption is equally as applicable to education. For example, in its discussion of the 'reinvention of the university' through the 'creative destruction' of digital technology, *The*

Economist (2014, n.p.) concluded bluntly: 'The internet, which has turned businesses from newspapers through music to book retailing upside down, will upend higher education.'

As words such as 'disruption', 'destruction' and 'reinvention' suggest, these are highly provocative propositions. Some people reason that educational institutions have little choice but to make significant adjustments to their 'traditional' arrangements. In this sense, digital change that can be perceived as a 'game-changing opportunity' for 'agile' and digitally responsive organisations and an 'existential threat' for others (Vial 2019). As the veteran online learning advocate Tony Bates (2004) put it, this view positions educational institutions as simply having to 'transform or die' in the face of technological progress. An even more radical view is that digital technology effectively renders most established arrangements of education provision obsolete and redundant. In other words, educational institutions look set to 'die' whether they change or not. While this might appear to be extreme rhetoric, statements about the digital 'disruption' of schools and universities continue to be made frequently in mainstream popular and political debates about the likely future of education.

Overestimating Technological Change in Education

These are bold and far-reaching propositions, yet need to be approached with a degree of caution. Surely such changes cannot be *totally* inevitable, or *wholly* beneficial? At this point, we need to be careful to avoid what was referred to earlier as an 'unquestioning acceptance' of popular assumptions of technology and educational change. Instead, we need to pay close attention to the significance and nature of the changes implicit in these claims about education and the presumed 'imperatives' and 'innovations' of technology. As such, there are a number of caveats to consider amid such talk of educational change and disruption. Everything described in this chapter so far should be treated with caution. These are persuasive ideas that nevertheless merit robust scrutiny.

It is fair to say that none of these touted imperatives and disruptions have fully transpired. Even the most enthusiastic proponents would concede that the realities of digital technology use in education often fail to match the rhetoric. While the past few decades may have seen the increased presence

of digital technologies in schools, colleges and universities, the much-promised technology-led 'transformation' of educational processes and practices has failed to be fully realised. Inefficiencies, inequalities and injustices continue to persist across education systems. For every case study of innovative technology use, there are many other instances of the same technology being used to little or no effect. Although digital technologies and other personalised technologies may well have potential to support students, educators and institutions, it seems that this potential is being realised only on occasion. As Martin Oliver (2016) observes, seasoned observers are often left with a nagging sense of having 'seen it all before' when presented with the latest technological innovation that eventually goes on to have an inconsistent impact on actual educational practice.

This has led some commentators to contend that educational technology is beset by a recurring cycle of hype, hope and disappointment. The past forty years has seen a steady succession of innovations that failed ultimately to deliver on the promises initially made on their behalf. For example, the 1980s were times of high hopes for the transformatory effects of technologies such as the Logo programming language – described by its inventor as destined to 'blow up the school' (Papert 1984). Similarly, the 2000s saw MIT's audacious 'One Laptop Per Child' (OLPC) plan to distribute millions of notebook computers to the world's poorest children eventually fade into little more than a 'cautionary tale about technology hype' (Ames 2019, p.17). The 2010s saw this cycle continue – including the exaggerated promises of educational transformation associated with technologies as diverse as 'brain training' games, 3D Printers and 'interactive whiteboards', as well as promises of 'massive open online courses' (MOOCs) leading to free and democratised access to high-quality higher education. All of these technologies were extensively taken up in the short term, but ultimately failed to result in sustained impacts – living up to what Larry Cuban (2001) once described as the tendency for new educational technologies to be 'oversold and under-used'.

This is not to say that these digital technologies have had no impact on education at all. On the contrary, the adoption of digital technologies is clearly having a significant influence on how education now takes place. It is hard to imagine learning without laptops, Google and word-processing. Resources such as Wikipedia and YouTube are the first places that many people turn to for information research and learning new things. Live video streaming has become a familiar part of university classes. Yet while digital technologies are altering the nature of learning and teaching, the resulting

changes often do not match the spectacular transformations that many EdTech developers and vendors would have us believe. This is perhaps unsurprising if we think about the nature of education in general. As Michael Fullan has observed, educational change is not a straightforward process. Not everyone benefits from an educational innovation in the same way, and (from a more practical perspective) the consequences of educational change are often difficult to assess. Indeed, we cannot simply assume that technological change is an inevitable force for good in education. As Fullan (2007, p.6) reminds us, 'change is not necessarily progress.'

Clearly, then, it can be difficult when discussing education and technology to make full sense of the diverse ways that technologies are used in education, and with what consequences. So why might this be? This disjuncture between the rhetoric and reality of technology use in education points to a number of issues that we need to bear in mind throughout the rest of this book.

Technological Solutionism

This gap between how technology *could* be used and how it *actually* ends up being used highlights the dangers of imagining new technologies as ready solutions to existing education problems. Much of the enthusiasm for education and technology outlined so far in this chapter reflects a recurring belief in technology as some sort of corrective or 'technical fix'. As Sean Johnson (2018) points out, faith in a pre-digital 'technological fix' peaked in the 1960s when there was development of nuclear power and space technology, along with other innovations of the Cold War period. This momentum has continued into current beliefs of 'technological solutionism' through AI, biotechnology and other innovations. At the same time, the history of education has also been long characterised by attempts to use the 'power' of technology in order to solve problems that are non-technological in nature (Robins and Webster 1989). This has been accompanied by a tendency to ignore the often-ineffective or damaging outcomes that can result from technology use.

Nevertheless, people continue to be drawn towards the idea of digital technology offering a ready solution to the major problems that blight contemporary education – from social injustices to classroom overcrowding and school underfunding. An extreme example of this logic is the recent

push for digital technology 'solutions' to mitigate school shooting incidents in the United States. The past ten years has seen the development of bulletproof whiteboards, object detection surveillance systems, social media monitoring systems and even 'first-person' role-playing video games where teachers can act out the role of being a school shooter. At best, these technologies could be seen as ambitious and innovative attempts to address a horrific problem. However, it could be contended that these products unrealistically imagine the capacity of digital technology to affect change, and distract attention away from the realities of contemporary problems in the United States regarding gun culture, mental health, racism and the multiple other contributing factors to the 'problem' of school shootings. There are many shortcomings in education that cannot be overcome by simply introducing more technology.

Of course, people's continued willingness to turn to technology as a ready way out of such problems is understandable. In making sense of the OLPC initiative, Morgan Ames (2019) raised the notion of 'charismatic technology'. This describes the ways in which new technologies gain traction through the promised association of impressive technical progress with equally far-reaching social progress. Education is certainly an area where 'charismatic' technologies raise hopes that seemingly entrenched problems might perhaps be overcome. A similar argument is offered by Christo Sims (2017), who points to a 'sincere technological idealism' among many technologists (often with no previous educational experience) who genuinely feel that they can make a difference and 'do good' by applying new technologies in education. Sims contends that these technologists tend to underestimate the education 'problems' that they have identified because they approach education through a technical mindset – leading to a 'tunnel vision' where attention is only paid to aspects of education that fit with the tools that are being developed. This analysis echoes Abraham Maslow's aphorism that 'when you have a hammer everything looks like a nail'. Sims argues that this narrowness of perspective tends to marginalise concerns for the wider social contexts that shape schools and universities, and often glosses over issues of wider structural inequalities altogether. In this sense, regardless of the good intentions of innovators and the technical sophistication of their products, the resulting implementation of new technologies in education rarely matches their expectations and promises of improvement.

It therefore makes sense for anyone who is studying education and technology to steer clear of assuming that digital technology has the ability

to change things for the better. History reminds us that technical fixes tend to produce uneven results – rarely resulting in similar outcomes across populations and often replacing one social problem with another. Even when a technology is seen to 'work', then it can be difficult to ascertain why, especially when the application of that technology has been accompanied with other (non-technological) interventions. Often technical 'solutions' will deal only with the surface manifestations of a problem rather than its roots. Indeed, the social problems of education are usually distinctly different (and more complex) than most of the technical problems of education. Social problems tend to be much less specific and bounded in nature, with many different causes, and do not operate within a closed system. In short, we should not assume that the social issues surrounding education are easily 'fixable' via technology. As Megan Erikson (2015, n.p.) concludes, 'education is not a design problem with a technical solution'.

Technological Essentialism

Implicit in many of the benefits, improvements and changes outlined at the beginning of this chapter is an underlying assumption that digital technologies have consistent, durable qualities regardless of when, where and for what purposes they are being used. This way of thinking can be termed 'technological essentialism' and lies behind three common-sense ways of thinking about technology. First is seeing technologies as distinct from the social and historical conditions from which they emerged ('ahistoricisim'). Second is the claim that the essence of technology somehow resides beyond the humans that develop and use it; in other words, technologies function in an autonomous manner that is largely outside of human control ('substantivism'). Third is the belief that all technological devices express the same essence ('one-dimensionalism'). These understandings of technology tend to result in one of two responses: either 'an uncritical embrace of the totality of technological devices' or 'a technophobic rejection of technology *tout court*' (Thompson 2000, p.432).

These ways of thinking continue to underpin a surprising number of conversations about digital technology and education. As Laura Forlano (2019, p.12) notes, 'digital essentialism still haunts many studies of emerging technology today', even the simplistic assumption that 'digital' technologies are inherently quick, precise and/or convenient. As such,

many of the justifications and 'imperatives' for using digital technologies outlined earlier in this chapter imply uses and outcomes that are universally possible regardless of local context. This can lead to some rather broad-brush assumptions about how technologies might 'work' in education. For example, the OLPC initiative proposed at one point to drop laptops into impoverished villages by parachute, so that children could simply pick them up and start learning. This extreme mindset is not too different from the idea of the 'one-to-one' classroom, where the main challenge is seen to be ensuring that every student has their own personal device – after this point, it is generally assumed that 'learning' will occur.

Of course, while they might look the same from the outside, laptops, smartphones and other digital devices do not have consistent educational or social qualities that exist prior to being used within a specific setting. The same make and model of a tablet computer can function in substantially different ways in different classrooms and with different groups of students. There is no 'core essence' or 'inner truth' within an iPad that determines how it will be used in school classrooms in a particular way. Instead, it is important to remain mindful of the ways in which people bring technological objects into being. As such, it is perhaps best to reframe what might instinctively be termed as 'technology use' in more nuanced terms of 'technology enactment' (Mol 2002, Seaver 2017).

This distinction is reflected in the problematic ways that people often talk about the 'affordances' of particular technologies in education. It remains common to hear talk of 'essential learning affordances of digital information objects' (Neuman et al. 2019) or 'designing digital learning affordances' (Aguayo et al. 2020) as if these are essential qualities that can be 'baked-in' to a technology and subsequently triggered by any user. Indeed, Jesper Aagaard (2018) contends that the field of educational technology has erroneously taken the idea of affordances in a literal sense to mean actions that are technically possible. Instead, the idea of affordances originated as a far more complex concept in fields such as evolutionary psychology and design studies. As Dan Norman (2013, p.13) puts it, 'many people find affordances difficult to understand because they are relationships, not properties'. In other words, the idea of 'affordances' does not relate to functions and outcomes of technology use that are universally possible. Instead, they relate to 'accomplishments' that *might* be possible within the confines of the structurally situated and contextually bound nature of any instance of technology use (Vertesi 2019).

The need to move away from simplistic ideas of technologies having essential qualities and inherent affordances is beginning to be widely recognised outside education. Jenny Davis (2020) makes the powerful point that we should not be simply thinking about what technologies afford. Instead, the key questions are about how technologies afford, for whom and under what circumstances. Davis (2020) describes this in terms of 'mechanisms' and 'conditions'. Seen along these lines, educational technologies might be said to work in ways that encourage, allow, request or demand particular forms of action (mechanisms). At the same time, they might also discourage or refuse other forms of action. What is important, however, are the conditions in which the technology is used. These conditions work to shape how these mechanisms are experienced by different individuals in different contexts. These conditions might include individual perceptions and dexterities, as well as broader issues of cultural and institutional legitimacy. Whether or not a technology results in learning therefore depends upon a lot of factors above and beyond the properties of the technology itself.

Technological Determinism

All of these previous points relate to the attendant issue of what is often referred to as 'technological determinism'. This is the common-sense assumption that technologies 'cause' things to happen regardless of social context or social influence. In other words, while it is important to acknowledge that technologies are an important part of changes in education, it is mistaken to assume that technologies are responsible for these changes of their own accord.

This can be a difficult line of reasoning to tread. In its simplest form, 'technological determinism' can be seen as a way of thinking that presumes technology to determine social change. In its most extreme form, 'hard' technological determinism assumes that technology is the only factor in social change. While many people in education would feel uncomfortable in making such direct associations, most would perhaps concur with a 'soft' form of technological determinist thinking which assumes technology to have a strong influence on social change. Take, for instance, this seemingly reasonable claim:

> [We live in] a society in which new technology is rapidly altering people's ways of thinking, believing, behaving, and learning. It follows that education itself ought to reflect the change. (Bromwich 2014, n.p.)

Many of the claims and arguments presented earlier in this chapter were based around determinist assumptions that digital technology is set inevitably to change various aspects of education. Yet, if nothing else, the uneven nature of educational change over the past forty years or so suggests that this relationship is not as straightforward as some people would like to think. There are many good reasons to move beyond technological determinism, not least because such thinking often leads to incorrect analyses and unrealised expectations. If the relationships between education and technology are understood only in instrumentalist 'cause-and-effect' terms, then the main task of anyone studying education and technology is simply to identify the impediments that are delaying the march of technological progress. This can lead to the denigration of all human factors to the status of 'obstacles' to be worked around by technology designers and developers (Peters 2017).

Technological determinism therefore leaves little room for manoeuvre, deviation or other forms of social agency in the implementation and use of technology. At best, educators, students and everyone else involved in education are positioned as having to respond to technological change by making the most 'efficient' or 'best' use of the devices and artefacts that they are presented with. As Martin Oliver (2016, p.8) observes,

> Conceptions of technology influence the kinds of claims that we make. If technology is viewed instrumentally, work orients towards questions of efficiency using a simple, causal model; if it is viewed in terms of practices or culture, questions of meaning, experience and value open up.

Taking a Sociotechnical Approach towards Education and Technology

So, if we are now a little clearer about how *not* to think about education and technology, how *should* we be thinking differently? Everything that has been just argued points to not treating technology as somehow separate from the social, economic, political, cultural and historical conditions that it is developed, produced and used within. This can be described as taking a 'sociotechnical' approach. As Thomas Hughes (1983, p.1) put it, this is the idea that 'technological affairs contain a rich texture of technical matters, scientific laws, economic principles, political forces, and social concerns'.

As this book continues, we need to take a close interest in the ways in which social, political and economic factors influence the technologies that end up being developed and implemented in education – paying particular attention to the contested nature of technological design and uptake. Yet, while we need to avoid being overly determinist in our thinking, this is not to say that technology is without consequence at all. Indeed, the significance of the more nuanced relational notions of affordances as socially situated 'accomplishments' described earlier 'is its capacity to recognize technology as efficacious, without falling prey to technological determinism' (Davis and Chouinard 2016, p.241). As such, it is still worth asking what consequences and outcomes are associated with the increased presence of digital technologies in education. In this sense, we are interested in the nature of technology-driven change – albeit not assuming that technology itself is leading this change. As Wiebe Bijker (1997, p.274) concludes, 'Society is not determined by technology, nor is technology determined by society. Both emerge as two sides of the sociotechnical coin.'

In this respect, it makes sense to pay particular attention to the social conditions, social arrangements and social relations that underpin the use of digital technologies in education. It also makes sense to refer back to the ideas of 'technology as practice' and 'technology as context', and consider how social and cultural aspects of education processes and practices may influence the use of technology. In this spirit, we finish this chapter with three different aspects of what a more socially circumspect approach to understanding the relationship between education and technology might look like. In particular, we can return to a set of important issues introduced in Chapter 1 that need to be foregrounded in our subsequent discussions – notably, issues of contexts, politics and values.

Recognising the Contexts of Technology Use in Education

First is the need to expand our understandings of what it means to think about the various 'contexts' of technology use in education. These first two chapters have already referred to issues of context in a number of different ways – for example, the 'settings', 'circumstances', 'backgrounds', 'environments' and even 'social milieu' of technology use. More specifically,

we have highlighted various constituent elements implicit in any instance of an individual engaging in the processes of using digital technology. We have also talked about the organisational cultures and micro-politics of educational institutions such as schools, colleges and universities. We have considered the concerns of other institutions such as the family, the workplace and wider community. We have also noted how these contexts are themselves set within a range of even wider social milieu – not least societal structures and cultures, commercial marketplaces, nation states and global economies.

As suggested by the diversity of this list of different factors, we need to think as broadly as possible when accounting for the contexts of technology use in education. One common approach within the social sciences is to focus on different levels of analysis where social actors and interests may influence the use of technology – what can be termed the 'macro', 'meso' and 'micro' levels of description. Of course, the micro level of the individual student or teacher is undeniably important and merits sustained consideration, not least in terms of the continued importance of immediate 'local' contexts in framing learning processes and practices. Yet these micro-level concerns can only be understood fully through consideration of what could be termed 'the bigger picture' of education and technology. This includes the meso level of organisational structures and goals of educational institutions, as well as the macro level of broader cultural, societal, political and economic values. Such issues might seem far removed from the usual topics of concern in discussions about educational technology, but all are important elements of making full sense of the ways in which education and technology come together.

As this book progresses, it is important that we develop understandings of how these different concerns work to influence each other. If we are thinking as broadly as possible, then our discussions need to cover everything from the biological workings of an individual's body and mind through to the planetary-level consequences of the vast computing infrastructures that stretch around the world. In this sense, there are at least six broad but distinct levels of context that need to be taken into consideration (see Figure 2.1).

At each of these levels are many different specific factors and issues that need to be brought to bear on how we make sense of education and technology. Some indicative examples are listed in the following list:

Individual contexts	
i) Brain	An individual's neurological, cognitive and psychological make-up
ii) Body	An individual's physiology, affective and emotional states
iii) Background	An individual's social background and characteristics
Student contexts	
	Prior educational experiences Current educational expectations and goals Peer group 'Student identity'
Educational contexts	
i) Teacher/classroom	Pedagogical styles Instructional design Curriculum and assessment
ii) School, university	Time and funding constraints Organisational policies, norms and procedures Student/teacher relations
iii) Broader educational system	Time and funding constraints Education policies
Lifeworld contexts	
	Family and household Local community Job/paid employment Unpaid labour – for example, caring responsibilities Subcultures and social groups
Societal contexts	
	Politics and political systems Economic systems (e.g. capitalism, market economy) Cultural systems (e.g. media religion)
Planetary contexts	
	Global supply chains Planetary computing infrastructure Materiality Mineral resources Energy production Natural environment and ecosystem

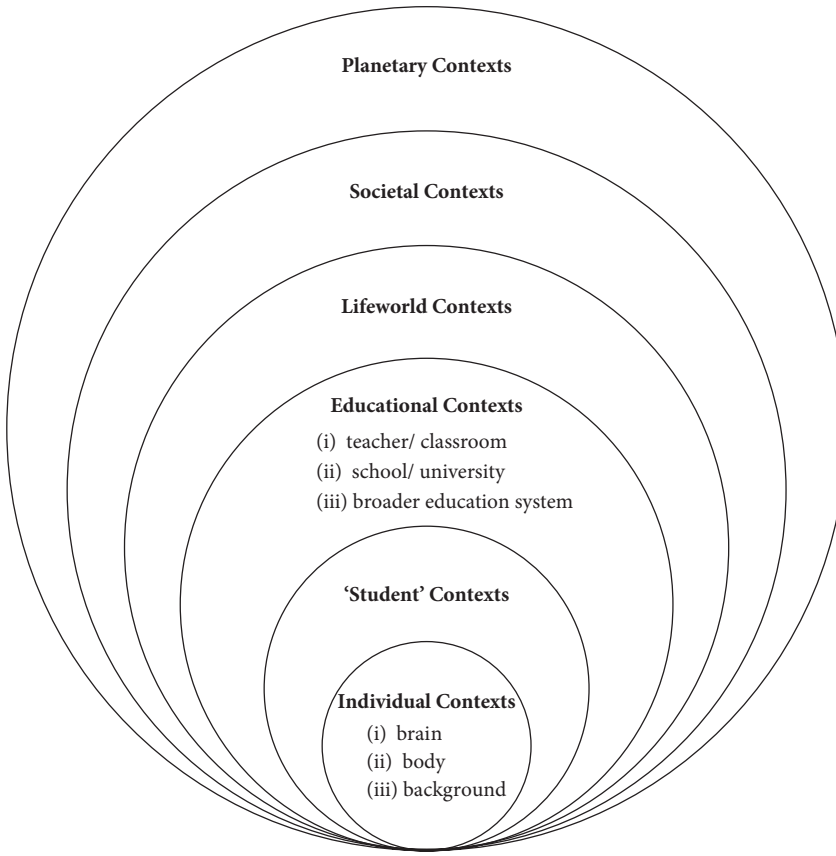

Figure 2.1 Six broad levels of 'context' implicit in education and technology.

Paying attention to these different contexts can help us think differently about what might otherwise seem to be mundane and mostly harmless instances of technology use. Take the example of hosting live online classes using video conferencing platforms. On the face of it, video classes held through platforms such as Zoom allow teachers and students to come together on a flexible and convenient basis. This use of technology has become an established feature of university and school study over the past few years. Yet, even this innocuous example raises a diverse range of different issues and factors. For example, from an individual physiological level, many readers will be familiar with the exhausting process of participating in video classes. Viewing a screen while also being continuously visible to others is cognitively straining, and can lead quickly to the so-called 'Zoom fatigue' (Lovink 2020). Conversely, at a planetary level, live video classes incur obvious streaming, processing and storage costs. For example, it is

estimated that holding a one-hour high-definition video meeting involving two people for 250 days a year results in equivalent carbon emissions to driving a car 375 kilometres per year (McGovern 2020). By contrast, switching off cameras during a web call can reduce these footprints by 96 per cent, while streaming content in standard definition (rather than in high definition) can bring about an 86 per cent reduction (Obringer et al. 2021). These figures are clearly compounded for repeated large-scale classes of 30 or perhaps even 300 people.

Elsewhere, from an institutional perspective, it is important to consider how video classes transgress into students' (and teachers') domestic spaces. In this sense, arguments over whether teachers should allow students to turn their cameras off during video classes relate to issues of equity – notably for students who do not have private spaces that they are comfortable broadcasting to their peers. Conversely, in terms of the wider 'digital ecosystem', online classes are also shaped by the ways in which video conferencing platforms connect easily to other platforms. For example, students can replace their static profile pictures with short looped videos of themselves appearing to pay attention created on platforms such as TikTok. More maliciously, some students even post the class log-in details to gaming platforms to allow uninvited guests to disruptively 'bomb' the class. It is also interesting to consider the political connotations of this technology. For example, occasional reports of videoconferencing companies deciding to shut down university seminar sessions that the company deems inappropriate raise obvious questions over the control that third-party platform providers now exert over what is taught. As just these few examples illustrate, the educational adoption of any digital technology is often much more complicated than it first appears.

Recognising the Politics of Technology Use in Education

Second is the need to move beyond the idea that technology is neutral. A neat introduction to thinking about the (non)neutrality of technology is offered by Langdon Winner's (1980) much-discussed question, 'Do artefacts have politics?'. Winner highlights two ways that this is the case. On the one hand, he argues that technological artefacts can be designed and implemented (often unconsciously) to have particular social effects.

Here Winner recounts a commonly told story of bridges on the Long Island Expressway being designed to be sufficiently low to allow passage for cars but not public buses – therefore seeming to advantage people from the social classes likely to have privately owned cars. On the other hand, Winner also argues that some technological artefacts can be 'inherently political' in that they require specific social conditions and political arrangements to operate. Winner illustrates this with the example of nuclear power reactors requiring the existence of a strong centralised, authoritative state. These examples can prompt us to think about how educational technologies might be similarly designed to permit, allow or encourage certain forms of action that are associated with particular power structures and forms of control. We can also think how certain educational technologies might find a supportive home within particular institutional contexts and institutional politics – for example, surveillance technologies being readily adopted in already authoritarian school systems.

This idea of talking about the politics of technology use in education obviously contrasts with technological determinist accounts of technologies having a fixed character, purpose and agency. Another useful perspective from within the field of Science and Technology Studies (where Winner's work is usually located) is the notion of the 'interpretive flexibility' of any technological artefact, especially during initial stages of technology design and use. From this perspective, there is no necessary or obvious way that any technological artefact should be designed or initially used. Indeed, designs and early uses will vary between different groups and contexts, and often result in conflict between competing views and ideas. Subsequently, the diversity of interpretations of a technology is likely to diminish over time, often until the agreed meaning of a technology reaches a stage of 'stabilisation' and sometimes 'closure'.

From this perspective, then, there is no one script or pathway that an educational technology is destined to follow. Instead, there are different social groups and actors seeking to influence the eventual form that technology use in education takes. This highlights the need to pay attention to all 'relevant social groups' (from the most minor influences to the major shapers), as well as being open to identifying alternatives – particularly in terms of working out how technology might better act in the public interest. Our discussions so far in Chapters 1 and 2 offer numerous examples of this way of understanding technology. Take, for example, the ways that this book has talked about benefits of efficiency and effectiveness as compared to issues of care and justice. This is also reflected in the ways we tend to foreground

the perspective of 'Silicon Valley' and large US corporations such as Google, Facebook, Apple and Amazon. Of course, these are biases with deep historical precedents. For example, Lilly Irani (2018) notes that weapons and wheels are far more likely to be discussed and celebrated as exemplary 'early' technologies rather than textiles, pottery, and mud architecture. This reflects the priorities of industrial-era capitalists and European colonial powers, as well as North American and European anxieties about white racial superiority.

Recognising the Values of Technology Use in Education

Of course, talking about the politics of technology use in education raises the need to pay close attention to the values, interests and agendas that lie at the heart of discussions over education and technology. This can be a difficult thing to do – especially if these values are close to our own hearts and minds. Sometimes these values might be explicit in how we approach the topic of education and technology, but often they are not. Indeed, it is important to note our own subtle personal values and interests, as well as the values and interests of other people. As Sally Haslanger (2017) reasons, ideological assumptions and values are engrained in all aspects of public and private life – especially what we might consider to be common-sense social meanings, norms, scripts and default assumptions. Undoubtedly, many educational technologists consider their readings of technology in education as essentially 'neutral' and value-free. For example, for many people it might seem common-sensical that technology is a good way of providing students with 'flexibility' in choosing the ways that they personally prefer to work. Yet, this is itself a value-laden judgement – rooted in Western notions of individualism and rational choice and in specific theories such as 'self-regulated learning'.

Similarly, many educational technologists and teachers might celebrate the development of digital technologies to support students with mental and physical difficulties. This has been a boom area over the past twenty years for digital technologies in education. For example, there is much enthusiasm for 'assistive technologies' in classrooms (such as text-to-speech software or 'sip-and-puff' controllers), as well as technology that helps address 'special education needs' (e.g. 'visual scene display' software that allows students with autism to create lines of text from pictures). These are all welcomed widely as technologies that 'empower' students who would otherwise

struggle to learn. Yet, the broad enthusiasm for assistive technologies that pervades educational technology is a profoundly value-laden perspective – fitting what Ashley Shew (2020) terms 'techno-ableism'. The notion of techno-ableism highlights the problematic act of seeing any disability as a negative, individual problem that can be overcome through the innovative application of technology. The underlying assumption here is that technology can help disabled bodies and minds function in a 'proper' manner that fits with nondisabled assumptions and contexts. Similarly, as Spiel et al. (2019, p.1) contend with regard to autistic learning software, these 'technologies embody normative expectations of a neurotypical society, which predominantly views autism as a medical deficit in need of "correction"'.

These values can be (and are beginning to be) challenged. Instead of placing the burden of change on the individual disabled person to fit the classroom context through the use of assistive technologies, why not work to fit the classroom context to suit all individuals? It can be argued that the notion of giving disabled students 'independence' through digital technology is a value judgement that overlooks the ways in which all students (and teachers) are interdependent. Perhaps the best way to make a classroom or school genuinely inclusive is to meaningfully include dis/abled voices into the design process. Why not simply have classrooms, curriculum content and modes of working that cater for neuro-diverse students? Why not have classroom environments that cater for students with limited mobility? Why not listen to disabled people's ideas about (and experiences with) technology and disability? While advances in assistive technologies might appear supportive from able-bodied and able-minded perspectives, they could be seen as disempowering and exclusionary from disabled points of view.

These are challenging counterarguments to be making – yet they are indicative of alternate viewpoints of educational technology that do not often feature in discussions of the topic. For example, feminist perspectives might advocate for forms of technology use in education that lead to heightened accountability, collectivity, collaboration and care (FemTechNet 2020) – pointing to the disconnections and ruptures implicit in encouraging students to learn on a 'personalised' basis and 'go it alone'. Alternately, Christian perspectives on technology use in education might advocate for forms of technology that support the cultivation of civic virtue, character formation and spirituality – placing 'our whole beings in relationships with God and others' (Paulus et al. 2019, p.52).

Perspectives such as these highlight the fact that how we choose to talk about technology and education depends on how we see the world, what

values we hold dear and what interests and agendas we want to serve. In short, technology and education are a contested matter. As such, it is important to remember that the adoption (or imposition) of any technology in education is entwined with issues of power, and is something negotiated through existing social relations and inequalities (Cassidy and Rafalow 2020). This raises the need to be prepared to ask straightforward – but challenging – questions about any case of technology use in education. These questions might include:

- In whose interests do the technology work?
- Who gets to choose, decide or set the agenda?
- Who gets to define the 'problem' to which the technology is a solution?
- Who is this a 'problem' for and what other issues and inconveniences are *not* mentioned?

In short, as Evgeny Morozov (2020, n.p.) concludes,

> Don't say: 'Technology is not neutral'. Do say: 'The technologies we have are a function of power relations – and so are their effects'. Yes, [this is] somewhat longer but at least there's no confusion about the message.

Conclusions

This chapter has covered a lot of ground. These are ideas and issues that will be expanded as the book progresses, and will become clearer with repeated use. For the time being, it is worth approaching claims of technology being able to 'improve' or 'transform' education with a degree of caution and even scepticism. Similarly, we would do well to avoid talk of 'harnessing the power of technology' or 'disrupting education'. In particular, it is important to recognise that many of the key questions surrounding education and technology are not actually technological questions at all. Instead, they are related to wider questions of what education is and what we want education to be. The scale of such questions certainly suggests that we should not be seduced by promises of technological capacity to change everything for the better. Educational change is a complex and messy business. Questions about education are far too important to be left to magical thinking about the possible 'potential' of technology. Instead, we need to take a more socially circumspect approach towards everything discussed in this book.

While by no means a definitive account, this chapter has highlighted a wide range of interests and influences that need to be considered when

seeking to explain issues of education change and technology. Even at this early stage, it should be clear that there are many important issues that are often overlooked (or even deliberately ignored) in popular discussions of education and technology. It follows that one of the key aims for our remaining chapters should be to directly address these hidden issues and questions. For example, how is technology shaped by the institutional concerns of schools, colleges and universities? How does the 'lived' experience of teachers and students influence their use of technology? How is technology use in education entwined with issues of global economics or planetary climate change? While there may be no easy answers to these questions, they all deserve consideration and further thought if we are to develop clearer understandings of the highly negotiable and unpredictable nature of technology use in education.

Making sense of the sociotechnical nature of technology has implications for how the study of education and technology is pursued. There is an obvious need to look beyond the enthusiasm and hyperbole that can often infuse discussions of technology, and instead 'to expose the exaggerations, and to sort out the continuities from the discontinuities' (Wieseltier 2015, n.p.). This suggests that we concentrate mainly on understanding 'here-and-now' realities of technology use rather than speculative possibilities and potentials. As such, the predominant focus of the next six chapters will be on 'unpacking' the ordinary, mundane aspects of education and technology. As Nobel Prize–winning economist Paul Krugman (2015, n.p.) puts it,

> We ought to scale back the hype … writing and talking breathlessly about how technology changes everything might seem harmless, but, in practice, it acts as a distraction from more mundane issues – and an excuse for handling those issues badly.

Following this advice to 'scale back the hype', we can now turn to our next set of key issues and debates. Instead of indulging in forward-looking speculations, perhaps we are better off focusing on past forms of education and technology? Chapter 1 has already touched upon the 'long history' of technology development from prehistoric times onwards. If we are to gain a full understanding of the complex relationships between education and technology, it is perhaps worth paying closer attention to the 'recent history' of the past hundred years or so – what could be described as the 'pre-digital' period of analogue technology use. In this spirit, then, what useful lessons can be learnt from the educational implementation of technologies such as film, radio and television?

Further Questions to Consider

- Why do we need technology in education? Are digital technologies essential to supporting effective forms of education in the current 'digital age'? What do digital technologies allow to happen in education that would not otherwise happen?
- What examples of technological essentialism, determinism and solutionism are evident in popular discussions of education and technology? What are the essential qualities that people presume digital technologies to have? What 'effects' are these digital technologies commonly believed to 'cause'? For example, why might these ways of thinking be considered as misleading and reductive?
- What factors at the micro, meso and macro levels have an influence on how technologies are used in education? How is their influence apparent? What links and relationships exist between these different factors?

Further Reading

This short book provides a provocative critique of the key ideas and 'what passes for thinking' in popular discussions around digital technology:

Daub, A. (2020). *What tech calls thinking: an inquiry into the intellectual bedrock of Silicon Valley*. Farrar Straus Giroux.

By contrast, this book provides a neat introduction to main traditions of thought within the philosophy of technology:

Coeckelbergh, M. (2020) *Introduction to philosophy of technology*. Oxford University Press.

This short introduction to a special issue of an academic journal gives some useful pointers on how to best make use of different social theories to guide your thinking about education and technology:

Costa, C., Hammond, M. and Younie, S. (2019). Theorising technology in education: an introduction. *Technology, Pedagogy and Education* 28(4): 395–9.

3

A Short History of Education and Technology

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Introduction

The tendency to want to look towards the future rather than the past when thinking about technology is wholly understandable. Like many other areas of life, it is often more compelling to anticipate what is about to happen with technology than attempt to make sense of what has already happened. As the philosopher Andrew Feenberg (2003) notes, popular discussions of technology suffer from a recurring reluctance to frame arguments about 'new' developments in an historical context. This desire to focus only on what is about to happen is a bedrock of IT industry thinking. As Adrian Daub (2020, n.p.) puts it, Silicon Valley is 'a place that likes to pretend that its ideas don't have any history'.

At best, current trends in educational technology tend to be discussed alongside highly partial historical accounts of education. As Audrey Watters (2021) reminds us, arguments for technological implementation in education often lean heavily on well-worn stories of the supposed intransigence of education systems to develop and 'evolve' over the past hundred years or so. This often involves imagined histories of 'factory' schools not changing since the nineteenth century, with schools and universities stubbornly retaining 'industrial era' characteristics which are long past their relevance. At the same time, advocates for new forms of technology in education are usually unwilling to engage with more detailed accounts of previous technology use in schools and universities – therefore remaining ignorant of the historical precedents for their current enthusiasms. As Megan Erickson (2015, n.p.) laments,

> Education reformers express frustration with the continuity of traditional schooling methods – though most do not recognize the history to which they are intimately tied, since technological innovation is imagined to be as ahistorical as it is apolitical.

So, if we are to develop better understandings of education and technology, then it makes sense to pay closer attention to the history of the field. As we saw in Chapter 2, this involves moving beyond the assumption that technology drives human progress, or that education should simply adapt to technological 'change'. Instead, it is more useful to see technology as influenced by a range of social, cultural, political and economic factors – what was described in Chapter 2 as a 'sociotechnical' approach. This chapter develops a socially focused history of education and technology. In particular it focuses on the 'pre-digital' uses of technology in the schools, colleges and universities of the twentieth century. What lessons can be learned from the introduction of various 'new' technologies into classrooms from the 1900s until the declining use of educational television at the beginning of the 1980s?

Taking an Historical Perspective on Education and Technology

Looking back at the history of education and technology allows us to consider a number of issues and factors that quickly come to attention with the 'benefit

of hindsight' (Cassidy 1998). In particular, taking an historical approach has three specific advantages. First, historical accounts frame the development of technology within a long-term perspective, allowing us to understand how one technology may have ramifications for proceeding technologies, rather than one technology simply 'replacing' or 'superseding' another. Following this line of thinking, we can see how emerging technologies often pay homage to preceding technologies, drawing upon and refashioning them, as well as challenging and rivalling them. The historical development of technological forms can therefore be framed in terms of continuity as well as change, with 'new' technologies often seeking to both borrow from and surpass earlier forms. In this sense, we can only begin to properly understand the significance of a current technology if we have a sound understanding of its predecessors.

Secondly, it could be argued that the social significance of a technology is only fully apparent after some time has passed. Only now are we beginning to develop sufficient 'distance' on technologies such as the television or computer to gain a sense of what their influence has been on society. Most people would agree that it is still too early to be completely certain of the internet's influence on society (or indeed its influence on education). While it might feel as if digital technologies are developed and thrust upon us in rapid succession, the integration of any technology into society is a long-running and iterative process. An historical approach allows us to identify the significant long-term issues and concerns at play as specific technologies become 'embedded' into everyday life.

A third advantage of taking an historical approach relates to 'letting the dust settle' and looking back at the exaggerated enthusiasms and fears that often pervade initial understandings of what a technology is and what it can do. In particular, looking back at pre-digital histories can remind us of the ways in which 'new' technologies tend to be heavily promoted and 'sold' to education audiences. Re-examining the history of a technology without its original hyperbole can offer insights into how common-sense expectations and assumptions about technologies are formed. History can provide us with clearer views of the meanings and significances that are attached to technologies before they become seen as inevitable, invisible and somehow natural.

These benefits of hindsight can be achieved in two different ways – what historians of technology refer to as taking a 'contextualist' approach or an 'internalist' approach. Internalist approaches tend to focus on the history of the invention, design and development of technology – charting the

progression from one technology to another in a manner similar to describing the history of art. Internalist accounts of the history of technology can be particularly insightful and revealing. As David Nye (2007, p.57) describes, 'internalists usually find that creativity is no means assured or automatic … emphasis[ing] alternative solutions to problems'. Contextualist accounts, on the other hand, tend to focus 'on how the larger society shapes and chooses machines. It is impossible to separate technical and cultural factors when accounting for which technology wins the largest market share' (Nye 2007, p.59).

While 'internalist' accounts of the invention, design and development of educational technologies are of considerable interest, this chapter concentrates on the contextualist approach. Contextualist accounts are especially well suited to examining the social history of technology use – shedding light on present relationships between education and technology. Contextualist accounts can provide useful descriptions of the social and technical issues that shape the use of technology in 'real-life' contexts such as schools and classrooms. As David Nye (2007, p.62) concludes,

> If one takes a contextualist approach then it appears fundamentally mistaken to think of 'the home' or 'the factory' or 'the city' as a passive, solid object that undergoes an involuntary transformation when a new technology appears. Rather, every institution is a social space that incorporates or doesn't incorporate [new technology] at a certain historical juncture as part of its ongoing development. [New technology] offers a series of choices based only partly on technical considerations. It's meaning must be looked for in the many contexts in which people decide how to use it.

In this spirit, this chapter now goes on to reconsider three major waves of 'new' technology of the twentieth century – film, radio and television. These examples help develop our understandings of how a technology comes to find a place in education, and also help us address a number of wider questions about the relationship between education and technology. For instance, we need to consider the different ways that technologies are implemented into educational settings. What claims tend to be made on behalf of new technologies as they are introduced? What meanings get attached to specific technologies – first by proponents of the technology, and later by the people who are expected to use it? It is also useful to consider why specific technologies are judged to 'work' or 'not work' in education. For example, what 'barriers' and 'enablers' tend to be identified at the time as influencing the perceived 'success' or 'failure' of a technology? What forms of

'evidence' are used to substantiate the educational effectiveness of technology implementation? All of these questions will now be explored by going back to the early 1900s and then reflecting on the history of some key educational technologies that emerged throughout the twentieth century.

The Recent History of Education and Technology

This focus on the twentieth century is not meant to imply that the history of education and technology goes back no further than 1901. Indeed, various technologies have been linked closely with the development of education thinking and reforms for the past 5,000 years or so. The appearance of the Mesopotamian abacus around 2700 BC reminds us of the long history of 'educational' technology. Indeed, technological artefacts and practices were an integral part of the forms of education and learning envisaged by everyone from the Elder Sophists of the fifth century BC, through to medieval scholars, and the social reformers of the eighteenth and nineteenth centuries. Technologies such as the abacus, chalkboard, hornbook and textbook all played fundamental roles in supporting learning, education provision and the development of knowledge across thousands of years.

It should be remembered that some of these early technologies continue to be a significant part of contemporary education. For example, Comenius' production of the first textbook in the mid-1600s (titled *Orbus Pictus*/*The World in Pictures*) is generally considered to mark the beginning of a long-standing educational dependency on printed texts. The implementation of the chalkboard in the 1800s also persists in many contemporary classrooms (albeit increasingly in electronic 'whiteboard' rather than slate 'blackboard' form). All of these technologies have had significant bearing on the character of educational settings and practices, and all have been accompanied by substantial promises of change and transformation. In 1841, for example, the chalkboard was lauded by one contemporary observer in effusive terms, proclaiming that 'the inventor or introducer of the system deserves to be ranked among the best contributors to learning and science, if not among the greatest benefactors of mankind' (cited in Tyack and Hansot 1985, p.40). As this tribute suggests, the digital technologies of today are by no means the first artefacts to be 'hyped' up by enthusiastic educational commentators.

This long history notwithstanding, the educational technologies of the twentieth century perhaps offer the most useful comparisons with the use of contemporary digital technologies. The twentieth century was a period of intense technological innovation – from the emergence of audiovisual technologies such as radio and television to the first digital computers and the early incarnations of the internet and worldwide web. While all these technologies became integral parts of twentieth-century society, their use in education was often compromised. The US educationalist Larry Cuban provides a comprehensive overview of the difficult history of twentieth-century education technologies in his book *Teachers and Machines: The Classroom Use of Technology since 1920*. Here Cuban examines education's 'fickle romance' with technologies such as film, radio and television, and details how these technologies were used (and often not used) in twentieth-century classrooms. Tracing the implementation of these technologies in education, Cuban explores the capabilities, claims and uses that characterised common understandings of 'educational technology' at the time. It makes sense to revisit these examples for the purposes of our own chapter, starting with one of the 'wonder technologies' of the early 1900s – the motion picture.

Educational Film

School teachers in North America and Europe began experimenting with the projection of static pictures displayed on pieces of film during the second half of the nineteenth century. Following on from the use of 'magic lantern' slide projectors and stereograph viewers, the most popular of these technologies was the filmstrip. This involved pictures being projected from strips of film, with the teacher winding forward a sequence of images at appropriate intervals while reading aloud an accompanying narrative text. This use of static pictures was praised at the time as offering students a 'window on the world', leading to growing enthusiasm for what was quickly termed 'visual instruction' and 'visual education'.

Despite these early efforts, it took the development of motion (as opposed to still) picture technology in the early 1900s to establish widespread interest in visual instruction, hastened in no small part by the booming general popularity of newsreels. On the one hand, motion pictures provided a ready response to political demands for improved classroom efficiency – a growing concern resulting from Taylorist 'time and motion' studies that were

beginning to be conducted in schools. Of course, enthusiasm for film use in education was also driven by interest in the technology itself, particularly in light of the emergence of the silent movie industry as a major cultural form across North America and Europe. Accordingly, much of the initial impetus for educational film came from the originators of the technology, not least the US inventor Thomas Edison. As Edison predicted at the beginning of the 1920s,

> I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks. … The education of the future, as I see it, will be conducted through the medium of the motion picture. (cited in Cuban 1986, p.9)

During the first years of the twentieth century, Edison invested considerable time and money into his educational film ventures. From these beginnings, growing numbers of schools began to introduce film into their teaching provision. Classrooms were equipped with blackout shades, silver screens and 16mm projectors, lending a distinct aura of modernity to the teaching process. As Bill Ferster (2014, p.32) notes, film 'played an important role in establishing the need to develop infrastructure to support educational technology in the classroom'. A range of content was produced to cover topics suitable for all levels of teaching and learning. Films commissioned by Edison for his educational film library included titles such as *Life History of the Silkworm*, *Magnetism* and *Microscopic Pond Life* (Saettler 1990). By 1910, the *Catalogue of Educational Motion Pictures* listed over 1,000 different film titles categorised into 30 different topics and subject disciplines.

This activity was matched by the development of a substantial bureaucracy to support the use of film in US schools. Only twenty years after the first school districts had committed themselves to classroom use of motion pictures, twenty-five states had established visual education departments and bureaus tasked with overseeing schools' use of film. Universities and teacher training colleges ran courses to train teachers in classroom film use, and five separate national professional organisations for visual instruction were established by 1930 (Saettler 1990). Educational films began to be produced by companies responsible for manufacturing projectors, such as Kodak, Western Electric and Bell & Howell. All told, the use of motion pictures was an officially endorsed icon of 'modern' and 'progressive' teaching (Cuban 1986).

Enthusiasm for classroom use of motion pictures grew during subsequent decades. One popular justification was that film was a potent means of

improving public education at scale – as one US Commissioner for Education put it, film offered a 'most valuable weapon for the attack on ignorance the world has ever known' (Tiagert 1923). Many commentators were especially impressed by the ability of films to 'bring learning to life', promising a means to represent reality in visual form, and to animate the spoken and printed word. As Charles Hoban (1937) argued in *Visualizing the Curriculum*, the primary advantage of visual instruction was its degree of realism. This, in turn, was seen to relate to key instructional objectives such as 'imparting a knowledge of facts, teaching perceptual-motor skills, and influencing motivation, attitudes and opinions' (Allen 1956, p.125). As one US journalist marvelled in the early 1920s, film promised to do nothing less than animating and enlivening the act of learning:

> To the schoolboy of the year 1995, history will not merely be something to be memorized out of books. It will be visualized and made real for him by the moving pictures that are being made now. The people of our time will not be mere history book ghosts to this boy but living creatures who smile at him and walk and play and love and hate and work and eat. (cited in Erickson 2015, n.p.)

Such enthusiasms were accompanied by a burgeoning body of research and evaluation literature. Early experimental studies, for instance, found that groups of students using film were 'greatly superior in learning information and concepts' when compared to students using traditional methods (Allen 1956, p.132). A number of surveys and evaluations also reported a belief among educators that 'a body of factual information such as high-school science could be taught by films alone almost as effectively as by a teacher using conventional classroom procedures, and even better if the films were introduced and supplemented by brief study guides' (Allen 1956, p.126). Other studies, however, were less certain of the 'effect' of film-based education. As Smith (1962) concluded, any overall findings of learning gains relating to the use of film 'were equivocal'.

Indeed, growing concern over the tangible outcomes preceded a subsequent decline in classroom use of motion pictures. By 1954, one study of Michigan schools reported use of educational film in the classroom to be 'the equivalent of a one-reel film about every four weeks' (Dale 1958, cited in Cuban 1986, p.16). As the 1950s progressed, it became apparent that films were not having a major impact on how schools, colleges and universities went about educating students, despite the continuing popularity of the medium in the entertainment industry. As Larry Cuban (1986, p.17) described,

> Most teachers used films infrequently in classrooms. Films took up a bare fraction of the instructional day. As a new classroom tool, film may have entered the teacher's repertoire, but, for any number of reasons, teachers used it hardly at all.

Suggested reasons and explanations for this relative failure are varied. A national survey of US teachers at the beginning of the 1950s highlighted four main areas of deficiency. These included a perceived lack of time, 'central coordination' and necessary resources to equip classrooms, underpinned by the need for 'better support' (cited in Hornbostel 1955). Based on his reading of the research of the time, Larry Cuban offers four similar reasons for the decline of film use in educational settings. These include the following: teachers' lack of skills in using the equipment; the high cost of the films, equipment and upkeep; the inaccessibility of equipment when it was needed; and the difficulty of finding and fitting the right film to the class. All told, film enjoyed a relatively brief period as a mainstream classroom technology.

Educational Radio

Of course, film was not the only 'wonder technology' of the early twentieth century. During the 1920s and 1930s, the attention of many educationalists shifted to potential uses of radio in the classroom. Again, initial widespread enthusiasm was expressed for the educational promise of this technology soon after its development. The first US 'educational radio station' was established at the University of Wisconsin in 1917. Three years later, the Radio Division of the US Department of Commerce issued several broadcasting licenses that supported the establishment of radio stations to broadcast educational programmes for the general public. One celebrated example was the 'RCA Educational Hour', a music programme that reached a peak audience of six million listeners. Alongside the efforts of established broadcasters such as RCA, more than sixty universities and colleges provided radio-based instruction for students, with some school districts developing broadcasting stations and programmes that were integrated into everyday school lessons (Cuban 1986). One particularly ambitious educational radio project was the establishment of the 'World Radio University' in 1937, broadcasting classes in twenty-four languages to over thirty countries (Saettler 1990).

Perhaps the most extensive educational use of radio was the so-called 'Schools of the Air'. Starting in the 1930s, US commercial broadcast networks,

state universities, colleges of education and local school boards established over a dozen School of the Air initiatives that offered remote access to school education (some lasting into the 1970s). These services offered courses in subject areas designed to fit alongside traditional school instruction. Schools of the Air used were deliberately designed to mimic traditional 'bricks-and-mortar' schools by using gradated curricula, following term-time schedules and even providing learning support materials that could be used in classrooms. For example, the CBS-run 'American School of the Air' launched in 1930 to broadcast lessons in subjects such as history, literature, art and health. At the height of their popularity, it is estimated that School of the Air radio programmes were used by over one million students across the United States – constituting nearly 10 per cent of the nation's school children (Bianchi 2008). At its peak, the use of radio in education was deemed important enough for the US Office of Education to establish a dedicated 'Radio Section'.

The educational use of radio was accompanied by considerable excitement and enthusiasm. One obvious advantage was the capacity of radio technology to transmit high-quality teaching and learning content to a large number of classrooms and students at negligible additional cost. As the founder of the Ohio School for the Air observed,

> The central and dominant aim of education by radio is to bring the world to the classroom, to make universally available the services of the finest teachers, the inspiration of the greatest leaders … and unfolding world events which through the radio may come as a vibrant and challenging textbook of the air. (Darrow 1932)

Young people's booming interest in radio outside of school gave some educators hope that the technology was capable of increasing student engagement with learning when in school (The Instructor 1928). Other commentators reasoned that the immediacy of live radio broadcasts allowed school lessons to have a heightened relevance to recent events (Morgan 1931). Radio was also felt to be a democratic medium that provided access to high-quality education regardless of geography or socio-economic circumstances. As one proponent of educational radio put it, 'with radio, the under-privileged school becomes the privileged one' (unattributed quotation in Cuban 1986, p.23).

As all these examples illustrate, many educationalists held high hopes for the instructional use of radio in school, college and university education. As the director of Cleveland Schools' Radio reasoned at the end of the Second World War, 'the time may come when the portable radio receiver will be as common in the classroom as the blackboard' (cited in Dreyfus 2001, p.27).

Indeed, the presence of radios in educational settings grew steadily throughout the first half of the twentieth century. While radio receivers were initially scarce due to their high cost, by the late 1930s prices had dropped. Studies in the early 1940s found that more than half of Ohioan schools had radio sets, with two-thirds of Californian schools owning one or more sets (Cuban 1986). There was also occasional evidence of the educational effectiveness of radio as a teaching tool. One experimental study in the 1930s, for example, compared students' retention of information from lectures and radio broadcasts, concluding that radio was an efficient and effective means of imparting information (Matthews 1932).

Yet, by the end of the 1940s it become clear that the educational potential of radio was not being realised fully across the US school system. While many schools owned sets, studies suggested that most teachers made sporadic use of radio. One survey conducted in 1937 found that 73 per cent of schools reported using radio programmes for 'little or none' of the time (Atkinson 1938). Another study of the Wisconsin School of the Air found that teachers who were accessing the service reported making use of radio programmes in their teaching on average three times per week. Reviewing the overall national use of educational radio at the end of the Second World War, the US Federal Communications Commission concluded that 'radio has not been accepted as a full-fledged member of the educational family … and remains a stepchild of education' (Woelfel and Tyler 1945, p.85).

While educational radio continues to be used in the present day (especially in low-income countries and remote rural regions), the medium has had a much more modest impact on formal education in North America and Europe than was initially expected. Again, research studies of the time point to a number of contributory factors – typified by a survey in 1941 which garnered reasons from US high-school principals for radio not being used in their schools (cited in Cuban 1986, p.25). This survey highlighted a range of logistic, technical and educational issues:

- No radio-receiving equipment – 50 per cent;
- School schedule difficulties – 23 per cent;
- Unsatisfactory radio equipment – 19 per cent;
- Lack of information – 14 per cent;
- Poor radio reception – 11 per cent;
- Programmes not related to the curriculum – 11 per cent;
- Class work seen as being more valuable – 10 per cent;
- Teachers not interested – 7 per cent.

Educational Television

The examples of film and radio highlight various recurring factors that seemed to shape the introduction of 'new' technologies into educational settings during the twentieth century. As Cuban and others have observed, most of the emerging technologies and innovations of the twentieth century – from the X-ray machine to the airplane – stimulated initial enthusiasm over their educational potential, followed by modest and inconsistent take-up across school systems. Indeed, while it is too simplistic to conclude that education was simply 'resistant' to film and radio, there were clear discrepancies between the potential and eventual take-up of these technologies by schools and teachers. This pattern of what might be described as 'compromised' technology use in education is illustrated in the case of television – one of the defining consumer technologies of the twentieth century.

Experiments in the educational use of closed-circuit television stretch back to 1939. The widespread use of broadcast educational television was initiated soon after by the US Federal Communications Commission's decision in 1952 to set aside over 240 television channels for educational purposes. As well as prompting the development of public and community television stations, this decision encouraged some universities and colleges to establish educational television stations (Morehead 1955). Federal funding for these educational television projects was accompanied by support from various commercial organisations. Most notable was the Ford Foundation's 'Fund for the Enhancement of Education', which committed $100 million for trials of educational television projects across more than 250 school systems and 300,000 students. Up until the 1970s, educational television grew in prominence and popularity around the world. For example, in 1980 each of the three main national TV channels in the UK were reported to be annually producing around fifty television series for schools and colleges, with three-quarters of schools using television programmes in some of their lessons.

It would be fair to say that initial enthusiasm for educational television surpassed the excitement and hyperbole directed towards film and radio before it. Indeed, some of the most vocal early proponents of educational television were those who had previously supported these earlier technologies. William Darrow, for example, described television in glowing terms of 'radio with its eyes open', later reasoned that 'when the eye and the ear have been remarried in television we shall indeed be challenged to open wide the school door … there will be no "blindness" gap to be bridged' (cited

in Cuban 1986, p.26). Four decades on from its introduction, proponents of educational television continued to enthuse about the medium's ability to provide educators with 'unique teaching resources' – supporting a range of learning 'from the concrete to the abstract' (Bates 1988, p.215). As with film before it, the visual qualities of television were seen to offer 'a window on the world for our students' coupled with 'the "enjoyment factor" which well-produced television brings to learning' (Bates 1988, p.214).

These sorts of positive claims were advanced regularly from the 1950s onwards. This included arguments that television could 'provide the closest thing to real experiences for many children' (King 1954, p.20). As with earlier enthusiasms for film and radio, most supporters considered television to be capable of enhancing the quality and quantity of instruction. As Lawrence Conrad (1954, p.373) reasoned, 'television could well prove to be the power tool of education … television could certainly increase the effectiveness of teaching, and it might well expand the size of the classroom'. All told, most educators welcomed television as a 'quick, efficient, inexpensive means of satisfying the nation's instructional needs' (Hezel 1980, p.173).

These claims were reinforced by empirical studies and evaluations of the time. For example, a number of self-report studies during the 1950s found a large majority of 'early-adopting' teachers to consider television-based lessons 'valuable enough to continue' (Allen 1956, p.129). Other researchers provided persuasive case studies of particularly successful television projects and initiatives. Larry Cuban describes some of the more celebrated case studies of school systems that were making extensive use of educational television. In the Pacific island of American Samoa, for example, a national scheme of television-based instruction was introduced to supplement what was felt to be a poorly trained and poorly qualified teaching workforce. Cuban (1986) reports that by 1966 four in five school students in America Samoa were spending between one-quarter and one-third of their class time watching televised lessons which were then supplemented by follow-up exercises and question periods led by teachers. Similar 'immersive' projects in US states suggested that television-viewing students could improve their position in league tables of test scores when compared to national norms.

These success stories notwithstanding, as the twentieth century drew to a close, educational television was generally deemed to have failed to impact on school, college and university education, especially when compared to the popularity of domestic television-viewing. As Larry Cuban (1986, p.39) describes, by the middle of the 1980s it was being reported that 'most teachers seldom use the medium. When teachers do use television, they do

so infrequently and for only a tiny fraction of the instructional day'. A survey by the UK's Independent Broadcasting Authority in 1990 suggested that a number of reasons could be associated with this failure. These included issues such as: the cost of television and video equipment; a lack of teacher training to use television in teaching; the incompatibility of television programme content with the school curriculum; and the perceived low quality of programming (see Moss et al. 1991).

A further impediment that emerged from some research studies of television use in schools was the suggestion that programme viewing clashed with the norms and routines of the classroom. Larry Cuban, for one, reasons that television was often inserted into classroom settings without sufficient consideration for the nature of the social contexts of schools and schooling. As he argued, 'television was hurled at teachers. The technology and its initial applications to the classroom were conceived, planned, and adopted by non-teachers' (Cuban 1986, p.36). Other observers reasoned that the 'culture' of television did not necessarily complement established practices and understandings among teachers, classrooms and schools. As Richard Lewis (1962, p.564) concluded,

> Television is a significant creator of alarm. … TV, in a dramatic way, cuts sharply across all aspects of an instructional program and prods deeply into the traditionally private classroom life of teachers. Reactions to proposals to use television in instruction include the normal range from uncritical acceptance to automatic rejection.

Learning Lessons from the Past

All of these phases of 'pre-digital' technology implementation predate the mainstream emergence of stand-alone 'micro-computers' in the 1980s, 'online' networked computing during the 1990s, the emergence of 'social media' and 'apps' during the 2000s and 2010s, and the ongoing emergence of personalised learning systems and AI-driven tools during the 2020s. As such, all of the educational technologies discussed in this chapter are now sufficiently 'in the past' to allow for detailed and objective reflection on their rise and eventual decline. Hopefully, these accounts have illustrated the benefits of looking backward at a topic that is usually imagined in forward-looking terms. As Lizzie O'Shea (2019) argues, there is much to be gained from making use of historical trends in order to make sense of

possible technological futures – what she frames as a 'usable past'. While the history of early twentieth-century film strips might not appear to be directly comparable with online education in the 2020s, there is much that can be learned from the logics, justifications and underpinning politics of all these pre-digital technologies.

So, what can a 'long view' of film, radio and television in education tell us? Certainly, one is struck by the repeated failure of initial promises to be realised in practice. Although these technologies were accompanied by the promise of diverse benefits for education and learning, all failed to meet the substantial expectations that surrounded them. Given the considerable impact of film, radio and television in domestic, business and entertainment contexts, it could be reasonably concluded that these failures were linked (at least partially) to issues specifically related to education. If this is the case, then it would seem sensible to bear these issues in mind during subsequent discussions of contemporary digital technologies.

In particular, all three waves of technology development detailed in this chapter were surrounded by optimistic but speculative hopes of improving education provision and education practice. This is an important point to consider, as how and why technologies are introduced into social contexts will have a significant bearing on how they are used. It is clear that technologies such as the motion picture were not introduced specifically in response to strong demand from educators or students. Instead, these technologies appear to have been introduced in largely 'top-down' ways. Often these technologies were introduced in response to what was referred to in Chapter 2 as 'external' imperatives – not least the expectation that the use of these technologies would bring education 'up to speed' with the rest of society. Indeed, film, radio and television could all be said to highlight a trend for technology being introduced into education as a 'solution in search of a problem'.

Certainly, we have seen throughout this chapter how successive introductions of film, radio and television into education were accompanied by considerable hyperbole and hucksterism. Many claims were made about the enhanced nature of technology-based learning, the resulting improvements to learning, as well as the establishment of 'fairer' conditions for 'rich' and 'poor' students and schools. We also saw how research 'evidence' was produced quickly to 'prove' the 'effect' of these technologies, especially in terms of learning gains – regardless of the fact that this evidence was inconclusive and equivocal. Aside from expectations of enhanced learning, it is notable how many of the 'educational' rationales for these technologies

were based on ambitions towards the mechanisation of the teacher's work, increased efficiency and economies of scale (Watters 2015). As Bill Fester (2014, p.42) concludes, the 'siren's call' of film, radio and television technology in education was repeatedly one of 'potentially solv[ing] issues of cost, consistency and quality'.

It could be concluded that film, radio and television all perpetuated what was referred to in Chapter 2 as a 'technological solutionism'. Of course, education was certainly not the only area of twentieth-century society in thrall to the transformative potential of new technologies. Any educational enthusiasms for these technologies must be seen as a subset of wider societal enthusiasms. In general, the twentieth century was a period when many people were keen to proclaim the 'power' of various technologies to affect substantial societal change. Alvin Weinberg (1966, p.69), a physicist who had worked on the Manhattan Project, wrote a seminal paper in the 1960s criticising the eagerness of politicians and policymakers to seize upon any 'quick technological fix for profound and almost infinitely complicated problems'. The flaw in this reasoning, Weinberg argued, was that 'social problems are much more complex than are technological problems', requiring 'social engineering' rather than technological remedies. Although Weinberg was more concerned with issues of warfare and poverty than education, his analysis holds true in terms of the burgeoning interest throughout the twentieth century for audiovisual technologies as potential solutions for the perceived shortcomings of national education systems.

Most of the commentators who have charted the history of education and technology throughout the twentieth century make sense of these observations in terms of a clear 'cycle' of events that is more or less repeated with each 'wave' of technology development. This cycle is seen to begin with substantial promises for the transformative potential of the technology backed by research evidence and other instances of scientific credibility. Yet despite initial enthusiasm and expectations, educators then go on to make inconsistent use of the new technologies for a variety of technical, professional and personal reasons. Perhaps most importantly, relatively few substantial changes appear to occur in the arrangements of educational institutions. A number of rationales are then proposed to explain this 'lack of impact' such as resourcing, funding, educational bureaucracy or a general 'teacher resistance'. As memories of initial enthusiasms for the technology begin to fade, educators are then 'sold on the next generation of technology, and the lucrative cycle start[s] all over again' (Oppenheimer 1997, p.47). As far as most historians are concerned, this cycle of 'hype', 'hope' and 'disappointment'

is perhaps the biggest lesson about education and technology to be learnt from the twentieth century. As Margaret Cassidy (1998, p.181) concludes,

> While it is never entirely accurate to claim that history repeats itself, or that patterns and similarities are accurate predictors of future events, it is probably fair to think that some of the obstacles that stood in the way of radio [and] television … are still in place.

As this chapter has shown, there are certainly a number of recurring issues arising throughout the history of film, radio and television in twentieth-century education. All these technologies could be said to have been hampered by a number of practical issues such as inadequate resourcing, technological unreliability, increased financial cost of upkeep, inadequate training and teachers' lack of confidence in the technology. Many of the recurring issues throughout the different waves of educational technology highlighted in this chapter also hint at deeper structural issues and 'clashes' – not least issues of congruity and 'goodness of fit' with pre-existing education structures. For example, as Margaret Cassidy (1998, p.178) observes, all of these technologies certainly 'posed problems in terms of fitting into the schedule of the school day'. As many of the examples illustrated in this chapter suggest, this lack of 'fit' related to issues of time, content and relevance to the curriculum. There is also a sense that these technologies struggled to find a niche within the social and cultural contexts of the educational institutions they were meant to be implemented into. Indeed, two of the recurring obstacles to successful implementation identified by Larry Cuban (1986) were the nature of 'the classroom and school as work settings', and the 'situationally constrained choice' that teachers face when working in schools, colleges and universities.

This history of classroom technology certainly illustrates the apparent ability of educators to accommodate these new 'innovations' and shape their use around existing practices. As Larry Cuban (2013, pp.110–12) reflects, one of the notable features of schools over the past 100 years is the 'remarkable stability in how teachers have taught and do teach now. … For the most part, teachers have tamed technological innovations seeking fundamental reforms in pedagogy to fit their classroom practice since the early twentieth century'. Yet, it is important to stress that teachers are not solely responsible for the limited showing of these technologies in education provision and practice. It is also notable how these technologies were constrained by issues relating to the substantial structural changes in schooling over the twentieth century – particularly the introduction of standardised curricula and examination regimes, the need for standardised

timetabling and centralised forms of organisation and governance. In short, there were many formal and informal features of schools and schooling that these technologies had to fit around.

It could also be argued that the technologies in this chapter provide good illustrations of the continuities that are implicit in any technological change. In particular, these examples highlight the tendency for 'new' technologies to continue practices, techniques and competencies established around preceding technologies. This is apparent in the (lack of) progression from film in the 1920s to television in the 1960s. One could argue that many of these screen-related practices persist in forms of online video tutorials and lectures used in the recent provision of 'remote schooling' during the Covid-19 pandemic, as well as the ongoing trend for 'flipped classrooms'. Similarly, echoes of the static film strip from the early 1900s are apparent in the recent predilection for using slideshow applications such as PowerPoint in schools and universities (Smith 2015). All told, the examples featured in this chapter remind us that 'new' technologies in education are haunted by ghosts of old technologies. In other words, traces of the technical principles of what might be presumed as 'dead media' remain, even though the technological artefacts might not. As Eugene Thacker (2014, p.129) puts it, 'with dead media, the object is no longer in use, but the form of the object remains active'.

If nothing else, this chapter illustrates the complex nature of technology implementation. We have seen that there is little historical reason to assume that technology use leads to inevitable and sustained educational improvement. Instead, there is plenty of evidence to suggest that the implementation of technology in education is rarely a predictable or controllable process. As Robert Reiser (2001, p.61) concludes, 'of the many lessons we can learn by reviewing the history of instructional media, perhaps one of the most important involves a comparison between the anticipated and actual effects of media on instructional practices'.

So what key issues can be taken forward from this chapter's 'contextual' account of old technology? All of the examples in this chapter have certainly shown how educational institutions are social spaces that mediate any 'choices' offered by new technologies. Indeed, the main benefit of taking a contextualist approach has been to highlight the sociotechnical nature of technology-related change in education. The 'wonder' technologies of educational film, radio and television are best understood as embedded social practices. All of the examples in this chapter illustrate how the implementation of technology in educational settings is a matter of human

actions and institutional inertia – not simply the relentless march of technological progress.

While film, radio and television can all be associated with specific changes to classrooms and schools during the twentieth century, none of these technologies could be said to have 'caused' or generated widespread or systemic improvement. Instead, any changes are better understood in terms of how each technology was appropriated within social relations and structures. This goes some way towards explaining the seemingly slow, unpredictable and frustrating nature of educational change throughout the twentieth century – a period that was in many ways characterised by rapid and far-reaching technological advancement. As Brigitte Wessels (2010, p.28) contends, 'although some aspects of technological change may be fairly rapid, social and cultural change usually occurs more slowly … reflect[ing] the complexity and indeterminacy of the social'.

Conclusions

For the remainder of this book we turn our attention to the uses of twenty-first-century digital technologies. Yet, in doing this we should remain mindful of technical, social, cultural and political continuities from earlier forms of technology. As Neil Postman reasoned at the beginning of the 1990s, the high-profile 'failures' of educational television, film and radio leave little excuse for educators to approach the implementation of any new technology 'with their eyes closed' (cited in Oppenheimer 1997, p.62). That said, all the examples in this chapter can also help us reflect on the ways in which the current wave of 'emerging' technologies may differ from their predecessors. What possible discontinuities as well as continuities may be apparent with contemporary forms of educational technology? We should not automatically presume that the development and implementation of technology in the 2020s is necessarily a case of 'history repeats'. It may well be that emerging forms of personalised digital technologies and AI-driven technologies encounter many of the issues that have recurred in the past. But there may also be good reason to expect the current wave of digital technologies to perhaps be 'the one' that finally overcomes these issues, and achieve the long-anticipated technological transformation of education.

Indeed, many technologists would contend that the digital technologies of the twenty-first century are substantially different from the analogue

technologies of the twentieth century. For example, contemporary digital technologies certainly represent a 'convergence' of different media uses, which means that they are perhaps not comparable directly with the technologies of the twentieth century. A modern 'multifunctional' digital device such as a smartphone can operate as a television, radio and computer (as well as a telephone, camera, internet device and games machine). In addition, these contemporary technology devices are often highly portable, not beholden to fixed power sources, and owned and brought into the classroom by individuals rather than controlled by educational institutions. Contemporary technology is also more 'interactive' in nature rather than relying on the 'broadcast' mode of transmission that characterised twentieth-century technology. Perhaps most significant is the sheer amount of economic interest now invested in pushing these new technologies onto education. In this sense, Hillman and Couldry (2020, n.p.) offer a warning to historians of twenty-first-century classroom technologies:

> History is littered with failed predictions of how technology will 'change everything'. … But the [current] determination among large business and policy forces to shift education decisively into online spaces should not be underestimated.

As such, many people might well feel that the current generation of digital devices and artefacts are finally capable of meeting the promises made for the less-capable technologies of the twentieth century. Perhaps the likes of Thomas Edison were not wrong when enthusing about the transformative potential of new technologies in education per se. Instead, perhaps these promises were just being made 100 years too early.

One further possible reason to not expect history to repeat is the altered nature of what now constitutes 'learning'. Indeed, many educationalists would contend that contemporary forms of technology can now support radically different forms of learning than was possible and/or desired in the twentieth century. Whereas film, radio and television did little more than support the presentation of content and provide resources for the passive reception and 'doing' of learning tasks by individual students, contemporary digital technologies are capable of supporting networked and active forms of learning which are based around collaboration between large groups of people. Many of the modes of teaching and learning that accompanied the classroom use of film, radio and television now appear in hindsight as notably restricted, often doing little more than reinforcing the teacher

controlled 'broadcast' of information. Yet as was detailed in Chapters 1 and 2, contemporary digital technologies are more individually centred and socially oriented. In these terms alone, many educationalists and technologists now expect digital technology to break out of its cycle of hype, hope and disappointment. With these expectations in mind, we can now move to another set of key issues and debates – the changing relationship between technology and learning.

Further Questions to Consider

- How has the use of film, radio and television endured in education, and could even be said to still play an important role into the 2020s? What reasons can explain this longevity when compared to relative 'failures' of these technologies to be adopted in formal classroom settings of the school, college and university?
- The smartphone could be seen as a telephone, computer, television, radio and camera, all rolled into one. To what extent do networked digital devices like this represent the 'convergence' of previous technologies? Are any of the issues associated with the historical use of 'separate' technologies still applicable to the converged devices and platforms of today, or are these issues now largely overcome?
- How might the history of a recent educational technology be written in twenty years' time? For example, consider the educational use of iPads. What examples of 'hype', 'hope' and 'disappointment' can already be associated with iPads and other tablet computers? What wider issues and factors appear to have compromised the educational potential of these devices?

Further Reading

Larry Cuban's book on the history of classroom technologies in the twentieth century expands upon all of the different technologies discussed in this chapter. It is well worth finding a copy if you can:

Cuban, L. (1986). *Teachers and machines: the classroom use of technology since 1920*, Teachers College Press.

Bill Ferster updates many of Cuban's discussions on the rise of using broadcast media to teach – from twentieth-century experiments with radio and television, through the MOOCs of the early 2010s:

Ferster, B. (2016). *Sage on the stage: education, media and how we learn*, John Hopkins University Press.

Audrey Watters offers an in-depth exploration of the history of the automation of education – including detailed accounts of work by psychologists Sidney Pressey and B. F. Skinner to develop behaviourist automated teaching machines:

Watters, A. (2021). *Teaching machines.* MIT Press.

4

Technology and Learning

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Introduction

As discussed in Chapter 1, learning is a key part of what most people understand 'education' to be. As such, technology use in education is often seen primarily in terms of supporting acts of learning in one form or another. In fact, many people working in the area of educational technology would describe themselves as being 'learning technologists' and perhaps might characterise their work as part of the 'learning sciences'. We have recently seen the emergence of 'learning engineers' working to improve the area of online education. As such, we cannot fully understand education and technology unless we consider the key issue of how technology use can support, enhance and even redefine learning.

The links between digital technology and matters of thinking, intelligence and learning stretch far back into the history of computer development. As we will discuss in more depth in Chapter 7, the development of the computer during the 1950s and 1960s was rooted in the field of AI. This led to an early emphasis within computer science on the challenge of teaching machines to think intelligently, or at least being able to add 'thinking-like' features to technology. A belief that computers are 'machines for thinking' has therefore long persisted in technological and educational circles. As Martin Cohen (1993, p.57) reasoned at the beginning of the 1990s, 'computers are not just machines that seem to think – they promise to do people's thinking for them and much else besides. It is in this sense that the computer is an "educational tool"'.

These processes of learning and thinking continue to feature prominently in how contemporary digital technology development is imagined and anticipated. Now it is argued that computer technologies can have a profound influence on how humans think. Over the past decade or so, for example, neuroscientists, cognitive psychologists and others concerned with the study of brain development have begun to document the possible links between technology use and people's capabilities for learning and processing information. This has prompted excitement among some commentators over the technology-induced capacity of people to process information and think differently than before. As Susan Greenfield (2014, n.p.) enthuses, 'the human brain will adapt to whatever environment in which it is placed; the cyber world of the twenty-first century is offering a new type of environment; the brain could therefore be changing in parallel, in correspondingly new ways'.

One of the key cognitive changes is seen to be the increased quantity of learning that can take place. The vast networks of information, resources and people now available through digital technologies such as the internet are seen to be restructuring and extending young people's mental facilities and ability to learn. As Marc Prensky (2012, p.202) speculates,

> Given that the brain is now generally understood to be massively plastic, responding, changing and adapting to the inputs it receives, it is even possible that the brains of people receiving all these inputs on a constant basis – i.e. searchers for wisdom – will be organized and structured differently in some ways from the brains of today's wise people.

These claims about the changing nature of cognition give credence to wider 'common-sense' assumptions that digital technology is inherently beneficial

to the learning process. Indeed, few educators would contest the idea that digital technology use (when properly applied) can contribute to some form of learning gain or benefit. Digital technology is now used throughout educational institutions as a means to support learning – either as an information tool (i.e. as a means of accessing information) or as a learning tool in its own right (i.e. as a means of supporting learning activities and tasks) (Tondeur et al. 2007). As such, there are many different ways in which different digital technologies are seen to be capable of supporting learning. Take this list of 'key affordances' of learning technologies (US National Academies of Sciences, Engineering, and Medicine 2018, p.165):

- **Interactivity:** Digital technology systematically responds to actions of the learner.
- **Adaptivity:** Digital technology presents information that is contingent on the behaviour, knowledge and characteristics of the learner.
- **Feedback:** Digital technology gives feedback to the learner on the quality of the learner's performance, sometimes including how the quality could be improved.
- **Choice:** Digital technology gives students options for what to learn and how to learn so they can regulate their own learning.
- **Non-linear access:** Digital technology allows the learner to select or receive learning activities in an order that deviates from a set order.
- **Varied representations:** Digital technology provides quick connections between representations for a topic that emphasise different conceptual viewpoints, pedagogical strategies and ways of presenting material. Such connections support cognitive flexibility to support learning.
- **Open-ended learner input:** Digital technology allows learners to express themselves through natural language, drawing pictures and other forms of open-ended communication that encourage active learning.
- **Communication with other people:** An individual learner communicates with one, a few or many other 'persons' who may range from peers to subject matter experts.

These (and other) types of capability underpin the common assumption that digital technology and learning are inextricably linked. The key issue for this chapter to consider is *how* exactly can digital technology support learning? *What* types of learning result from the digital technology uses described so far in this book? *Why* can technology support learning that

would not otherwise take place? We therefore need to examine the ways in which digital technologies are associated with learning, and think a little more carefully about what learning 'gains' and improvements can be said to derive from technology use. In order to do this, we first need to review key theories of learning that have been developed over the past hundred years or so, and consider what explanations they provide for the role of technology in learning.

Getting a good sense of these different theories of learning is an important part of being able to make sense of the educational application of any technology that purports to support teaching and learning. In short, any classroom-focused 'educational technology' should have ideally been designed around a clear idea of how it will support learning – what might be termed 'learning design' or 'instructional design'. This might also include an intentional model of how the technology can be used to support teaching – what might be termed 'pedagogical design'. Of course, some technologies are not designed and developed with educational purposes in mind – but even these will have some sort of implicit instructional or pedagogical design, if only by accident.

There is growing interest, therefore, in making explicit connections between educational technologies and theories of learning. In higher education, Diana Laurillard's (2002) 'Conversational Framework' is often used as a way of highlighting these connections. The Conversational Framework prompts reflection on the ways in which different forms of technology might best fit into the 'teacher's constructed learning environment' in order to support different forms of learning. For example, Laurillard distinguishes between 'Narrative' technologies that present material to the learner, and therefore are capable of showing, telling or demonstrating something to learners. These are specific processes that lead to distinct forms of learning. In contrast are 'Communicative' forms of technology that support discussion, debate and exchange among learners – again, processes that lead to other distinct forms of learning.

Seen along these lines, then, teaching with technology can be understood as what Laurillard (2013) has termed a 'design science' – that is, the job of finding the most appropriate forms of digital technology to support the types of learning that the teacher plans to stimulate and support. Clearly, this requires a sound understanding of how learning takes place and the ways in which technologies can support these processes. This is where a good knowledge of different learning theories becomes important. As such, this chapter now goes on to review five of the key learning theories developed

over the twentieth century – that is, behaviourism, cognitivism, constructivism, constructionism and sociocultural psychology. Just what contribution have these theories made to the use of digital technologies for learning?

Behaviourist Theories of Learning and Technology

Much of the history of 'pre-digital' technology use in twentieth-century education was aligned with 'behaviourist' theories of learning advanced by psychologists such as John Watson, E. L. Thorndike and B. F. Skinner. In particular, behaviourism grew to be a highly influential learning theory during the 1950s and 1960s, and continues to remain relevant to the use of digital technology in contemporary education. Put simply, behaviourists are far more interested in the effects of learning rather than the processes of learning. In this sense, behaviourist accounts describe what goes on in the mind largely in terms of a closed 'black box'. Underlying the behaviourist view of learning is the idea that an individual's behaviour is 'conditioned' by a series of reactions and responses to various stimuli in their environment. In other words, the behaviourist approach suggests that when faced with a stimulus, a human will respond (i.e. behave) in a particular way. What then happens subsequently will influence how the human responds (i.e. behaves) when faced with the same stimulus again. If the consequence of this behaviour is reinforced by a reward or suppressed through a punishment, then it is likely to be repeated or curtailed according to the nature of the reinforcement.

For example, the model of 'classical conditioning' explains behaviour in terms of a series of stimulus/response interactions based on punishment (perhaps best known through Ivan Pavlov's experiments on the digestive glands in dogs). Here, learning is seen as the formation of a connection between the stimulus and the response. This chain of events was illustrated in John Watson's experiments during the 1920s with human subjects, most notably the purported 'little Albert' experiment. These experiments were based upon Watson's belief that the majority of human behaviours are based on conditioning. Watson set out to test this hypothesis by conducting a series of experiments to make young children (such as 'little Albert') afraid of rats. He achieved this through the association of a loud and unexpected

noise whenever a rat was touched. After a series of similar events, Watson demonstrated how this fear could then be generalised to other small animals. This fear could also then be 'extinguished' by subsequent exposure to animals without the noise.

While offering compelling explanations for a number of behaviours, the idea of learning being rooted in reactions to punishment was gradually superseded by the model of learning through 'operant conditioning'. Here learning was seen to be rooted in the event of being rewarded after correct responses. Skinner's experiments on conditioning the behaviour of rats, pigeons and dogs showed how certain kinds of behaviours could be generated easily through a response/stimulus process of feedback and reinforcement. Skinner's work on operant conditioning highlighted the importance of 'behavioural chaining' where a behaviour was learnt in a series of steps, with the individual incrementally mastering each step in sequence until an entire sequence is learned. Skinner demonstrated the concept of behavioural chaining through a series of experiments with animals learning to perform certain tasks. Take, for example, his experiments to condition pigeons to learn to pull levers in order to gain food. Here, a succession of behaviours were first rewarded, but then later left unrewarded as the sequence of actions were internalised (e.g. touching the lever, moving the lever and moving the lever to the left).

As these descriptions imply, the behaviourist view of the individual learner is largely as a passive recipient of learning experiences. In this sense, many people might describe behaviourism as a teaching theory rather than a learning theory. Indeed, much of Skinner's work was implicitly critical of conventional classroom teaching techniques. Skinner was particularly frustrated by the time lapse between a student's response and the feedback that their classroom teacher is able to provide. Skinner also bemoaned the infrequency of teacher-provided reinforcement and the lack of personal attention that could be given to students in large classes. As with many twentieth-century learning theories, behaviourism soon became a driving motivation for proposed reforms to the existing school system.

As the 1950s progressed, many behaviourists began to advocate a system of teaching and learning that became known as 'programmed instruction'. As Saettler (1990, p.14) describes, this involves 'a curriculum that is programmed step by step in small units, focused on immediately observable and measurable learning products'. Here the links between technology and behaviourist theories of learning were made explicit. In particular, the programmed instruction movement was built around the development and

use of a number of educational technologies and 'mechanical devices'. As Skinner (1958, p.95) reasoned at the time, the potential advantages of device-based learning were plentiful:

> If the teacher is to take advantage of recent advances in the study of learning, she must have the help of mechanical devices. … A teacher may supervise an entire class at work on such devices at the same time, yet each child may progress at his own rate, completing as many problems as possible within the class period. If forced to be away from school, he may return where he left off. The gifted child will advance rapidly, but can be kept from getting too far ahead either by being excused from arithmetic for a time or by being given special sets of problems which take him into some of the interesting by-paths of mathematics. The device makes it possible to present carefully designed material in which one problem can depend upon the answer to the preceding and where, therefore the most progress to an eventually complex repertoire can be made.

Early instances of programmed instruction techniques included mechanical multiple-choice machines and 'chemo-sheets' where students were required to check their answers with chemical-dipped swabs. Skinner himself devoted much time to the development of the 'teaching machine'. Built around the principles of operant conditioning, these devices required the student to answer a question and then receive feedback on the correctness of their response. Skinner's approach to the design of teaching machines was to divide the learning process into a large number of very small steps (frames), with positive reinforcement dependent upon the successful accomplishment of each step. By relying on a series of small learning steps, the teaching machines were designed to give frequent positive reinforcement to increase the rate at which the individual correctly learnt each step (e.g. some early teaching machines were designed to dispense candy rewards). The teaching machines also operated on the principle that students should compose their responses themselves rather than select responses from a set of prewritten multiple-choice options – reflecting Skinner's reasoning that responses should be recalled rather than simply recognised. Unlike conventional classroom-based activities, teaching machines were designed to keep students actively engaged with learning tasks at all times, providing immediate feedback for every response.

In their heyday, teaching machines were widely considered a success. Soon after developing the first machines for use in schools and universities, Skinner reflected that 'with the help of teaching machines and programmed instruction, students could learn twice as much in the same time and with

the same effort as in a standard classroom'. By 1963, there were seventy-three commercially produced teaching machines in various shapes and sizes, with companies such as Teaching Machines Inc. boasting sales of over 150,000 machines (Fester 2014). Although the popularity of programmed instruction began to wane in the 1960s, the approach played an important role in the emerging field of 'computer-assisted instruction'. Early forms of computer-assisted instruction borrowed heavily from behaviourist principles, especially in terms of the so-called 'drill-and-practice' computer programmes.

Behaviourism is by no means only a historical feature of educational technology. Drill-and-practice software continues to be used into the 2020s, most commonly designed to reinforce basic skills such as spelling words, vocabulary development and typing. Many forms of online learning rely on basic exercises and quizzes to provide students with 'instantaneous, crucial feedback at each step, usually in response to questions, and the students advanced through the content based on correct answers' (Ferster 2014, p.50). Similarly, many contemporary 'adaptive learning' systems allow users to determine the sequence of instruction or to skip certain topics, although in essence the technology is used to present instruction to the individual whose responses are then reinforced. Behaviourist principles also inform 'tutorial' software packages which present new concepts and provide step-by-step instructions on how to complete certain objectives. In all these cases, behaviourist theories continue to underpin the design and development of educational technology many decades on from the first teaching machines.

Cognitivist Theories of Learning and Technology

Behaviourist theory can be seen as one of the guiding influences on educational technology throughout the past sixty years or so. However, behaviourist principles are now often criticised as providing a rather bounded 'input/ output' understanding of learning. As just discussed, behaviourist accounts are concerned primarily with the individual's observable behaviour rather than the cognitive processes taking place within the brain. This distinction is made clear when one considers behaviourism's close links with methods of animal training. At best, behaviourism relies on observable changes in behaviour as an indication of what is happening inside an individual's mind. As such, behaviourism

is limited in its ability to explain exactly how learning takes place and how knowledge is constructed within the human mind.

By contrast, the theories of learning that have emerged from the field of cognitive science offer a very different perspective. Here, learning is understood more in terms of the thought processes that lie behind any observable behaviour. Unlike the behaviourist theories just described, learning is seen as an internal process of mental action. In particular, these 'cognitivist' theories of learning seek to describe the mental processes that underpin the act of learning within the human mind. Learning is seen primarily as a matter of symbolic manipulation, with the individual's mind involved in processing goals, intentions, plans, mental representations and logical computations. As Tenenberg and Knobelsdorf (2014, pp.4–5) describe,

> Viewing minds as symbolic machines that carry out inference procedures on symbolic representations leads to a particular view of learning: learning is the acquisition, change and application of symbol structures that denote knowledge about the world, such as scripts, plans and schemas.

The language of cognitivist theory involves quite complex descriptions of how stored representations are mentally processed. By describing and modelling how the mind should work, methods can be developed to support individuals in matching an 'ideal' performance. This interest in describing the mental processes of learning provides common ground for the alignment of cognitive psychology and technology-based education. Throughout the latter half of the twentieth century, cognitive psychologists became interested in developing computational metaphors of the mind – that is, descriptions of how the mind processes and 'computes' information. In particular, mental processes began to be conceived in terms of an internal knowledge structure where new information is compared to existing cognitive structures called 'schema'. It was argued that these schema could be combined, extended or altered to accommodate new information as it is acquired and processed by the mind. This computational orientation of cognitive psychology led to the development of computer-like models of the mind, involving three main stages of information processing where 'input' first enters a sensory register, then is processed in the mind's short-term memory, and is then sometimes transferred to long-term memory for storage and retrieval.

In envisioning this kind of information processing 'computer', cognitive psychologists see the mind as relying on a number of components that would be familiar to any computer scientist. Indeed, cognitivist theory was soon

informing the development and design of technology-based learning from the 1960s onwards – in particular providing the basis for the development of 'intelligent tutoring systems' and 'cognitive tutors'. Here computer technology is used to host a series of teaching exchanges between an individual and an 'intelligent system'. The intelligent system is designed to respond to a model of what the individual should ideally be doing during a task. The individual's performance is then compared with this model and the system is able to 'troubleshoot' where their mental actions have deviated from the ideal. On the basis of this comparison, the system is then able to provide 'intelligent feedback' to guide the individual in further attempts at similar tasks.

This approach is based around the idea of programming a computer to 'think' like a human mind – an ambition that drove early work in the field of AI. Indeed, initial work in AI during the 1950s and 1960s underpinned a range of technologies used in education towards the end of the twentieth century, often in the form of computer-based troubleshooting programmes as described earlier. A range of applications were developed from the 1960s onwards to diagnose students' understanding of the skills involved in mathematical and scientific procedures, with systems providing complete diagnostic model of common learning errors which an individual's performance could then be compared against.

Although applicable to all stages of education, such technologies and tools continue to be especially popular in work-related learning. Many of the 'intelligent learning environments' currently being used in work-based training contexts still follow cognitivist lines. Various simulation-based intelligent tutoring systems are regularly used in industrial and military settings to train professionals ranging from pilots to surgeons. Such systems often provide 'free-play' simulations that enable individuals to act in roles in realistically complex work-related scenarios. As well as simulating models of complex cause-and-effect relationships, these systems are designed to provide comprehensive and useful instructional feedback, allowing individuals to reflect on the appropriateness and effectiveness of their actions and decisions. Many of the intelligent learning environments developed in the 2000s and 2010s were based around graphical manifestations of the systems' intelligence in the form of the so-called pedagogical agents. These often took the form of 'conversational companions' such as cartoon characters or more realistic 'avatars' who directly talk with the learner on behalf of the intelligent system.

As Gertner and Van Lehn (2000) describe, the fundamental principles underlying the design of many of these intelligent tutoring systems can be

best described as computer-based 'coached problem-solving'. Often the computerised-system encourages an individual to construct new knowledge by providing minimal hints that require them to derive the remainder of the solution on their own. In a similar fashion to behaviourist views of learning, the technology gives immediate feedback after each action to minimise the amount of time spent on incorrect activity. These systems can offer users flexibility in the order in which actions are performed – sometimes allowing them to skip steps when appropriate. Many intelligent tutoring systems are based around a 'mastery' model, with individuals allowed to progress through tasks after mastering a large proportion of a given task. However, in contrast to the programmed learning technologies described before, individuals using an intelligent tutoring system are seen to learn by 'doing' rather than learn by being instructed.

Another allied cognitive model of learning that features increasingly in the logic of personalised learning, adaptive learning and learning analytics is the idea of 'self-regulated learning' (Zimmerman 1990, Winne 2020). This theory also conceives the process of learning in terms of information processing, with emphasis placed on an individual being able to self-monitor, self-evaluate and self-adapt their learning performance. Self-regulated learning posits that individuals are able to reflect on their own thinking (what is known as metacognition), respond to feedback about their learning and strategically progress onto subsequent episodes of learning by altering factors within their control in order to improve performance in light of feedback (i.e. regulating their own actions). Digital technologies can play a key part in these processes – such as setting goals and providing information to students to help them make behavioural decisions to meet these goals. The technology can also monitor and evaluate a student's performance and suggest ways of modifying subsequent learning strategies.

Constructivist Theories of Learning and Technology

The computational metaphor of information processing that underpins cognitive psychology offers a powerful explanation of learning. As the example of intelligent tutoring systems suggests, cognitivist theories certainly move the emphasis of technology-based learning beyond issues of behaviour and introduces an enhanced notion of learner control. However, cognitivist

theories can be criticised for encouraging a strongly individualistic approach to learning and knowing, and perhaps losing sight of the social nature of human learning. Models of learning are not universal, and differences are clearly evident between specific cultures and environments (Tenenberg and Knobelsdorf 2014). It is not surprising, therefore, that while behaviourist and cognitivist theories of learning have continued to influence the ways in which technologies are used in education, the past forty years have seen mind-based accounts of learning take a distinctly 'social turn'. In particular, the so-called constructivist theories of learning came to dominate the field of educational technology during the 1980s and 1990s. Much of this work drew inspiration from well-established learning theories developed by psychologists such as Jean Piaget and Jerome Bruner – although as we shall go on to discuss, a number of distinctive theories of learning can be classed as being constructivist in nature. It therefore makes sense to consider these learning theories and the implications they have for educational technology in a little more detail.

Much of the enthusiasm for computer-based learning throughout the 1980s and 1990s was driven by the notion of individuals learning by constructing their own understanding. Constructivist theories – not least the work of Piaget and his followers – describe learning as taking place best when it is problem-based and built upon an individual's previous experience and knowledge. In this sense, learning is rooted in processes of exploration, inquiry, interpretation and meaning-making. Constructivist theories portray learning as a more active process than in behaviourist and cognitivist accounts. The constructivist learner is not solely receiving and acting upon information that is transmitted to them from others. Instead, individuals are understood as constructing their own perspective of the world through personal experiences. One of the central ideals of constructivism is that human knowledge is developed through exploration, with individuals constructing new knowledge upon the foundation of previous learning. Human learning is seen to be highly iterative and exploratory in nature, often resulting from an individual problem-solving in ambiguous situations.

In presenting learning as an iterative process of using current experiences to update previous understanding, constructivist accounts place great importance on individuals' abilities to reflect upon their learning. Piaget described the developing mind as in an ongoing process of maturation – seeking equilibrium between what is already known and what is currently being experienced. From this perspective, notions of 'assimilation', 'accommodation' and 'adaptation' are seen as crucial elements of learning.

Assimilation refers to the ability to alter and modify incoming information to fit with what is already known. Conversely, accommodation is the ability to alter what is known in light of new incoming information. In ideal circumstances, the process of cognitive adaptation involves the individual using assimilation and accommodation as they explore and make sense of their environment.

As these concepts suggest, constructivist accounts tend to support models of activity-based learning that are more loosely conceived in comparison to behaviourism and cognitivism. Constructivist learning activities often take the form of problems that can be solved in many different ways according to an individual's approach. How individuals approach any learning experience will depend upon their existing knowledge and how they filter their current experiences through their previous experiences. Attempts to encourage and support constructivist learning often provide individuals with opportunities to explore and learn through successful and unsuccessful experiences. The role of the teacher is to orchestrate and support the individual's exploration, rather than directly provide instruction.

In this sense, technology is a key means of facilitating any individual's exploration and construction of knowledge. The past forty years has seen a growing belief among educationalists that technology is a powerful means of supporting constructivist principles in a learning environment. As David Jonassen (1991) describes, these principles include:

- Providing representations of real-world settings or case-based learning instead of predetermined sequences of instruction;
- Emphasising authentic tasks in meaningful contexts rather than abstract instruction out of context;
- Avoiding oversimplification and representing the complexity of the real world;
- Providing multiple representations of reality to be explored and made sense of;
- Emphasising knowledge construction instead of knowledge reproduction;
- Supporting collaborative construction of knowledge through social negotiation, rather than competition among learners for recognition;
- Encouraging thoughtful reflection on experience.

These principles are evident in a range of popular digital technologies, not least the early development of personal computers. In particular, Alan Kay's work on the 'Dynabook' at the beginning of the 1970s led to the development

of many core technologies and protocols that underpin the laptop and tablet computers of today (in particular the graphical user interface with its overlapping windows, icons and cursor). Such designs were influenced heavily by the work of Piaget, Papert and Bruner. As Mackenzie Wark (2015, n.p.) details,

> Kay and co wanted computers that could be a medium for learning. They turned to the psychologist Jerome Bruner, and his version of Piaget's theory of developmental stages. The whole design of the Dynabook had something for each learning stage. … For the gestural and spatial way of learning, there was the mouse. For the visual and pictorial mode of learning, there were icons. For the symbolic and logical mode of learning, there was the programming language.

Elsewhere, David Jonassen's work in the 1990s focused on developing the learning potential of 'HyperCard'. This application allowed information (in text, picture, audio or video form) to be stored in a series of 'cards' that were arranged into 'stacks'. Cards could be linked to each other through the use of a built-in programming language that used plain-English commands. While HyperCard was used in schools to teach programming concepts, it also allowed users to create interactive learning materials, build databases and generally support the construction and problem-solving processes that constructivist learning entails. More recently, attention has been paid towards the use of gaming environments to support constructivist forms of learning through exploration, problem-solving and reflecting on one's experiences (see Mayer 2019). As the games designer Sid Meier (2015, n.p.) reasons,

> Learning is going to be part of any good video game: it gives you interesting challenges, and you learn by doing, not by being passively taught something. Once you've played a game, you're a little smarter, a little more skilled than when you started.

Constructionist Theories of Learning and Technology

Perhaps the most prominent coming-together of technology and constructivist learning is evident in the work of Seymour Papert, who started his scientific career working alongside Piaget. Papert was a leading figure

in applying constructivist principles to emerging computer technologies during the 1960s and 1970s. As the historian Barbara Hof (2021, p.3) notes, this work took place amid broader cultural enthusiasms for free-thinking and technological experimentation:

> The history of constructivism is closely linked to technology in general, and to programming as a means of self-expression in particular. This in turn must be understood against the cultural background in which constructivism became relevant: Piaget's theory initially found recognition in the United States. This did not take place in isolation from the surrounding world. Rather, constructivism spread in the counter-cultural spirit of late 1960s America amongst actors who combined the idea of the free-thinking, playful, open-minded self with the use of educational technologies.

Papert is perhaps best known among educationalists for developing the notion of 'constructionism' and the attendant Logo programming language. Constructionism is an extension of the constructivist theories that describe learning as taking place through the exploratory building of objects that are themselves capable of doing something. As Lachney and Foster (2020, p.63) note, 'like Piaget, [Papert was] interested in how children build their own knowledge structures within "natural" settings'. By building an object and then manipulating it to do something, Papert suggested that children are able to learn from the process of thinking about how to get something else to think. Constructionists therefore talk of encouraging an individual's conversations with an artefact, positioning the technologies as tools to learn with, rather than learn from.

In his 1980 book *Mindstorms: Computers, Children and Powerful Ideas*, Papert reasoned that the use of computers for self-directed learning could result in the construction of what he called 'Microworlds'. These are simplified learning environments that are created as people build things and naturally encounter problems that require creative solutions. As a result, formerly abstract concepts can take on a real meaning, and tangible rewards can be experienced for exploring, experimenting and constructing one's own solution. As Papert (1993, p.11) put it, a Microworld can be seen simply as 'an object-to-think-with'.

One of the implicit characteristics of the constructionist approach is the use of technology to support the emotional aspects of learning, especially in terms of encouraging a childlike view of learning through building, making things and attributing inanimate objects with their own intelligence. Papert talked of 'animating learning' and 'capturing the imagination' of young and old learners alike. These characteristics are all evident in the learning

artefacts that stemmed from Papert's development of the 'Logo' computer programming language that was used in many schools during the 1980s. Logo users inputted simple English-language programming commands (such as Forward, Back, Left and Right) to provide movement and drawing instructions to an on-screen cursor (the 'turtle') and its associated 'floor turtle' robot with retractable pen. Logo allowed young children to programme the computer to produce line graphics, from simple squares and triangles to more complex geometric patterns.

Rather than simply being a sophisticated geometric drawing device, Papert saw Logo as a tool to improve the ways that children were able to think and solve problems along constructivist lines. The legacy of Logo and Turtle Graphics has been since extended into a number of products and applications. These include the use of sets of 'Lego' construction bricks (most recently the programmable Lego Mindstorms robotics kits) as well as an online manifestation of 'Net-Logo' where Logo-like programming commands can be used to explore and manipulate models of emergent phenomena (such as the evolution of a butterfly population or a country's economic performance). Constructionist learning is also seen to lie at the heart of 'world-building' video games such as The Sims, the classroom use of robotics kits, and the education application of the so-called 'Maker' technologies such as 3D printing and e-textiles (see Lachney and Foster 2020). By building, testing and refining digital representations of complex systems and artefacts, all of these technologies involve users in the type of self-directed exploratory learning that lies at the heart of the constructivist philosophy. Perhaps most significantly, Papert's work on the imitation of childhood learning fed directly into concurrent advances in the development of AI during the late 1960s (Hof 2021). Belying its modest appearance, the development of Logo continues to be seen as a major advance in the fields of technology and education.

Sociocultural Theories of Learning and Technology

As examples such as Logo and HyperCard illustrate, much of the appeal of constructivist and constructionist models of learning stems from their emphasis on activities and practices that are individually centred and individually driven. That said, these learning theories can be seen to position

knowledge as something to be acquired from autonomous and, often, solitary investigation and experimentation. Indeed, all of the different theories described so far in this chapter tend to present learning as individually centred. By contrast, growing numbers of psychologists over the past thirty years or so have turned their attention to understanding the influence of the wider social and cultural environments that surround any individual's learning and cognitive development. In this sense, many educationalists would now share the view that learning is a profoundly social process. While not contradicting the general principle of individuals constructing their own knowledge and understandings, increased emphasis is now placed on how these learning processes are located within 'sociocultural' environments.

Much of this recent thinking relates to the earlier work of psychologists such as Lev Vygotsky and the development of the so-called 'sociocultural' theories of learning. Vygotsky is associated with a number of concepts relating to the social and cultural nature of learning, not least the idea that any individuals' learning is mediated through their wider culture. Vygotsky saw most human action as involving what he called 'cultural tools' and resources. These tools and resources relate to all of the significant things that could conceivably exist in an individual's environment – ranging from material objects (such as pencils and hammers), to symbolic objects (such as language and writing). In this sense, the successful learner is someone who is able to appropriate and deploy all of these resources in their actions.

Vygotsky's work drew attention to the integral role of language in learning. In particular Vygotsky saw cognitive development as linked inexorably to speech – more specifically spoken oral language and silent inner speech. The sociocultural approach therefore stresses the importance of interaction with other people as a key resource for supporting cognitive activity and learning. In particular, other people are seen to play important roles in first selecting and shaping the learning experiences that are presented to individuals, and then supporting them to progress into the next stages of knowledge and understanding. This view of socially supported cognitive development sees learning as often involving a less-able individual participating in ongoing sociocultural practices and being able to reach shared meanings with the more-able others in their social environment. In this sense, Vygotsky's concept of the 'zone of proximal development' describes how tasks that are too difficult for a solitary individual to master could be learned with the guidance and assistance of more skilled or more knowledgeable others. As an individual becomes more proficient or knowledgeable, this support can then be gradually withdrawn until it is no longer required – a process

referred to by psychologists such as Peter Woods and Jerome Bruner as 'scaffolding'.

The notion of learning as a collaborative and socially situated process has found particular resonance with many people working in the area of educational technology (see Luckin 2010). First, many psychologists and technologists concur that digital technologies can act as powerful social resources in an individual's learning contexts. It is argued, for instance, that people often treat technologies as social beings, even interacting with digital devices as if the technology is more able and more knowledgeable than themselves (Bracken and Lombard 2004). Digital technology is also seen as an effective means of providing individuals with enhanced access to sources of knowledge and expertise that exist outside of their immediate environment.

There is now considerable interest in the field of 'computer supported collaborative learning' where individuals collaborate and learn at distance via online tools such as blogs, shared documents and other online collaborative workspaces. As Leask and Younie (2001) contend, online technologies can support access to knowledgeable others beyond the individual's immediate environment and become an important part of the 'scaffolded' learning process. Many people's enthusiasm for these forms of digital learning stems from the wider sociocultural principles of 'situated learning' and the associated notion of 'communities of practice'. These terms describe learning as best taking place in the form of 'real-world' activities and interactions between people and their social environment. Learning is seen to be a highly social activity that takes place in realistic contexts and activities – often centred around the social groups that are involved in these activities and contexts. This concept is made clearer if we consider how a worker learns to do their job. Most occupations are based around groups of people all involved in the same work-based activity or practice. Within these communities of people all involved in the same practice, incoming members will often learn from pre-existing members how to do things. Indeed, Lave and Wenger's (1991) original coining of the phrase 'communities of practice' originated from their anthropological study of how butchers, midwives, tailors and Navy quartermasters learnt their occupations 'on the job'.

Sociocultural accounts often describe learning that is highly social and often informal in nature. While some learning may take place as formalised training or instruction, the individual is often socialised by others on an informal basis into the process of finding, sharing and transferring knowledge 'artefacts'. The acts of learning a particular skill, or understanding specific cultural and social practices, are largely tacit processes involving an

individual imitating what is observed from the actions of others. Often individuals will be initially shown the 'big picture' by a knowledgeable or expert other, then shown how to deal with it, and then led through the different components of the task. Situated learning therefore relates to learning through active participation and apprenticeship, with an individual involved in the co-construction of knowledge with more able peers and, importantly, being held to account for the competence with which they perform. Ideally, this learning is situated in the 'real-life' environment where the practice or activity takes place.

The idea that learning involves participation in a full version of what is being learnt has led to growing interest in the design of digital environments that attempt to approximate the conditions for participation in 'authentic' learning. In these terms, many educators see technology-based environments as an ideal means of supporting in situ forms of socially 'augmented' learning. For instance, much interest has been shown in the sociocultural learning potential of participating in 'massively multiplayer online games' (MMOGs) such as Minecraft, Fortnite and League of Legends. Indeed, it is now recognised that various learning activities and processes arise from inhabiting and exploring these online environments. For example, these online spaces are based on large groups of users encountering, interacting and engaging with others. These processes often lead to the formation of informal and formal communities where people work together in groups with hierarchies of expertise and learning. Participating in virtual environments can involve a range of learning practices – from ongoing processes of developing expertise through to learning socially produced conventions relating to issues such as identity, etiquette and trust (see Baek et al. 2020, Shonfeld and Greenstein 2021). Perhaps most significantly, much of what takes place in an MMOG involves collaborative activities between users (such as pursuing collective challenges and 'quests'), all of which involve creative and collaborative learning practices. Whether one is tending a melon farm, or learning to be a warrior king on an alien planet, online gaming can support the 'social dynamic' that many people believe is at the heart of effective learning. As Tom Chatfield (2010, p.28) puts it,

> We are deeply and fundamentally attracted, in fact, to games: those places where efforts and excellence are rewarded, where the challenges and demands are severe, and where success often resembles nothing so much as a distilled version of the worldly virtues of dedicated learning and rigorously coordinated effort.

Contemporary Accounts of Technology, Information, Knowledge and Learning

All of the learning theories described so far have had a substantial influence on the field of education and technology. While educationalists and technologists differ with respect to their preferred theoretical approach, very few would question the fact that digital technologies are capable of supporting learning. However, while these theories may provide powerful explanations of how technologies might be designed and used to support and enhance learning, they do not necessarily provide realistic accounts of how technologies are actually used to support learning. It should be remembered that none of the theories outlined earlier were developed specifically with technology-based learning in mind. Many of the descriptions provided so far in this chapter rely on the adaptation of well-established learning theories in light of technologies that have been developed many decades after.

Indeed, some commentators question the 'goodness of fit' between twenty-first-century digital technologies and twentieth-century theories of learning. It can be argued that technology-based learning requires new theories of learning that account directly for what takes place when individuals engage with digital technologies. In particular, there are growing arguments that digital technologies are perhaps used more commonly as 'information tools' rather than 'learning tools'. In this sense, it is perhaps more accurate to see the educational significance of today's digital technologies in terms of the ways in which they alter people's relationships with information and knowledge. Put in these terms, the main relationship between an individual and technology may not be related to processes of learning per se, but based around their relationship with networked information and networks of other learners. This relates to what might be loosely termed as an interest in broad 'learning ecologies' rather than narrowly focused descriptions of individual learning (Sangrá et al. 2019).

Various different explanations of 'networked learning' relationships between digital technologies, information and other people have been taken up within the field of educational technology. While these are best described as frameworks rather than 'theories', they have all proven remarkably influential in guiding thinking over the past twenty years or so. One well-known framework relating to informal learning in the internet age is the

notion of 'connectivism' – the idea that learning now relates primarily to the ability to access and use distributed information on a 'just-in-time' basis (see Siemens 2005). Rather than knowing and retaining information on a long-term basis, connectivism reasons that individuals need to develop personal, meaningful networks of learning – nurturing and maintaining connections between nodes where knowledge is stored. From this perspective, 'learning' can be described in terms of an individual's ability to connect to specialised information nodes and sources as and when required. Similarly, being 'knowledgeable' can be seen as the accompanying ability to nurture and maintain these connections. As George Siemens (2005, n.p.) puts it, learning can therefore be conceived in terms of the 'capacity to know more' through networked digital technologies rather than relying on the individual accumulation of prior knowledge in terms of 'what is currently known'. One of the interesting features of connectivism is the acknowledgement that learning is not wholly under the control of the individual learner. Instead, connectivism celebrates 'non-linearity and unanticipated network effects in the learning process' (Li and Greenhow 2015, p.3).

Like connectivism, the notion of 'Connected Learning' also marks a significant attempt to better describe the processes of young learning with networked technologies. Unlike connectivism, however, it pays considerable attention to physical, real-world spaces such as schools, colleges, homes and community sites, as well as activities and practices that take place in online spaces. In one sense, Connected Learning updates many ideas already described in this chapter – not least sociocultural theories of dialogic learning taking place through interactions with other people and resources. It also echoes constructionist theories of learning taking place 'by doing' – particularly through experimenting, 'making' and producing things. The distinctiveness of Connected Learning stems from how it relates these basic principles to the fluid forms of learning that take place in online spaces and networked environments. In this sense, digital media is valued in terms of its capacity to connect an individual's personal interests, social relationships and community, academic opportunities. While these ways of learning are not unique to networked technologies, networked technology is an ideal means for learning to take place. As Mimi Ito and colleagues argue,

> Although Connected Learning does not require technology, the emerging landscape of social and digital media can potentially make connected learning more accessible to young people with diverse interests and backgrounds. New digital tools support new forms of literacy and self-expression, and

> online affinity networks enable young people to connect to a wider range of specialized communities of interest. (Ito et al. 2020, p.4)

Educational Technology and Learning Theory: An Uneasy Relationship

On the one hand, recent efforts such as connectivism and Connected Learning reflect the continued importance of having a theoretical underpinning to any efforts to apply digital technologies to support learning. All of the theories and frameworks outlined in this chapter offer a useful means of conceptualising the different relationships that can exist between technology and learning in more nuanced ways. As Costa et al. (2019, p.395) reason, a 'particular challenge' in theorising the relationships between teaching and learning 'is to articulate the relationship between person, tool and environment'. These theories highlight the point that 'learning' is not a homogenous concept – there are different forms and types of learning. Moreover, these theories also highlight that 'learning' does not simply occur of its own accord – especially when technology is involved. It makes little sense to simply presume that digital technologies are inherently capable of 'making learning happen'. Instead, technology-supported learning is something that needs to be given careful consideration and planning – what we referred to earlier as a 'design' process.

Unfortunately, there is growing evidence that theoretical understandings of learning are not always at the forefront of how technologies are planned and developed for use in education. Perhaps understandably, it has been noted that many educators and practitioners make little or no use of learning theories in their use of digital technology – relying at best on 'folk theories' based on personal experience, or 'pseudo theories' such as 'learning styles' or 'digital nativism' (Drumm 2019). Less understandable is the apparent lack of theoretical underpinning in the initial design of educational technologies. One of the key points implicit in the list of eight ways that digital technologies can support learning, as noted at the beginning of this chapter, is the need to deliberately align types of learning with the digital technology being used:

> Recent advances in technologies for learning can offer significant benefits, but the results will depend on the alignment of goals for learning, contexts, the type of content to be learned, characteristics of learners, and the supports

> available for learners and instructors. (National Academies of Sciences, Engineering, and Medicine 2018. p.196)

Of course, there are many examples of educational technologies that have been designed explicitly around particular conceptualisations of learning. Some of the most prominent examples have been noted in the previous sections – from the constructionist design of Logo to the cognitivist design of intelligent tutoring systems. However, many of the most popular forms of digital learning software currently being produced are less obviously linked to intentionally designed forms of learning. In the absence of any theoretical underpinning, there is a growing sense that many contemporary educational technologies veer towards behaviourist models of training, rather than any more sophisticated forms of socially based learning. Some of the most widely used educational technologies often retain simple designs that reward 'correct' behaviours, attempt to influence decision-making towards preferred options and generally attempt to guide and train an individual's responses. Behaviourist principles are even apparent in seemingly complex attempts to develop technology-based support for socioemotional learning and critical thinking. As Mark Garrison (2021) notes, these characteristics tend to be rendered in terms of 'skills' and 'competencies' that can be developed, assessed and managed through technology. This leads to mechanised forms of digital 'learning' that stem directly back to Skinner's core tenets of behavioural training and conditioning. As Audrey Watters (2020, n.p.) contends,

> I think that [Skinner] is truly the most influential person in the development of education technology. I think other people would like it to be someone like Seymour Papert. They would like to say that education technology's origins are constructionist, but I think that really they are behaviourist. … It really is foundational on the Skinnerian notion of operant conditioning, rewards for behaviour, shaping behaviour through machines.

On the other hand, it is important to remember that all of these models, frameworks and explanations of learning and technology are theoretically driven rather than empirically grounded. While such accounts are very good at telling us why something could or should be happening, they are far less certain of what is actually happening and why. Here most academic commentators would turn to empirical investigations and measures to ascertain precisely what relationships exist between technology use and learning. Yet achieving any degree of confidence of a discernible 'cause-and-effect' relationship between technology and learning is difficult, if not

impossible. While the vast amounts of funding and vested interests now underpinning in digital education means that there is a significant imperative to 'prove' that digital technologies improve learning (see Newton 2018), the evidence base remains defiantly inconclusive.

This has certainly been the experience of researchers who have attempted to apply rigorous 'scientific' methods of enquiry to the topic of teaching and learning with technology. Because education and technology are entwined with many other contextual 'variables', it has proved very difficult to design any kind of experimental study to investigate the influence of technology use in learning settings. Those researchers who have attempted to pinpoint causal effects of using technology on learning tend to find what can be charitably termed 'mixed results'. For example, a number of large-scale studies conclude that technology use is sometimes associated with modest improvements in learning performance (e.g. Chauchan 2017). However, a number of 'meta-studies' (i.e. that analyse the results of many other studies) find no difference, or even negative relationships (see, for example, Kulik and Fletcher 2016; Clark et al. 2016; Falck et al. 2015). Recent large-scale studies continue this trend. For example, one randomised controlled trial (with 1,300 students, 80 classes and 29 instructors at the US West Point military academy) found 'flipped classroom' approaches to have no long-term learning gains, but an associated effect of increasing achievement gaps in favour of white, male and higher-achieving students (Setren et al. 2019). As an earlier review of various meta-analyses between 1990 and 2012 was forced to conclude: 'the correlational and experimental evidence does not offer a convincing case for the general impact of digital technology on learning' (Higgins et al. 2012, p.3).

Conclusions

The latter studies raise the point that the relationship between technology and learning is a complex issue with no straightforward associations. Indeed, a mass of conflicting debates and arguments surround this topic, reminding us of the need to think carefully about the complicated relationships that exist between education and technology. On the one hand, this chapter has highlighted the benefits of using learning theories to think about why technologies should be used in education. All the theories outlined in this chapter offer ways of thinking about how technology might

be used to support learning. Yet on the other hand, these accounts can all be challenged and criticised. In particular, the theoretical approaches presented in the first half of the chapter make different assumptions about what it is 'to learn' and what it is to be 'a learner'. As such, they all present different sets of beliefs about the processes of learning with technology. These include different beliefs about the psychological basis of learning and cognition; different educational beliefs about pedagogy and the best way to support learning; different beliefs in the freedom of individuals to make decisions and 'choose' different pathways; and different epistemological beliefs about the nature of reality and knowledge. None of these approaches can be judged objectively to be 'better' or more 'accurate' than others. Instead these theoretical accounts offer different insights into how technologies can be designed and used to fit different types of learning – whether this is rote-learning or problem-solving, 'knowing what' or 'knowing how'.

It is also important to bear in mind that debates over technology and learning are often driven by personal beliefs and opinions, rather than being empirically reasoned and informed. As such, digital technologies are a key focus for ongoing debates, ideas and arguments about learning. We therefore need to question the values and ideological assumptions that often underpin claims made about the potential of digital technology to 'transform' learning. Indeed, many debates over technology and learning appear to be driven by wider beliefs of what constitutes 'good' or 'desirable' learning. Enthusiasms for increased digital technology use in education are often driven by ambitions to get certain forms of learning into formal educational settings that are otherwise seen to be lacking. This could be argued to be the case with present-day socio-constructivist technologies, just as it was with the behaviourist-inspired teaching machines of the 1950s and 1960s. Some educational technologists have referred to this as the 'Trojan Mouse' approach – describing the use of digital technology as a means to 'leverage' broader philosophies of teaching and learning into educational settings. As Eric Klopfer (2008, p.12) was honest enough to acknowledge when arguing for the learning benefits of mobile games,

> It isn't all about the technology. Most of the intellectual capabilities previously defined are relevant to understanding most modern issues and problems. They need not necessarily be associated with technology at all. Many of these skills are equally relevant to constructivist learning that has been promoted

by education reformers for decades, and could be fostered without technology. Technology, however, is the vehicle for getting these intellectual capabilities into schools discretely.

With such caveats in mind, it is important to recognise the contested nature of any claims made for technology and learning. It is perhaps best to see technology simply as a focal point through which a range of wider debates about learning, information and knowledge are filtered. As Paul Standish (2008, p.351) reasons, matters of technology and learning 'cannot be broached without consideration of the essentially ethical question of what counts as worthwhile learning'. As this chapter has illustrated, recent discussions of education and technology are based around assumptions that worthwhile learning should be active, interactive, learner-centred, social, communal, authentic, and so on. While many readers may sympathise with these assumptions, it is important to acknowledge that such characteristics involve a commitment to particular sets of values. Moreover, it is important to acknowledge that these values are often at odds with the nature of the settings and contexts that learning often takes place in. Against this background, debates and disagreements over how technology supports learning look set to continue for some time yet.

Further Questions to Consider

- How valid it is to use 'pre-digital' theories of learning to make sense of how learning takes place with digital technologies? In what ways can knowledge of 'traditional' learning processes be transferred over to technology-mediated contexts? In what ways does existing knowledge of 'traditional' learning lack relevance to contemporary digital technology use?
- Why is it so difficult to measure accurately – or even identify objectively – the 'effect' of technology on learning? Is this question even worth asking?
- To what extent are digital technologies designed and developed as a means to promote particular ways of learning (e.g. child-centred learning, play-based learning, discovery-based learning, democratic or critical learning)? Alternatively, to what extent are digital technologies a 'blank canvas' that can be used to promote any learning theory or approach one wishes?

Further Reading

Skinner's seminal paper on behaviourism and learning technologies can be found online. The full reference is as follows:

Skinner, B. (1958). Teaching machines. *Science*, 128(3330):969–77.

Some of the classic texts on learning theory and technology are now rather dated, but are worth seeking out:

Duffy, T. and Jonassen, D. (1992). *Constructivism and the technology of instruction*. Routledge.

Papert, S. (1980). *Mindstorms: children, computers and powerful ideas*. Harvester Press.

Pea, R. and Sheingold, K. (eds) (1987). *Mirrors of the mind: patterns of experience in educational computing*. Ablex.

This book gives a good overview of various seminal learning theories and the way they are applied in educational practice:

Kirschner, P. and Hendrick, C. (2020). *How learning happens: seminal works in educational psychology and what they mean in practice*. David Fulton.

This book offers an overview of recent thinking about education and technology from sociocultural and networked learning perspectives:

Harasim, L. (2017). *Learning theory and online technologies*. [second edition]. Routledge.

5

Technology and Educational Institutions

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Introduction

As the past four chapters have shown, digital technology is often imagined in terms of supporting new and improved ways of doing things. This is especially the case when people talk of technology use in organisational and institutional settings. Digital technology is seen as having profound impacts on the ways that organisations and institutions go about their business – from small local hospitals to vast transnational corporations. As we saw in Chapter 2, it is common to hear people celebrate the capacity of digital technologies to 'disrupt' organisational hierarchies and structures. Indeed, contemporary institutions and organisations are often described as operating in ways that are more open, networked and non-hierarchical than before, largely as a result of computerised and telecommunications technology.

Such changes are evident across many sectors of society – from government and the economy, to leisure, entertainment and domestic spheres. In terms of government and civic affairs, for example, digital technologies have had a significant influence on key functions and processes, such as how election campaigns are conducted, and the ways that citizens engage with government services. Similarly, increasing amounts of commerce and trade now takes place through online 'e-tailing' instead of 'bricks-and-mortar' shops. Perhaps most obviously, the leisure and entertainment industries are undergoing widespread restructurings – with the TV, newspaper, music and book publishing industries all struggling to maintain relevance in a world where unlimited, instantaneous and often unpaid access to online 'content' is seen by many consumers as an inalienable right.

It is argued that these digitally driven 'reorganisations' are significantly altering the relationships that individuals have with the institutions and organisations in their lives. For example, many people now have distinctly different ways of interacting with banks, public services, retail organisations and their places of work. Moreover, the online provision of entertainment and leisure is also noticeably more 'client-centred' and 'on demand'. Yet, while we might be accustomed to dealing with the likes of Netflix and Amazon when watching television series and buying consumer goods, such changes are less clear-cut when it comes to education provision. It could be argued that educational institutions have undergone notably less obvious changes and reorganisation over the past few decades. As John Crouch (2018, n.p.) – long-standing vice president of education for Apple Inc – wrote just before his retirement,

> Today we live in a world of rapid technological innovation, where seemingly every day a new start-up comes out of nowhere with a new invention that changes things. Overflowing with creativity and empowered by the latest technologies, these visionaries from around the world have disrupted status quos, revised inefficient designs, upgraded outdated systems, and reshaped entire industries, except for one: education. There have been no revolutionary changes to our education system in the past century. Even where local successes at the school and classroom level show promise, nothing new ever seems to scale.

As the 2020s progress, many technologists still echo Crouch's frustration over what might be seen as an apparent educational inertia, especially when it comes to the 'traditional' institutions of schools, colleges and universities. This chapter considers the significance of these educational institutions in contemporary education. How can long-standing and slow-

moving institutions such as the school or university be said to be coping with the demands of digital technology? What elements of education appear to be relatively untouched by digital change? Conversely, what aspects of education are perhaps being irrevocably altered?

In particular, this chapter tackles such questions in terms of 'compulsory' schooling – that is, the elementary and high schooling that is provided free of charge by the state, and is generally mandatory for all children and young people. Compulsory schooling is one of the few common experiences for people in the developed world. Nearly all readers of this book will have attended a school for much of their childhood and adolescence. For better or worse, students and teachers continue to spend upwards of six hours per day at school for up to 200 days of the year. Such is the familiarity of our own personal experiences of schooling, that most people rarely stop to think about what schools actually are and how school systems operate.

Before considering the relationship between digital technology and schools it is important to clearly define our terms of reference. This includes making a distinction between the concepts of 'school' and 'schooling'. In the most basic sense, schools can be understood as the institutions where children and young people receive education, usually learning under the guidance of a teacher. Schooling, on the other hand, refers to the processes of teaching and/or being taught in a school. While this difference may appear pedantic, it highlights the need to approach schools and digital technology in terms of structures as well as processes. For example, with regard to defining the 'structure' of schools, most people would think of the material aspects of schools as places – that is, their buildings, corridors and classrooms. In this sense, schools are physical structures whose architectural design and organisation of space influences what goes on inside them. Yet we should also think of the structures of schools in a non-material sense. In particular schools are based around a range of social and cultural structures. These include the hierarchical roles that people assume within the school organisation, the hierarchies of knowledge that constitutes the school curriculum and the organisation of time that constitutes the school timetable and academic calendar. While often out of sight and rarely talked about, all of these structures are integral elements of the organisation of schools and schooling.

In terms of the 'processes' of schooling, most people would first think of obvious aspects of the school day such as teaching, learning, communication and decision-making. However, schooling also involves key processes of socialisation, regulation and control. Again, all these processes are often

implicit and rarely acknowledged, yet they form a core part of the 'business' of schools as organisations. All of these latter processes and structures highlight the fact that schools should not be seen as neutral contexts within which digital technologies are implemented and then used. Instead, we need to consider how digital technologies 'fit' with these structures and processes. How do digital technologies complement or challenge the established organisational processes and structures of school? In what ways might digital technologies be capable of supporting the 'reconstitution' of schools and schooling?

Are 'schools' No Longer 'fit for purpose' in the Digital Age?

Before considering the ways in which digital technologies combine with the institution of school, we should first pay a little more attention to the perceived shortcomings of schools and other educational institutions. Many critics are keen to highlight what they see as inherent deficiencies of contemporary school systems. Yet, these criticisms also evoke idealised alternative visions of school that give a sense of what might be possible if education was to be reconfigured along digital lines. By the end of this chapter, we should be able to gauge to what extent these alternate versions of schooling should be taken seriously.

The past twenty years or so have seen growing criticism that current models of schooling are no longer 'fit for purpose' for our digitally driven societies. The argument is often made, for example, that conventional schools are 'broken', 'nineteenth century' and frustratingly 'cookie-cutter' in nature and form; in other words, these are outmoded and obsolete products of a bygone era. Commentators speak with exasperation of the 'industrial era classroom', schools resembling factories overseen by 'ivory tower' educators and so on. In short, schools are felt to have had long enough to adapt to the imperatives and opportunities of digital technology. As Alan Lesgold (2019, p.1) argues in his call for 'learning for the age of artificial intelligence',

> Our education system got its basic shape in the early and middle twentieth century. Back then, parents' goals for their children were to get them into a good job that would be theirs for life. Whether as a worker in a steel mill, as a farmer or as a partner in a law firm, the assumption was that everything you

> needed to do well in the job would be learned up front. … School's primary purpose was to prepare children for productive life in a relatively slow-moving world. … This kind of schooling is common today. Changes have been made in the curriculum for subjects like mathematics and science, but the hidden curriculum has remained about as it was 75 years ago. The problem is that the world has changed. People don't keep the same role for life. They get displaced by smart machines and must find different jobs. They continually need to learn a lot, since all the routine stuff is getting done by those smart machines.

The connotations of such arguments are clear. Take, for instance, the metaphor of the school as 'factory'. As Larry Cuban (2014, n.p.) points out, at the beginning of the twentieth century this comparison was used as a term of approval, praising modern schools for their 'standardization, efficiency, and up-close connections to the economy'. Now, however, the term is taken firmly as an indictment of the harmful and outmoded conditions that persist within schools – for example, compartmentalised forms of knowledge and learning, age-restricted classes and the standardised testing of students.

The broad-brush criticism of schools being 'broken' also sits in front of a number of more specific dissatisfactions among those looking to promote the reform of education. For example, from a social justice perspective, schools seem to be able to do little to disrupt well-worn patterns of inequality and disadvantage – such as the 'school-to-prison' pipeline, patterns of youth unemployment, poor housing and structural racism. As Kimberley White-Smith (2020, n.p.) puts it, 'The American education system was not created to support the liberation of the powerless. Instead, it was designed to instil skills, habits, beliefs, and discipline that would allow for better control of the masses.' Conversely, objections to schools being 'broken' can also be raised with more elitist intentions. For example, as Todd Hixon (2014) reasoned in the financial journal *Forbes*, the main value of schools and universities (what he describes as a 'ticket to upper-middle-class life') is no longer guaranteed by continued participation in education. It is therefore sensible for ambitious students and their families to seek 'new ways to education'. According to Hixon (2014, n.p.), traditional models of education offer

> a product that does not work, ridiculous costs, and an antiquated business model. For many years we accepted this because we see extraordinary value in education. Now, most middle and upper-middle class parents find they cannot give their children the education they enjoyed. Technology has recently put a spark to this fuel: on-line education works and dramatically

improves costs and access. This is a big opportunity for entrepreneurs and investors.

It is worth considering the provenance of these arguments in a little more detail. Looking back over the issues and debates covered so far in this book, it would seem that people's enthusiasms for different forms of technology-based education are usually driven by two interrelated beliefs. First is the widely held assumption that digital technology offers a better way of 'doing education' – what could be referred to as a technological 'pull' factor. Secondly, is general dissatisfaction with the schools and schooling currently on offer – what could be described as an institutional 'push' factor. Together, these beliefs can be seen as underpinning most people's desire for a technology-centred redefinition of schools. It makes sense to give further thought to the ideas, beliefs, values and agendas that inform these arguments. Are schools as they currently exist really a dysfunctional institution? Do digital technologies really offer more efficient and/or fairer ways of organising and providing educational opportunities?

In this first respect, the outmoded nature of school is often justified in relation to the diverse and more dynamic forms of learning that digital technology can supposedly support. The differences between traditional 'school' learning and 'digital' learning are illustrated, for example, in the descriptions of Connected Learning and constructionism in Chapter 4. Indeed, one of the main implications of Connected Learning is the need to rethink the traditional spaces, places, contexts and institutions of learning. In essence, the Connected Learning framework suggests three design principles, that is, the ideas that

- Learning starts from (and is stimulated by) a shared purpose and shared interest;
- Learning is centred around practices of production;
- Learning takes place through open networks and is inherently collaborative in nature.

These principles clearly present a challenge to the shape and form of most present-day schools. For instance, if we take the idea of Connected Learning seriously, then there is an obvious imperative to better imagine how schools relate to other contexts and settings – such as popular culture, students' home life and local communities. How might schools be reorganised in ways that provide ongoing opportunities for students to 'bring' learning from other spheres into their classroom activities? While in school settings,

how might students be offered pathways to cross over into other contexts? In short, Connected Learning implies forms of schooling that are more porous and less isolationist than most schools that we currently have.

While descriptions of Connected Learning still presume that schools will continue to have an important place in the overall 'ecology' of learning opportunities, other viewpoints are less accommodating. Many of the most forceful accusations of the outmoded nature of school stem from a desire to see the imposition of different forms of organisation and innovation that digital technology can now support. This certainly underpinned the support during the first half of the 2010s for what was described in Chapter 2 as 'disruptive innovation' within education. This is perhaps epitomised by Jeff Jarvis' (2009) assertion that 'education is one of the institutions most deserving of disruption – and with the greatest opportunities to come of it'. Such arguments continue to surface regularly among technologists, entrepreneurs and other reformers when bemoaning state-run education systems and the bureaucratic agencies and organisations that surround them.

Many of these arguments are certainly driven by opposition to the perceived mismanagement of education by monolithic institutions that are seen to be inherently undemocratic. In contrast to the 'flattened' forms of digital organisation found in other sectors, schooling is criticised as a sector where ownership, control and power are concentrated in the hands of elites – from state education departments and education professors, to school district superintendents, tenured teachers and their unions. As with many large administrations and bureaucracies, these are seen to be institutions that are unresponsive, incompetent, untrustworthy, ungrateful, self-serving and greedy (Downes 2010). By contrast, it is often suggested that digital technologies might offer alternate ways of organising and providing education along more consumer-centred lines.

Such arguments tend to be enthusiastically taken up by conservative reformers, keen to push agendas of individual freedoms and 'small government'. For example, as Tucker Carlson (2020, n.p.) reflected during the turn to online education in response to the initial Covid lockdowns: 'You can do the whole thing online. The higher education establishment is hurting this country and has for a long time. Reform is essential – this is a good and needed thing.' In comparison to popular digital technologies outside of education, schools and universities are therefore framed as institutions that clearly 'deserve' to be swept away. Newt Gingrich (2014, n.p.) continues in the same manner:

> If, as the popular saying goes, the definition of insanity is doing the same thing over and over and expecting a different result, the people who run our public schools fit that description. For several generations now, schools have been failing students the same ways over and over and expecting a different result. Teachers lecture, students sit and some listen. Class happens at the same time, with the same material, and at the same pace for everyone. This is an 1890s' model of education – teaching to the 'average' student, rather than the individual. In an age when most information and knowledge is transmitted digitally and is increasingly personalized – think about how Netflix, Pandora, Twitter and Facebook work – we should be able to do much better than that.

Although many of these commentators might only have vague understandings of the specific digital technologies that they hope might replace schools and universities, the popular appeal of such arguments are clear. The suspicion that it is high time for a digital renewal of educational institutions continues to grow among many powerful interests and prominent voices.

The Actual Nature of 'school' in the Digital Age

In contrast to these imagined transformations, we can now turn attention to how digital technologies are actually present in contemporary schools. Here, it is difficult for anyone who has actually set foot in a school in recent times to claim that classrooms have not changed since the 1890s. On the contrary, even the smallest school is now likely to be full of digital technologies. Students and staff bring an array of powerful laptops, tablets and other devices into school. From an institutional point of view, school administrations are reliant on large-scale 'learning management systems' and other platforms. In short, most school processes and procedures now involve (either directly or indirectly) some form of digital technology. Of course, there are a number of surface-level features that might evoke memories of schooling from previous centuries. For instance, most schools of the 2020s continue to have student desks that face the teacher, fixed schedules and end-of-year examinations. Yet, beneath these surface features, schools have become notably digital over the past couple of decades.

For example, schools have long been full of digital devices. The promise from many policymakers in the early 1980s of 'a computer for every school' was superseded quickly by efforts to provide 'a computer for every classroom',

'a laptop for every teacher' and, then in the 2000s, considerable enthusiasm for establishing 'ubiquitous' states of 'one-to-one' access (i.e. a device for every student and teacher). More recently, this emphasis on institutionally provided devices has been overtaken by the increasing presence of personally owned and highly portable forms of computing being brought into schools by individuals. The 2010s saw the notion of BYOD ('Bring Your Own Device') superseded by talk of 'BYOT' ('T' standing for technology). These shifts in emphasis reflected the distinction between the physical hardware 'device' and the assemblage of applications, software, preferences and settings that go to make up an individual's own 'technology'. Recent developments include the notion of 'Bring Your Own Devices' (plural), 'Bring Your Own Connectivity' and '2:1' and '3:1' computing. All these labels describe the ability of students, teachers and administrators to come into schools with their own smartphones, tablets and laptops, and crucially connect these devices through personally controlled mobile networks.

In addition, a variety of educational software and apps are now used in schools to support learning practices within the classroom, at home, and all points in-between. Classrooms are awash with software, and a growing amount of pedagogic work is conducted on a 'virtual' basis. Students now combine face-to-face and online lessons, and the trend for 'flipped' modes of delivery has seen instructional elements of courses increasingly delivered through preparatory videos, with face-to-face classes then used for discursive and interactive forms of learning. In addition, day-to-day management and administration of schools is underpinned by software systems that support and structure the actions of students, teachers, administrators, leaders and parents in a variety of ways. Many 'traditional' school processes and practices are now digital in nature. Paper-based textbooks have been replaced by digital textbooks and e-books. Examinations, tests and other forms of assessment are now administered online rather than taken in paper-and-pencil form. All told, students' and teachers' daily encounters and engagements with 'school' are increasingly mediated through apps and software.

Alongside these classroom applications, perhaps the dominant forms of software in most schools are school-wide digital systems and platforms. This includes the 'learning management system' (LMS) and similar platforms that channel the bulk of a school's daily teaching activities. The LMS is the defining technology in most schools – a 'one-stop-shop' for teachers to deliver content to students, coordinate classroom activities, interact with colleagues and students, keep records, make reports and generally dispense

with administrative and bureaucratic duties. Students are also expected to upload work and communicate with their peers, while some schools allow parents to view student profiles and online work. Engaging with 'the LMS' is now a fundamental part of teaching and administrative work in every school.

Other prominent digital systems within schools are centred around the technological automation of the teaching and learning process. One growing area of interest along these lines is the use of 'personalised learning systems' which support the adaptive sequencing of learning resources in light of each student's previous performance. These systems use large-scale data techniques to calculate what form of online tuition each enrolled student should be taking part in, the next education resource and service they should be using, when and how they should be learning. Once a student logs onto these systems, data is collected on every interaction that a student has with the computer. This data is used to model various aspects of the student's learning, such as their motivation and proficiency, and more contested measures such as 'learning style'. These profiles of students' learning are then used to recommend the most appropriate educational resource that should be used next.

Many of these platforms and systems also support the regular feedback of data on students' performance – for example, dashboards, portals and 'learning analytics' that offer teachers additional insights into the effectiveness of their teaching. In this sense, schools now make increasing use of data generated by digital technology. Usually this data processing of actions and behaviours is framed in terms of making better sense of learning – in particular profiling, predicting and positioning of individual students in terms of their learning 'engagement' and 'outcomes'. As Jose van Dijck et al. (2018, p.579) put it, 'learning processes are translated into data processes and turned into tracking systems that continuously relate individual progress to standardised performance.'

The (Un)changing Nature of Schools in the Digital Age

The evolving presence of all these school technologies certainly confounds popular criticisms of institutions that are stuck in nineteenth-century ways of operating. Yet, despite the device-laden, platformatised nature of current schools, concerns over the slow-changing fundamental structures

of schooling persist. Beneath these surface appearances, to what extent has the organisation and purpose of school really altered? In this sense, it is not wholly clear that the core tenets of schooling are substantially different.

The School Remains the Same?

On the one hand, strong arguments can be made that schools have not actually changed radically in nature or form. While schools are full of digital devices and digital systems, it can often seem that there is little that is substantially different about how, why and with what effect these digital technologies are being used. In this sense, many people might reason that schools are carrying on essentially as they always have. Beneath the digital surfaces, it can be argued that much of what is actually taking place in schools is a case of 'business as usual'.

Take, for instance, the logics underpinning some of the main digital technologies being used in contemporary schools. Many of these digital technologies retain a character, form and feel of pre-digital technologies and tools they are supposedly replacing. For instance, the look and feel of digital 'content display' technologies echo their analogue predecessors in a variety of ways. A teacher working with an interactive whiteboard is often doing little different than if they were writing on a chalkboard. Students reading e-books on iPads are often doing essentially the same as previous generations reading textbooks. Elsewhere, teachers filling out 'grade-books' and 'roll-calls' on their school's learning management system are upholding centuries-old administrative practices. While schools might pride themselves on no longer using chalkboards, paper report cards and textbooks, oftentimes the technical principles of these 'dead' educational media remain alive.

So, even as we progress through the third decade of the century, it is worth reminding ourselves that there is no such thing as an entirely 'twenty-first century school'. Instead, there are many long-standing school structures, processes and customs that endure into the digital age. Schools continue to prioritise student discipline, physical attendance, achievement, throughput and progression. Hierarchies between staff, administrators, students and parents persist much as before. Knowledge remains compartmentalised into discrete curriculum areas and assessed through 'high-stakes' standardised testing. Indoor and outdoor campus spaces remain delineated by predesignated functions. Many schools continue to expect students to stand in lines before class and wear mandated school uniforms. All-in-all, the

arrangement and organisation of schools continues to be centred around long-standing principles of standardisation, order and hierarchy. While it is disingenuous to claim that schools have not changed at all over the past 100 years or so, a set of very strong reference points have certainly persisted throughout this time.

The endurance of these basic school logics was reaffirmed by the ways in which most schools continued to function during the Covid lockdowns at the beginning of the 2020s. The first wave of school lockdowns in 2020 saw nearly 1.6 billion school students (nearly 85 per cent of the global school population) unable to attend physical school. Many school systems in industrialised countries had stable digital infrastructures that allowed them to switch over to fully online provision. That said, these digital systems were used largely to replicate existing processes and practices. Live classes were led by teachers on video conference platforms. Pre-lockdown timetables were adjusted, homework was set and tests were administered. Within the physical settings of students' houses, the basic structures of 'school' were largely replicated and maintained. When schools subsequently reconvened on-campus, surprisingly few long-term changes to pre-pandemic arrangements were apparent. In this sense, the Covid shutdowns provided ample evidence of the resolute and durable nature of 'school' as an institution.

Such contentions echo Larry Cuban's observations as to why school computers in the early 1990s were used largely in constrained ways that failed to live up to their much-touted potential to initiate educational change. Cuban's (1993) brief summation of 'Computers meet classroom – classroom wins' is more complex than might first appear. Cuban was not intending to demean or denigrate the actions of teachers, students or schools for somehow being out of step, or mistakenly not recognising the clear potential of the technology. Rather, Cuban was acknowledging the durability of the regular structures and rules that tend to organise the work of schools. These relate to standardised organisational practices of dividing school time and space, classifying students and allocating them to classrooms, as well as curricular processes of segmenting knowledge into 'subjects'.

In particular, Cuban linked the modest nature of schools' use of computers to the idea that incoming technologies tend to be enrolled into a residual 'grammar of schooling' (Tyack and Tobin 1995), rather than challenge and/or transform the status quo. Even in the 2020s, it is still possible to argue that digital technologies continue to be an integral means through which schools fulfil their main 'batch processing' functions – that is, monitoring and controlling student bodies, assigning tasks and ensuring these tasks were

completed. These arguments are notably taken up by Steven Hodas in another enduring critique of schools and technology from the 1990s. Here, Hodas (1996, p.213) noted the tendency for school technology to work in 'support of highly normative, value-laden institutional and social systems' that constitute 'school'. According to this analysis, new digital technologies tend to find a place within schools in ways that fitted with the 'social purposes [that schools] serve, the manner in which they serve them, or the principles of […] cognition from which they operate' (Hodas 1996, p.214).

These arguments continue to have relevance over three decades later. As Cuban (2020, p.670) reflects, schools continue to incorporate some reforms and changes, but often reshape the character of any 'incoming' additions to 'fit within existing structures'. This leads to 'hybrid' forms of technology practices that do little to alter the essential grammars of schooling such as age-graded classes and teacher-centred instruction. In this sense, Cuban (2015, p.436) remains confident to predict the continuation of these essential features of schooling for at least a few decades more:

> I would predict that well over 90% of US schools a quarter-century from now will be age-graded and brick-and-mortar, not virtual ones. There will be much more blending of online and face-to-face instruction in classrooms as students get older – more of the latter in elementary schools and more of the former in secondary ones. Most teachers – at least 75 percent – will use some form of device regularly in parts of daily lessons because they have expanded their repertoire of teaching activities to achieve their goals for student learning. Those uses by teachers and students will be far more integrated into daily lessons, yet will still be criticized by that future generation of techno-enthusiasts as obsolete and unimaginative.

The Shifting Character of Contemporary Schools

As we saw in Chapter 3, Cuban's observations are made on the basis of his thorough understanding of the history of education and technology over the past hundred years or so. As such, his analysis perhaps carries more weight than the opportunistic impressions of political commentators such as Tucker Carlson. Yet, we need to consider the possibility that schools might have recently altered more in character than historians such as Cuban reckon. While schools have clearly not been reoriented fully towards student-centred forms of digital learning, the increased presence of digital

technologies might be associated with more insidious and less-celebrated reconfigurations and rearrangements. These can be described along at least three different lines.

First is the changing spatial conditions of school – in particular the need to see contemporary schools as what Kitchin and Dodge (2011) term 'code/space'. This refers to the fact that 'school' is now an assortment of material spaces that are entwined with (and increasingly defined by) digital code. The idea of 'code/space' describes settings where physical spaces and software code 'become mutually constituted … produced through one another' (Kitchin and Dodge 2011, p.16). This raises the idea that we have perhaps passed the point where digital systems are simply layered 'on top' of schools. Instead, computation is interwoven around the built environment and everyday experiences of many schools to the extent that computation is a crucial component of what the school is.

This idea is illustrated by the contention that if institutional software crashes in a code/space, then it is difficult (if not impossible) for the environment to continue to function. One obvious example of this is an airport. As James Bridle (2018, p.37) puts it, 'a software crash revokes the building's status as an airport, transforming it into a huge shed filled with angry people'. Schools are perhaps not as wholly dependent on software in the same way that an airport is. However, if a school's network, Wi-Fi and LMS all fail to function, then it would be difficult to sustain the full running of that school for long. Conversely – as the Covid school lockdowns proved – a child in her bedroom with a laptop using the school network can still practically be considered to be 'at school'. In this sense, schools of the 2020s are distinctly different from schools of the 2000s, let alone schools of the 1890s.

In this sense, it is worth acknowledging the ways in which coded systems deployed within a school can act as organising mechanisms for the staff and students using them, setting the parameters of what can (and what cannot) be done within the face-to-face environment of school. Put simply, schools are now institutions that increasingly operate according to a logic of control that is ultimately reduced to what can be represented digitally. Digital systems now assume an authoritative role in schools – rendering what goes on throughout a school as 'legible, recordable, and knowable via particular numeric and linguistic constructions' (Franklin 2015, p.xix). The administration and organisation of individuals, classrooms and campuses is driven by a logic of control that stems from a confidence and certainty of everything 'being on the system'. This logic is epitomised by the imagined

ideal of the 'smart school' – where school environments are full of sensor technologies that measure, monitor and regulate the building and its occupants (de Frietas et al. 2020).

This coded extension of the boundaries of 'school' relates to a second notable shift – that is, the intensification and extension of the 'times' and 'places' that 'schoolwork' occurs. These changes are experienced in various ways. For example, during the formal 'school day', school teachers and students are increasingly expected to engage in multiple forms of work along asynchronous and multitasking lines. Students and teachers are well-used to working on multiple devices and 'second-screening', as well as 'chunking' through recorded content at sped-up rates of playback. In addition, many digital technologies can also encourage the acceleration of schoolwork – for example, in the form of continuous feedback, on-demand responsiveness and predictive logics.

Similarly, what was traditionally considered to be 'leisure' time can be taken over by digital forms of schoolwork. While students and teachers have always engaged in schoolwork outside of 'school hours', digital technologies extend the scope of this additional work. For example, teachers can now interact directly with students, parents and colleagues regardless of time or place. In theory, students can always engage with their schoolwork through digital technologies – at home, in transit or any other non-school context. Digital technologies can therefore foster an altered understanding that everywhere is 'school', while also fostering a sense that nowhere is specifically 'school'. This can lead quickly to what Nancy Baym (2015, p.15) describes as a 'sense of placelessness'.

Third is the reorganisation of schools in light of the increased dominance of software platforms. The ubiquity of working through 'platforms' – from school-specific 'learning management systems' through to large corporate platforms such as Google and Microsoft Teams – could be said to leading to what was described in Chapter 1 as a 'platformatisation' of schools and schooling. As reasoned earlier, these platforms and systems are key intermediaries in the organisation of most schools – structuring the actions of students and teachers by capturing their practices through preset interfaces, protocols and preprogrammed responses. Schools are certainly not unique in this shift. Indeed, the past ten years or so have seen the rise of the 'platform' as the dominant infrastructural and economic model (Helmond 2015). In this sense, many of the large platforms used in schools can be seen as an 'intermediary' architecture that meshes with other applications. This is illustrated, for example, in the ways that a school's LMS

might connect and interact seamlessly with 'non-school' platforms such as YouTube, Facebook or Zoom.

This platformatisation is arguably leading to a number of significant but subtle shifts to the ways in which 'school' gets done. First is the logic of 'taskification' – that is, the online separation of the entangled activities implicit in schoolwork into smaller discrete tasks (Poutanen et al. 2019). Also of note is the logic of 'platform authoritarianism' – that is, the ways in which students' and teachers' work can be managed and monitored through platforms (Arole et al. 2019). For example, system permissions and levels of consent can be altered for different teachers to reflect differences in status and hierarchy. In addition, school platforms play an inherent supervisory role. Working through a platform supports the 'increased legibility of activity' (Ajunwa and Greene 2019, p.64), with every click, swipe and interaction resulting in a data trail. Finally, students and teachers can find themselves having to work in preprocessed ways that can be easily translated into 'platform ready' forms (Helmond 2015). The platforms being used in any school play a key role in setting the conditions of how that school is experienced.

The Mutual Shaping of Educational Institutions and Digital Technologies

All told, the actual 'digitalisations' of schools over the past twenty years contradict some of the more extreme arguments that education 'needs' to adapt to the demands of the digital age. As just described, in many ways schools are profoundly digital in character and form. That said, the ways in which schools are adopting and adapting to digital technologies needs to be seen as entwined with existing school structures, processes and cultures. As Mogens Olesen (2018, n.p.) reasons, 'the educational system faces a fundamental challenge of balancing logics and principles of digital learning with traditional, paper-based learning.' Schools are not completely digital-free environments, yet neither are they embracing new digital technologies to the extent that education reformers and technology-advocates feel is necessary.

Essentially, any arguments over the need for schools to radically change in light of digital technology are often based on desires to radically change schools. As Larry Cuban (2015, p.436) intimated earlier, regardless of how

schools and teachers make use of digital technologies, they are destined to 'still be criticized by that future generation of techno-enthusiasts as obsolete and unimaginative'. Calls for intensified forms of digital technology use in schools are often simply calls for 'reschooling' – that is, remodelling the major institutional structures and organisational processes of schooling while keeping the existing physical and spatial environments of the school. In other words, many calls for the increased digitisation of schools essentially follow the logic that even if schools continue to look the same from the outside, what goes on within them needs to be is substantially different from before. As Greg Whitby (2012, p.139) put it, 'schooling needs a remodel, not simply a DIY renovation with a few shiny new appliances but a rethink of the structures, architecture and functions of schooling'.

The difficulty of putting this theory into practice is evident in a series of largely unsuccessful attempts over the past twenty years or so to recast educational institutions as sites of technological innovation and exploration. Celebrated examples of reimaging schools along technology-led principles have usually either survived for short periods of time or else left to drift back towards more conventional forms of schooling. This latter fate befell 'Quest To Learn' – a celebrated New York City public school designed deliberately around principles of games-based learning and game design. As Cristo Sims' (2017, p.xiii) detailed ethnography concluded, this ended as a classic case study of 'how a technologically cutting-edge philanthropic intervention – in this case, the attempt to redesign the American school for the twenty-first century – ended up most remaking the status quo, as well as its problems'.

Other, highly celebrated alternate schools have met similar fates. 'Alt-School' was a small chain of schools set up explicitly around principles of data-driven analytics and personalisation. Despite being led by Google's ex-director of personalisation and backed by over $170 million of investment from the likes of Mark Zuckerberg and Peter Thiel, these schools were abruptly shut down at the end of the 2010s, and the company 'pivoted' to focus on software development. As Peter Greens (2019, n.p.) put it, Alt-School was example of wealthy IT industry interests that were 'convinced that their expertise in other areas can be translated into education reform, rebirth, and revival … in the process discover[ing] that fixing schools is not as simple as they thought it was'. In 2021, it was reported that Alt-School's assets had been purchased by a company wanting to roll out online Montessori schooling. Despite recurring failures, the desire to reinvent schooling certainly remains alluring to some investors.

As such, it makes sense to move away from questions of when (and how) schools and other educational institutions might substantially alter in light of digital technology. Efforts to radically redesign educational institutions along digital lines are perhaps missing the more important aspects of debates around education reform. This was highlighted in research by Kirschner and Stoyanov (2020) which canvased experts from across education, employment and professional development sectors for the best ways 'to prepare youth to optimally function in tomorrow's labour market'. This study found strong support for refocusing schools around the development of cognitive and metacognitive skills. It also found strong support for making stronger connections between learning and authentic situations. By contrast, one of the least important changes was felt to be redesigning schools. As Kirschner and Stoyanov (2020, p.503) concluded,

> It seems to suggest that there is not a need, at least in short term, for radical changes in curriculum and school organization. … Radical changes in school organization are perhaps not needed but the focus should be shifted towards developing cognitive and metacognitive skills, linking learning with authentic, real-life situations and selecting (or developing) methods for learning and teaching that match such educational contexts and goals.

Of course, it is far easier to make broad calls for the wholesale redesign of schools, than it is to work to develop cognitive-based pedagogies. As such, discussions over the changing nature of schools in the digital age might best concentrate on the implications of the actual changes outlined in the previous section – that is, the subtle shifts associated with the increased coded nature of schooling, the shifting temporal and spatial nature of schoolwork, and the increased prominence of schooling being conducted through data-driven platforms.

Perhaps the most pressing questions that arise from this chapter are not concerned with why schools appear to continue to function along broadly similar lines. Rather, we need to discuss the less obvious ways in which schools are *actually* changing. In particular, this relates a number of issues, such as the changing ways that students and teachers are expected to work, the increased influence of commercial providers of platforms and the programmers that work for them, as well as the increased power given to data and computational forms to make decisions and generally regulate what goes on in schools. In this sense, the actual digitisation of schools could be argued to be associated with changing values that underpin the institutional provision of education. While these agendas are not unique to the increased

use of digital technologies in school, they are certainly exacerbated by them. Indeed, most of the major changes associated with digital technologies described earlier could be attributed to the ongoing realignment of education along the lines of what is variously referred to as 'corporate reform', 'neoliberal reform' or the 'global education reform movement' (Sahlberg 2016). Broadly, these labels describe a sustained prioritisation and imposition of business models on education over the past thirty years or so. These are education reforms focused on harnessing the benefits of market forces, competition and business management ideals of efficiency, effectiveness and standardisation.

It is important to consider exactly how these broad logics might be implicit in all the forms of digital technology use outlined in this chapter. For example, in practical terms, school technologies play a key role in enforcing various forms of self-evaluation, comparison and general accountability. Digital systems are used to standardise, harmonise and routinise – in short, to make what happens in every classroom knowable, predictable and hopefully more 'effective'. From the results of high-stakes examinations to in-class surveys of student 'well-being', digital technologies are used to generate and circulate various data-based 'indicators of teacher, school or system performance' (Sellar 2015, p.132). The push for technology-based ways of 'working efficiently' perpetuates long-standing discourses of New Taylorism and work-related efficiency and productivity (Briken et al. 2019).

All these aspects of technology use raise a range of specific questions with regard to the subtly changing nature of schools and schooling in the digital age. For example, these technologies are certainly altering the nature of the work that teachers and students are expected to carry out – raising questions over the capacity of teachers' to exercise their professional expertise and judgement in the classroom, as well as the tendency to blur distinctions between work and leisure, school and home, productive work and busy work. Moreover, these technologies are also raising the importance of data within schools – especially data generated through digital technology use. Of course, such uses of data can be justified as supporting active and efficient modes of governance and management. Nevertheless, a range of questions need to be levelled *against* such possible benefits. These include issues of reductionism and the privileging of an 'instrumental rationality' that presumes the disaggregation of complex social and cultural situations into neatly modelled and calculable problems that can be addressed through computational means (Mattern 2013). Further questions are also raised

regarding the exacerbation of unequal social relations between powerful and non-powerful groups through data-based calculations and judgements (Selwyn 2015).

Conclusions

This chapter has pointed to the limitations of simply demanding the digitally driven reform of educational institutions. Talk of the digitally transformed school or university might be headline-grabbing, but such descriptions remain simplistic and de-contextualised. As we have discussed, schools are being altered significantly through the growing use of digital systems and digital technologies. However, these shifts seem to be often occurring in ways that support the 'corporate reform' of educational institutions (i.e. along more efficient, effective and business-like lines). While educational systems are now highly digitised, they continue to function in relatively familiar ways.

Clearly, the idea that digital technologies offer a ready basis from which to develop alternatives to established ideas of schools and schooling is going to continue to inspire people to push for reform. In particular, IT industry actors remain keen to reinvent education in the 2020s – from the establishment of Amazon's 'Bezos Academy' preschools through to the fast-track 'Google Career Certificate' programme. Yet it would be foolhardy to imagine the imminent demise of the school or university. Indeed, despite the alternative agendas of these expensive efforts, school systems the world over continue to be based around the 'cookie-cutter' model of the two-semesters-per-year, highly structured and regulated institutions. At best, such alternate models might develop to the point of supporting a 'mixed economy' of school provision over the next few decades, where digital technologies support alternative niche choices to traditional schooling. Yet as historians such as Cuban intimate, the future of the traditional form of school would seem to be assured for a few more years yet.

In many ways, the discussions and arguments covered in this chapter reflect the complex and contested nature of education provision and education reform. Challenges to the continuation of schools and schooling have been raised for many decades, and will undoubtedly continue for many more. As this chapter has illustrated, such debates are often ideological in

nature and driven by wider arguments over ideal educational and societal arrangements. As Levinson and Sadovnik (2002, p.2) put it, debates over school reform 'are a Pandora's box for visualizing a number of conundrums currently facing liberal democratic societies'.

That said, we should not dismiss altogether the concerns and criticisms raised throughout this chapter. Many of the issues noted in this chapter point towards the need for some degree of change in order for schools and other educational institutions to make the most of digital technology. Moreover, schools as they stand are clearly not perfect. Indeed, large numbers of students (and teachers) can experience schools as unpleasant and uncomfortable places. Nevertheless, it could well be that these changes can be achieved through relatively modest 'readjustments' to digital practices that do not disrupt existing institutional structures and boundaries. We should be wary of giving up on the entire notion of the industrial-era school or university as it currently exists. Instead, it may be more productive (and certainly more practical) to set about addressing the 'problem' of formal education and technology in less 'disruptive' ways than radically altering educational institutions, or even disposing of them altogether. In this sense, we need to think carefully about the future shape and form of education provision in terms of individual *and* collective concerns. These issues are now continued in Chapter 6, where we focus on the changing nature of teaching and teachers.

Further Questions to Consider

- What immediate changes could (or should) be made to existing forms of school curriculum and assessment to help realise the potential of digital technology? Think in particular about the nature of digital information and knowledge. What implications would these changes have for what is learnt in schools and how this learning is assessed?
- Relating back to the idea of code/space, to what extent do you think that schools or universities are now defined by the software, systems and platforms that are used within them?
- Might schools have future value as places where young people do *not* have to communicate, interact and work through digital technology, as places where young people can switch off, slow down and properly engage in face-to-face, social activities?

Further Reading

This book offers an in-depth portrayal of technology use in a contemporary urban school:

Rafalow, M. (2020). *Digital divisions: how schools create inequality in the tech era*. University of Chicago Press.

Following our discussion of reschooling, this book considers how the structures and processes of contemporary schooling could change:

Zhao, Y., Zhang, G., Lei, J. and Qiu, W. (2015). *Never send a human to do a machine's job: correcting the top five EdTech mistakes*. Corwin Press.

These two articles provide a thorough overview of the nature of school organisation and culture. Although written over twenty-five years ago, both articles develop powerful analyses of why schools appear to 'resist' technological change:

Hodas, S. (1996). Technology refusal and the organizational culture of schools. In Kling, R. (ed.), *Computerization and controversy: value conflicts and social choices*, Academic Press.

Tyack, D. and Tobin, W. (1995). The 'grammar' of schooling: why has it been so hard to change? *American Educational Research Journal*, 31(3):453–79

6

Technology and Teachers

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Introduction

The relationship between teacher and learner is a cornerstone of most forms of education, be it in the guise of classroom teacher, lecturer, trainer, instructor, coach or guide. In simple terms, a teacher is a person who supports others to learn – that is, helping someone else to acquire knowledge and skills. As John Dewey put it, someone can only be said to be teaching if others are learning. More specifically, teachers are usually responsible for supporting the learning process within an organised setting. From overseeing large groups and classes to working with individual students in a tutoring or mentoring capacity, teachers are an integral part of what most people imagine education to be.

Regardless of context or sector, being a 'teacher' is usually considered a professional and prestigious position. In other words, teaching is recognised as a high-status vocation grounded in a period of specialist training and professional socialisation. Crucially, most teachers are 'content experts' who

possess some sort of expert knowledge about what is being learned. At the same time, teachers are also expected to possess 'pedagogic' knowledge and experience – a broad term referring to strategies, skills, understandings and theories of how to teach. All told, being a teacher is not an easy job. As Sean Delaney (2016, p.i.) puts it, 'Teaching is tough. A teacher's work is never done; even when you work hard there is always something more you could do.'

This complexity has prompted much debate over what makes a good teacher. Many people still refer back to Plato's description of the Socratic method which frames the teacher as acting as a dialogic 'midwife', leading dialectic questioning of alterative perspectives to push their pupils to develop and refine their understandings. Of course, these high-minded ancient ideals bear little resemblance to the administrative roles and bureaucratic tasks that many of today's teachers also find themselves involved in. Nevertheless, throughout this chapter it is important to retain a sense of what might be ideally considered to constitute 'good' teaching in the 2020s. For example, it is now widely recognised that teaching (of any kind) is not simply a process of transferring knowledge and skills over to students – what might be characterised as 'the filling of empty vessels'. Instead, good teachers will work hard to structure their students' learning and help individuals make connections with new knowledge. This might involve allowing individuals to experiment, explore and discover things 'for themselves', but always with the underlying support and direction of the teacher.

Any discussion of digital technology and education needs to pay due attention to teachers and teaching. Indeed, the relationship between teachers and technology is a contentious area. While enthusiastic teachers have pioneered many aspects of digital technology use in education, the teaching workforce continues to be blamed regularly for the limited uptake of digital innovations in schools, colleges and universities. Some observers (usually outside of the education profession) believe that digital technologies are now fully capable of conducting many tasks that were previously the preserve of human teachers. As such, it is suggested that digital technologies might now supersede expert professional teachers altogether. At the same time, however, many others (often working in and around education) continue to see digital technology as a means of extending and enhancing the work of teachers. This chapter aims to make sense of the contested relationship between digital technology and teachers. As we have found in previous chapters, such debates are rarely clear-cut. So, to what extent is digital technology a compatible or contradictory part of contemporary teaching and the working lives of teachers?

Digital Technology as a Benefit to Teachers

There are plenty of ways in which digital technologies are presumed to support and enhance the work of being a teacher. For instance, digital technologies have long been part of teachers' administrative duties. In this sense, various digital technologies are praised for their 'labour saving' potential – that is, 'freeing' teachers form the 'drudgery' of the many non-teaching aspects of the job (Ferster 2014). As discussed in Chapter 5, 'learning management systems' have become a defining technology for most teachers working in schools and universities. These systems offer a 'one-stop-shop' for teachers to deliver content to students, coordinate classroom activities, interact with colleagues and students, keep records, make reports and generally dispense with administrative and bureaucratic duties. As such, the learning management system is an integral element of a teacher's work.

Besides providing administrative and procedural support, digital technologies are also seen to offer a number of enhancements to the practices and processes of teaching – in other words, the core pedagogical work of being a teacher. For example, digital technologies can provide invaluable support to teachers in terms of planning and preparing their teaching in more diverse and informed ways. Digital technologies are also seen as a means for teachers to enhance their own subject area knowledge and their professional skills (Starkey 2020). Crucially, teachers now have access to an array of online teaching resources and collegial support. In particular, social media and content-sharing platforms are a popular way for large and diverse communities of educators to share their knowledge, experience and good practice with others around the world (Lantz-Andersson et al. 2018).

Digital technologies can also provide a range of in-class pedagogical support for teachers. For instance, technologies ranging from interactive whiteboards and clickers through to videogames and augmented reality have all been integrated into classrooms over the past twenty years to help teachers diversify their styles of teaching and modes of delivery. In theory, various technologies are now in widespread use in school to allow teachers to switch between individualised, teacher-directed forms of pedagogy and more student-driven collaborative arrangements. In this sense, many commentators stress the need for placing teachers at the centre of any technology-supported pedagogical process. As a much-shared quotation from Bill Gates put it, 'Technology is just a tool. In terms of getting the kids

together and motivating them, the teacher is most important' (cited in Chakravarti 2014, n.p.).

Such sentiments might appear comforting – especially when repeated by high-profile figures in the world of 'big tech' philanthropy like Bill Gates. Yet, while teachers are often praised when digital technologies are used successfully in education, teachers also tend to be held responsible for when technology is not seen to 'work'. As with other debates over the 'failures' of education systems, blame for the restricted use of digital technology in schools, colleges and universities is often attributed to perceived shortcomings of teachers. In fact, a range of teacher-related explanations have been given since the 1980s for the limited showing of computers and other digital technologies in formal education. For example, teachers have been deemed too old, uninterested or technically incompetent to fully integrate digital technology into their practice. Classroom technology use is also seen to be constrained by issues of self-interest, such as some teachers' reluctance to change habitual ways of working. It is suggested, for instance, that many teachers have a vested interest in maintaining arrangements and structures that ensure their continued employment and financial security. In particular, some teachers are seen to be unwilling to alter arrangements that may compromise or destabilise their authority, status or control in the classroom.

Such accusations might seem harsh, yet they reflect a continued tendency for teachers to vary considerably in their willingness and/or ability to incorporate digital technology into their work practices. While some teachers are able to effortlessly 'assimilate' digital technologies into their teaching, others achieve only a pragmatic 'accommodation' of technology into their established modes of working. At worst, some teachers might be said to make reluctant and begrudging use of technology (Ekberg and Gao 2018), or even resist outright the perceived threats of technology in their classrooms. As Peter Williams (2008, p.220) argues,

> The conservative profession of teaching has mediated the introduction of new technologies to render them 'safe'. … This may be partly a distrust of novelty and partly a lack of basic familiarity with the ways of new technology, but a major reason could be the threats the technology poses to teachers' existing practices and to the perceived maintenance of control.

Such criticisms tend to position teachers in opposition to digital technology. Of course, accusations of teacher reluctance and recalcitrance are not confined to the integration of digital technology into teaching – teachers have long been derided as conservative and resistant to change across

most aspects in their work (see Lortie 2002). Yet many of the arguments just described convey a sense that digital technologies somehow extenuate such tendencies within the teaching profession. At best, then, a substantial proportion of teachers continue to be seen as 'cautious onlookers' when it comes to digital technology, as opposed to being 'enthusiastic innovators' (Crook 2008, p.34).

Making Sense of Teachers' Actual Use of Technology

This tendency to 'blame' teachers for not embracing the benefits of digital technology should not distract us from fully considering the circumstances that different teachers find themselves working under. It is all too easy for enthusiastic commentators to indulge in 'teacher bashing' and portray teachers as technologically outflanked, ignorant or obstructive. Instead, it is worth exploring alternate explanations for the diverse ways that teachers across all sectors of education engage with digital technologies. As we shall go onto discuss, it could be argued that the nature of teachers' work acts to support some forms of technology use while discouraging others. In other words, technology (non)use needs to be seen as part of a teacher's labour process. However, alongside these issues we should first consider a number of popular explanations that frame technology use as a pedagogical process. These explanations tend to focus on presumed stages of technology adoption that teachers can progress through when implementing technology in their teaching. In this sense, technology 'integration' is framed as part of a teacher's 'practice' – something that teachers develop through experience and heightened awareness of how digital technology can support their teaching.

Models of Teaching with Technology

Sequential explanations of technology-driven pedagogic practice are a familiar feature of teacher education and professional development. While largely discounted by researchers and academics for its lack of theoretical grounding, one enduringly popular example with practitioners is Ruben Puentedura's 'SAMR' model. SAMR describes four possible

levels of integrating digital technology into teaching. First are the levels of 'Substitution' and 'Augmentation' – where technology use enhances what a teacher is already doing. More substantial, however, are the levels of 'Modification' and 'Redefinition' – where technology could be said to be transforming what the teacher was already doing. Puentedura describes the first two levels as 'enhancement' stages, where digital tools and techniques only lead to functional changes in what teachers and students are engaged in (e.g. being able to complete tasks more quickly, or perhaps in different ways). By contrast, the third and fourth levels are described as 'transformative' stages. These uses of technology are described as allowing different forms of teaching to take place (possibly resulting in different forms of learning). Here technology supports teachers to do things that they otherwise would be unable to do without the technology.

Another well-known pedagogic model of technology integration is the TPACK framework (Mishra and Koeler 2006). TPACK attempts to explain how teachers integrate technology into their teaching in terms of the different kinds of knowledge that are involved. This approach draws on the work of Lee Shulman (1986) who made the distinction between a teacher's 'Content Knowledge' (i.e. specific subject matter) and their 'Pedagogic Knowledge' of generic practices and methods of teaching (i.e. independent of content knowledge). Shulman (1986) argues that good teaching stems from a combination of both these forms of knowledge. In adding the 'T' of technology to Shulman's 'CK' and 'PK', Mishra and Koeler introduce the idea that technology is a distinct domain of knowledge that needs to be combined with these fundamental aspects of teaching. As Mishra and Koeler (2006, p. 1027) put it, digital technologies come with their own 'constraints' and 'imperatives' that set them apart from a teacher's general knowledge of how to teach:

> In the case of digital technologies, this includes knowledge of operating systems and computer hardware, and the ability to use standard sets of software tools such as word processors, spreadsheets, browsers, and e-mail. TK includes knowledge of how to install and remove peripheral devices, install and remove software programs, and create and archive documents.

The TPACK model marks an attempt to make sense of the different forms of knowledge that teachers draw on when they integrate technology into their classrooms (Voithofer et al. 2019). From this perspective, successful classroom use of technology occurs when teachers are able to combine all three forms of knowledge. This might include knowledge of how digital

technologies can support altered forms of teaching – for example, how different platforms and applications can support representations of content material, and how particular aspects of subject matter can be differently organised and adapted using technology. As Mishra and Koeler (2006, p. 1033) put it, it is not enough to either be a good teacher, a subject specialist, or a skilled user of technology – 'merely knowing how to use a technology is not the same as knowing how to teach with it'.

So, what can be learnt from these models of teachers' technology integration? Certainly, such models and frameworks direct our attention towards some important factors to bear in mind when making sense of teachers and teaching. For example, these models offer straightforward explanations why placing digital technology in classrooms does not lead automatically to better teaching or more effective learning. Models such as SAMR highlight the limitations of using new technology to support existing practices. A model such as TPACK also highlights the interrelated nature of pedagogy, content and technology when any device or application is used in a classroom. As such, these models remind us that the most important issues surrounding technology in the classroom are often not related to technology at all. Instead, these accounts highlight the importance of teachers' awareness and planning in the implementation of technology. This includes prior awareness of what is trying to be achieved through the use of technology, the prior skills and knowledge of students, and the nature of the concepts that are to be learned – what Mishra and Koehler (2006, p.1017) term 'thoughtful pedagogic uses of technology'.

The popularity of these models certainly lies in their essential optimism and relevance to classroom practices. In particular, these models chime with popular understandings of technology adoption taking place over time and spreading from a minority of 'early adopters' to a critical mass of 'mainstream users' and even 'laggards' (Rogers 1995). Yet such views of technology adoption and integration are clearly limited in their explanatory power. One obvious criticism of such models is their linearity. Puentedura is keen to stress that the SAMR model is not intended to be hierarchical – that is, that in some circumstances a teacher might be best advised to 'substitute' rather than 'redefine', or that 'no use' of technology might be an appropriate level for some classes. Yet the ways in which a model such as SAMR is used in practice tends to assume that 'modification' and 'redefinition' are preferable states of technology use. Similarly, the inference from Mishra and Koeler's work is that 'TK+PK+CK' is the ideal condition under which teachers should be using technology.

These models can also be accused of 'black boxing' technology use in education. As we have discussed in previous chapters, technology use is shaped by the local contexts and cultures that it takes place in. By contrast, TPACK and SAMR are notably context-free in their descriptions. Models such as TPACK can also be criticised for their imprecise definitions of 'Pedagogy' and 'Content'. Charles Graham (2011) observes that when researchers have attempted to measure these different constructs, it has proven difficult to establish clear boundaries between them. For example, where does a teacher's 'content knowledge' end and their 'pedagogical knowledge' begin? Are there further distinctions to be made between 'content knowledge' and 'curriculum knowledge'? Perhaps the most substantial caveat is the rather un-sophisticated way that these models tend to be used. For example, Graham (2011, p.1958) observes that these models are often applied by educators in a vague and empty manner, leaving a complex concept such as TPACK as simply just 'another generic term for technology integration'.

Technology and Teachers' Work

All told, any model of incremental technology adoption can be criticised as missing out on some key factors in explaining how teachers are able to engage with technology. Returning to our discussions in Chapter 2, it makes sense to also consider the contextual issues that might influence teachers' technology use. In this sense, digital technologies might be described in relation to the 'work' of being a teacher. This distinction recognises that every teacher is involved in much more than the prima facie task of supporting students in their learning. Teachers are also involved in all manner of accompanying work – from the administrative and bureaucratic tasks involved in formal education through to providing pastoral support and/or acting as disciplinary agents. In all these ways, teachers face an ongoing challenge of aligning various technologies that they encounter during their working day with the work that they are expected to be doing. Crucially, teachers find themselves having to fit these digital technologies with the various 'jobs' of being a teacher and, conversely, having to fit the 'jobs' of being a teacher with the demands of these technologies.

Seen from this perspective, there is a mass of work-related factors that underpin how digital technology interacts with the 'job' of being a teacher. Conversely, there are a number of different reasons why teachers may (or

may not) make use of digital technology. From one perspective, a teacher's use of digital technology as part of their work might be described (at least partially) as 'strategic'. In other words, teachers' technology engagement is often based on a combination of tactical and habitual decisions that allow them to 'discharge their duties in a predictable fashion and to cope with the everyday tasks that school boards, principals and parents expect them to perform' (Tyack and Tobin 1995, p.476).

This idea of strategic (non)use certainly contrasts with the accusations of reluctance and conservativeness outlined earlier in this chapter. Instead, teachers could be portrayed as pragmatic (or perhaps even strategic) users of digital technologies. Seen along these lines, teachers make use of technologies in ways that 'fit' with the wider 'job' of being a teacher, and turn away from technology use when it is of little direct benefit to their job. In these terms, the (non)use of digital technologies needs to be understood in light of the concerns that are foremost in teachers' working lives. These might include concerns of ensuring that students achieve 'good' grades in external and internal assessments of learning, or that classroom activities follow the prescribed curriculum and meet the varied expectations of managers, administrators, parents, future employers and other educational 'stakeholders'. As Larry Cuban (2015, p.428) reasons, 'in some situations with some innovations, teachers and other educators may have ample justification to say no to a new policy, a new device or software.'

A number of writers and researchers have explored the idea that digital technologies tend to be used where there is perceived 'complementarity' and 'workability' with the concerns of the teacher and their broader job of teaching (Lankshear and Bigum 1999). For example, it has been observed that digital technologies tend to be used less where teachers perceive a poor 'fit' with their immediate working concerns (Ekberg and Gao 2018). This can be seen in the many forms of time-related pressures that teachers face during their work. Studies of teachers' work often highlight the issue of time as an overriding concern for many teachers. As Dan Lortie (2002, p.xii) concluded from his exhaustive study of teaching as a labour process, 'time is the most scare resource' in educational institutions. While professional understandings of 'teacher time' reflect immediate concerns of being 'productive' and 'effective', it is important to recognise that technology use can intensify as well as reduce the pressures of time. At best, digital technologies might often be used to simply cope with the increasing time-related pressures of teaching – as Apple and Jungck (1990, p.235) put it, 'getting [work] done is substituted for work well done'.

It is important to pay attention to the ways in which digital technologies might diminish and constrain the quality of teachers' work and their working lives. This certainly challenges popular presumptions about the inherent 'benefits' of digital technology. Take, for example, the capacity of digital technologies to make it easier to engage with work on a 'flexible' basis regardless of time or place. By contrast, these flexibilities might be experienced as contributing to an extension and intensification of some teachers' work across all areas of their lives – such as '24/7' patterns of working in evenings, weekends and when commuting. Another questionable benefit is the way that digital technologies contribute to the 'unbundling' of teachers' work into smaller discrete tasks (Kenney and Zysman 2019). In theory, this can help outsource tasks that are repetitive, time consuming and otherwise unappealing to others. However, it could be argued that the unbundling of teachers' work (and the implicit separation of the conception of work from its execution) undermines the need for professional expertise and knowledge.

All told, it is important to consider how technology-bounded work might be experienced in ways that actually worsen the conditions and characteristics of teachers' work, and perhaps even diminish the experience of working as a teacher. For example, many of the digital technologies described so far in this book function in ways that support the increased monitoring, measurement and accountability of teachers' work. For example, most online activities now produce data 'traces' and metrics that can be used to monitor and track teachers' work. Questions can also be raised over how digital technologies are implicated in teachers' direction of their work, and underpinning conditions of autonomy and trust (Armstrong 1989). In other words, to what extent do these technologies enable freedoms and flexibilities that allow teachers to work in ways that best suit their circumstances? Alternately, to what extent do these technologies perpetuate asymmetrical power relations and inequalities?

Of course, some teachers clearly feel able to make good use of digital technologies to self-organise, save time, delegate and generally 'get things done'. Nevertheless, it is worth thinking how these individual 'benefits' are entwined with existing power relations. Indeed, many other teachers (even within the same school) might experience the same technologies as impeding their judgement, expertise and capacity for agentic action. For example, a school leader or senior teacher might find online calendars to be a great help in streamlining their work, whereas their junior colleagues might experience this technology as a source of control and stress. This raises the issue of

digital technology exacerbating the 'deprofessionalisation' and even 'alienation' of some teachers (Krutka et al. 2019). In particular, it could be argued that the increased influence of digital technology over how work takes place within schools might exacerbate some teachers' 'structural vulnerability' – in other words, the predicament of being responsible for, but not in control of, what takes place in and around one's teaching (Kelchtermans 1996).

The Digital Displacement of 'the teacher'?

As with all debates in education, each of the different lines of argument explored in this chapter might be said to partially explain the diverse use of digital technology by teachers across different levels of education. Clearly many teachers are able to 'progress' on to more sophisticated, thoughtful and successful forms of technology-based teaching as outlined in TPACK, SAMR and similar models. Yet the 'job' of teaching and being a teacher undoubtedly remains fraught with demands and pressures that can mitigate against the 'always on' modes of continual technology use that some people see as benefiting a 'modern' teacher.

Regardless of how technologically skilled and enthusiastic they might appear, many teachers remain in lockstep with the imperatives of assessment, curriculum, timetabling, and other 'system' pressures. Even the most innovative and inspiring forms of digital technology use remain constrained by variations on the 'situationally constrained choices' identified in Chapter 3 as restricting the uses of analogue educational technologies during the twentieth century. As this relatively recent history reminds us, many teachers are invariably constrained and compromised in what they can do with technology in the course of their teaching, regardless of how willing and able they might be.

These long-standing tensions are prompting growing calls among policy reformers, IT industry actors and other 'non-education' observers to fundamentally rethink the role of 'the teacher' in technology-rich educational settings. While opinions differ regarding the extent to which digital technology can take on teaching tasks and responsibilities, the logic of these arguments is consistent. Rather than continuing to encourage teachers to reconfigure their practices to make extensive uses of technology, perhaps it

is more appropriate for technology to take a more direct role in leading teaching and learning? After this, new forms of 'teacher' role can be established to support technology-based learning. This idea of rethinking and reinventing what 'the teacher' might be is illustrated in two different trends in recent educational technology development.

Displacing the Teacher: A 'guide at the side' and 'peer at the rear'

The first set of arguments will be familiar to many readers – starting from the well-worn aphorism that today's teachers need to shift from being an authoritative 'sage on the stage' to a more supportive 'guide at the side', or even simply a 'peer at the rear'. These ideas are evident in Malin Ideland's (2021, n.p.) summary of how 'teachers' tend to be described in IT industry descriptions of technology-based education:

> Such a teacher coaches rather than lectures, is flexible, and ready to work whenever and wherever. S/he customizes his/her work to the individual student and his/her needs of knowledge, location, and timeframes, emphasizing that education is a personal business. 'Boring' parts of the work (grading and assessment) are believed to be taken over by technology. The teacher should be the one promising fun and creativity in order to educate dreamers for the future and workers in a knowledge economy.

This sense of flexibility and 'teacher-as-coach' reflects a recurring ambition in technology circles to recast the teacher role into one of facilitator and supporter. Commentators such as Marc Prensky (2008, p.1) have long advocated a 'new pedagogy of kids teaching themselves with the teacher's guidance'. This role of guide or facilitator is markedly different from the traditional notion of the didactic teacher or lecturer. For example, the notion of the teacher-as-facilitator implies teaching and learning as an inherently collective endeavour, with teachers and students addressing and solving problems and engaging in open-ended enquiry together. At best, teachers are required to take an 'active' facilitation approach characterised by high levels of participation and involvement in assisting groups of students.

This perspective raises the need to define the roles that teachers are expected to play if they are no longer leading the teaching and learning process. Many social-constructivist-led accounts of education anticipate

teachers stepping back in deference to learning that is driven by peers, community members and (of course) the use of technology to access distributed sources of knowledge. This is particularly the case with the collaborative, creative and inquiry-based learning that is associated with the 'Connected Learning' approaches outlined in Chapter 4. The vision of technology-enhanced learning implicit in Connected Learning certainly challenges traditional notions of teacher-led instruction. Take, for instance, David Gauntlet's (2008) argument that one of the major 'problems' with contemporary technology-rich education is that personal devices and social media demand a shift from a 'sit-down-and-be-told' culture to a more creative 'making-and-doing' culture. Amid such enthusiasms over the creative and collective benefits of 'learner-driven' technology-based-learning, many commentators expect the role of the teacher to be considerably reshaped over the course of the next few decades.

These ideas certainly chime with a number of contemporary trends in digital culture. First is what is referred to as 'networked individualism' (Rainie and Wellman 2012), and the ways in which people in all walks of life now engage with digital technologies primarily to coordinate individually enriching networks of support. In this sense, a teacher can be seen as just one of many 'nodes' of support and guidance for anyone who is learning. From high school onwards, students might be described as using digital products and services to take an active 'surveillant' role in coordinating their learning – using digital technologies to manage and organise teachers in ways that benefit their own progress. Digital technologies that are based around a culture of instant access and on-demand services can certainly place a teacher in the position of having to work for their students (rather than students working for their teacher). Students are therefore refashioned into the role of what Stark and Levy (2018) term as the 'surveillant consumer'. Beneath promises of new technologies acting like an 'Uber for learning' or making schools 'more like Netflix' are radically different ideas of how 'teachers' should be working.

Second, these shifts also fit with the contemporary trend of viewing education primarily in terms of learning and supporting individuals to learn – what Gert Biesta (2015) describes as the 'learnification of education'. As Sian Bayne et al. (2020, p.26) continue, this is:

> the assumption that the individual student is an autonomous learner with a pre-existing, fully developed sense of individual agency and purpose leads to a shift in the perceived role of the teacher, who in 'learnified' discourses is

> often demoted from professional, expert provider to supporter and conduit for the self-determining individual learner.

Of course, it is important to remember that such learning-centred contentions stretch back well before the advent of digital technology. There is a long history of twentieth-century analogue technologies prompting calls for the displacement of the authoritative 'sage' teacher in favour of a more active, facilitative 'guide' role. If we think back to Chapter 4, some of the earliest learning theories associated with the use of technology in education also implied significant alterations to the nature and role of the teacher. For instance, behaviourist approaches to technology-based learning might be most accurately described as theories of teaching rather than theories of learning. In one sense, then, B. F. Skinner's ideas of the 'teaching machine' and 'programmed learning' imply the wholesale technological displacement of the teacher – albeit in ways that might relieve teachers of the burdens of mass instruction. As Skinner (1958, p.8) himself argued,

> Will machines replace teachers? On the contrary, they are capital equipment to be used by teachers to save time and labour. In assigning certain mechanisable functions to machines, the teacher emerges in his proper role as an indispensable human being. He may teach more students than heretofore – this is probably inevitable if the world-wide demand for education is to be satisfied – but he will do so in fewer hours and with fewer burdensome chores. In return for his greater productivity he can ask society to improve his economic condition.

Indeed, it is important to recognise that what might appear to be 'anti-teacher' sentiments within discussions of educational technology often acknowledge the continued value of having human teachers involved at important points in the learning process. This argument is also evident in what might appear to be learner-centred notions of constructivist and constructionist education. As Seymour Papert (1996) reasoned when responding to the question of whether people would still use the word 'teacher' in the future,

> Yes. Will they have adult professionals to facilitate the learning process? Yes. Will these teachers be people who are in a privileged position as the ones who know and the source of knowledge? I do not think so. Not at all. They will have a very different role. Sensitive, well-informed adults who understand deeply about learning processes and social interactions will be able to give advice. They will be able to spot that this kid has a problem, or this kid needs more interesting challenges, or put pressure on them and make suggestions.

Replacing the Teacher: Tutoring Systems and Personalised Learning

While the idea of 'teacher-as-facilitator' still envisages teachers exercising some forms of expertise, leadership and guidance, an alternate view sees the teacher's role reduced to little more than stewarding the delivery of technology-driven instruction. According to this logic, digital technology is well able to take care of the pedagogic elements supporting learning (i.e. the 'teaching'), leaving teachers primarily involved in ensuring and coordinating processes of 'delivery'. This is certainly the implicit rationale for the development of 'teacher-proof' education resources – that is, technologies that guarantee high-quality learning regardless of the individual teacher (Means 2019). The logical connotations of 'teacher-proof' digital systems and software are straightforward enough. If online systems are capable of conducting most of the educational heavy-lifting, then anyone is capable of stewarding the technology and occasionally troubleshooting any glitches. The role of the 'teacher' is therefore one of technician and 'proctor' to ensure that the system functions in whatever local setting it is being used.

This idea of digital technology taking responsibility for the direct provision of teaching is implicit in many recent developments in digital education. Take, for instance, recent enthusiasms for in-school use of online lectures and assessment packages such as those produced by Khan Academy, popular YouTube instructional videos and even TED talks. These technologies are based on the idea is that lessons, lectures and tutorials from a few 'rock-star' teachers can be consumed by hundreds of thousands of students. While these technologies 'are all staged in traditional ways, with someone talking and explaining so that others can watch, listen and learn' (Biesta 2019, p.55), digital technology profoundly alters issues of scale and scheduling. Moreover, a school class that simply involves watching Khan Academy videos and then working through the associated online exercises also raises the question of who can said to be the 'teacher' in the room.

Another pertinent set of technologies are the 'personalised learning' systems described in Chapter 5 that direct students' engagement with online learning resources. Personalised learning systems are sold as making use of sophisticated data-driven analytics to guide student decision-making. For example, once an individual is logged onto a personalised learning system, the platform monitors every interaction that the individual has with the computer. This data is used to model various aspects of the individual's

performance, such as their motivation and proficiency, as well as estimations of their mood or 'learning style'. These learning profiles are then used to recommend the most appropriate educational resources that the individual should use next. Each student benefits from the vast quantities of data being analysed, as claimed by some vendors to give these systems the capability to know more about any individual's learning than a 'real-life' teacher could ever hope.

Such systems are touted as providing the ultimate experience of having a 'one-to-one' tutoring experience for every student. Developers of these systems will sometimes point to the '2 Sigma' phenomenon reported by Benjamin Bloom as justification for their products. Bloom's (1984) study reportedly found that students who learn from one-to-one tutorials perform at considerably higher levels than those receiving conventional classroom instruction. The idea of software that can provide one-to-one tutoring is a long-held ambition among many computer scientists and educational technology developers. Indeed, despite the rudimentary computer technology of the time, computer scientists from the 1960s onwards have considered their development of dialogic 'computer tutors' capable of eventually providing learning experiences comparable to those described by the ancient Greek philosophers. As Patrick Suppes (1988, p.115) argued,

> We should have by the year 2000, or shortly thereafter, [computer-assisted instruction] courses that have the features that Socrates thought so desirable so long ago. What is said in Plato's dialogue *Phaedrus* about teaching should be true in the twenty-first century, but now the intimate dialogue between student and tutor will be conducted with a sophisticated computer tutor. The computer tutor will be able to talk to the student at great length and will at least be able to accept and to recognize limited responses by the student.

As outlined in Chapter 4, the development of these ideas during the 1960s and 1970s gave rise to the field of 'intelligent tutoring systems' – computer-based systems based around a programmed 'tutor' component that can monitor interactions between the learner and the system, and subsequently decide how and when to intervene. In this sense, intelligent tutoring and personalised learning systems continue to be designed to help people learn by being tutored rather than instructed. These systems are therefore considered to provide reliable and engaging forms of personal learning support and guidance. While not wholly comparable to having personal access to the wisdom of Socrates, these software tutors are nevertheless claimed to be capable of matching the quality of teaching that most people are likely to experience in their lifetime.

Developers of these systems are usually at great pains to argue that these technologies are not intended to replace teachers per se. For example, it is argued that personalised learning systems are intended to provide teachers with comprehensive information on each student in order to inform subsequent teaching. Intelligent tutoring systems are also argued to 'free up' teachers to work with 'struggling' students (Lester and Graesser 2018). Yet, however 'teacher-friendly' they might appear, these systems are designed ultimately to immerse students in one-to-one engagement with the system. Moreover, as far as any classroom teacher is concerned, these technologies are intended primarily to be directive rather than directable. In other words, these are systems that are designed to make decisions and provide clear guidance for students. At best, these systems are designed to make pedagogical recommendations that teachers are then expected to help enact.

Indeed, one of the key selling points of personalised and adaptive learning approaches is their inherent superiority to teacher-directed classrooms. The implication here is that technology-based personalised tutoring is significantly superior to the experience of mass classroom instruction. Art Graesser – one of the pioneers in the field of intelligent tutoring systems – grounded his work by analysing over 100 hours of videoed lessons from teachers who were untrained in tutoring techniques. This led him to conclude that 'normal' teachers 'are not prone to implement sophisticated tutoring strategies that have been proposed in the fields of education, the learning sciences, and developers of intelligent tutoring systems' (Graesser et al. 2009, p.182). Put in these terms, the idea of technology assuming responsibility for teaching is understandably appealing. As Terry Sejnowski (2015, n.p.) concludes, 'few can afford individual instruction, and the assembly-line classroom system found in most schools today is a poor substitute'.

In Defence of the Teacher in the Digital Age

The breadth of alternative forms of technology-based teaching just outlined certainly implies a considerable challenge to traditional notions of what a 'teacher' is. The pace of technological development over the past thirty years or so means that the notion of the professional expert teacher leading a classroom is no longer beyond reproach. As such, there is perhaps a need to more clearly define and defend the role of the expert human teacher

in technology-based education. In contrast to all the technologies just presented, what reasons remain for teachers to continue to take leading roles in the provision of education?

For most educators, this question will invoke an almost-instinctive response – it simply 'feels right' and 'natural' that learning is a face-to-face process that is led by a teacher. It might be reasoned that learning at all levels of education is fundamentally a 'human process enhanced by human beings' (Volungeviciene and Leduc 2006, p.26), with teachers playing a large part in this arrangement. Certainly, most technologists and computer scientists would not claim that computers are capable of the complex interpersonal, empathetic and caring work that human teachers perform on a daily basis. As Joseph Weizenbaum (1976, p.223) wrote nearly fifty years ago, 'No other organism, and certainly no computer, can be made to confront genuine human problems in human terms.' Yet, while such common-sense notions may 'feel' intuitively correct, they do not provide robust defence of the continued place of the human teacher in light of the technology-rich and technological-driven learning environments just described. We therefore need to move beyond vague romantic notions of teaching being an inherently 'human process' and, instead, consider the specific reasons why teachers should continue to be an integral element of how we imagine education in this era of increasingly advanced technology.

The need for Teachers When Using Technology in Education

First is the argument that expert human teachers are an integral part of ensuring that digital technology is used to its fullest educational potential. In short, as Sian Bayne and colleagues (2020, p.xx) put it, 'Good digital education lies in the hands of teachers.' This can be justified along a number of lines – primarily stemming from the argument that many aspects of technology-based education are social and embodied in nature and that these qualities are not easily simulated by technology. The philosopher Herbert Dreyfus touches upon this point when arguing against the notion of education that takes place wholly online. As Dreyfus (2001, p.49) concludes, technology-based teaching without the accompaniment of a teacher 'will produce only competence, while expertise and practical wisdom will be out of reach'.

These points resonate with other arguments that students benefit greatly from teacher orchestration and coordination of the social and embodied

elements of technology-based education. As Charles Crook (2008, p.33) observes, the increasing complexity and sophistication of emerging digital technologies introduces 'significant distractions and obstructions' that individuals must confront. In this sense, teachers play an important role in initiating and supporting students' supposedly self-directed activities. As Crook puts it, teachers can play key roles in 'arranging the furniture' of technology-based learning. Without the 'good core' and 'initial governance and impetus' of teacher guidance and support, uses of digital technology such as social media can often result in little more than an intermittent but relentless low bandwidth exchange that is more 'coordination' than 'collaboration' (Crook 2008).

This issue is especially relevant to the roles that good human teachers fulfil in online education contexts. Educationalists such as Sinclair and MacLeod (2015) contend that teaching online is a distinctly 'social' job, with learning taking place through conversations, dialogue and student-centred experiences. Online teaching is a situation 'when the ideas of narrative, communication and interactivity come into play – and effective teachers will realise that they draw on such narratives in creating their own students' experiences' (Sinclair and MacLeod 2015, p.95). This talk of narrative and interactivity implies a different form of pedagogy, where learning is seen to result from students being involved in experiences, rather than receiving instruction. It also implies a different form of teaching, where the teacher has less direct control. As such, it is reasoned that online teachers have to set up, arrange and manage the social experiences that students will encounter and engage in. This involves stimulating, provoking and 'inserting probes' into teaching situations, but also leaving spaces and gaps for students to work things out for themselves. This also involves paying close attention to matters of care, empathy and compassion for students that the teacher might have never met 'in person' (Head 2020).

In all these ways, then, online teaching can be seen as an active and creative process of encouragement, curation, motivating and directing. As Sinclair and MacLeod (2015, p.94) reason, 'Experience itself does not necessarily result in learning, which is why it has to be managed.' The various metaphors used to describe online education tend to depict teachers along similar lines to creative directors in the performing arts, or as designers, planners and architects. Sinclair also suggests that online teachers can benefit from assuming the role of as 'experience designers' – treating any learning episode akin to a story with a setting, plot, narrative, characters, props and intended conclusion. The teacher is therefore positioned in the role of a

director of a semi-improvised play, steering their cast of learners towards where the expert teacher wants them to end up.

The Educational Benefits of the Human Expert Teacher

Second is the argument that expert human teachers are an integral (and irreplaceable) part in any process of face-to-face learning, regardless of the technologies that might also be present. These arguments do simply hark back to a supposed 'golden age' of omnipotent teachers who stood in front of chalkboards and dictated to silent rows of students. As Gert Biesta (2016, n.p.) reminds us, there is little sense in defending the 'authoritarian' model of teaching as a form of control and 'in which the student can only exist as an object of the interventions of the teacher'. Yet this is not to reason that teachers should be reduced to an opposite extreme – for example as a non-directive 'facilitator' of learning. As Biesta (2016, n.p.) reasons, learning 'as a process of interpretation and comprehension' cannot be simply 'facilitated'.

In this sense, it can be argued that there are number of unique characteristics implicit in the act of learning directly from a human, rather than learning from programmed software or video recordings. For example, there is clear benefit from being with someone who can pass on knowledge, especially someone who has previously been in the position of having to learn that knowledge. The latter qualification is a uniquely human characteristic. When a student learns with an expert teacher, they are not simply gaining access to the teachers' knowledge, but also benefiting from the teachers' memories of learning it themselves. Technology can be preloaded with content of what is to be learned. Yet, no digital system or application is going to 'learn' something exactly the way a human learns it, and then help another human learn accordingly.

Similarly, it can be argued that a human teacher is uniquely placed to sense what another human is cognitively experiencing at any moment, and respond accordingly – what might be termed 'cognitive empathy'. In this sense, having face-to-face contact with a teacher offers students a valuable opportunity to engage in the process of thinking with another human brain. On the one hand, it can be thrilling to witness an expert who is modelling the process of thinking things through. Conversely, a human teacher is also able to make a personal 'cognitive connection' with another individual who

is attempting to learn. As David Cohen (2011, p.177) puts it, a human teacher is uniquely able to 'put themselves into learners' mental shoes'.

There are also a number of qualities arising from the performative aspects of an expert human teacher involved in the practice of teaching others. For example, listening to an expert talk can provide a real-time, unfolding connection with knowledge. A good presenter does not stick rigidly to a written text, but refines, augments and reframes their argument according to the reactions of their audience. Indeed, a key part of good teaching is the human capacity to improvise. A teacher speaking to a group of students therefore engages in a form of spontaneous revelation. Key to this is the teacher's role in leading and supporting learners to engage in active listening. As Gert Biesta (2015) reasons, being addressed by another person interrupts one's ego-centricism – drawing an individual out of themselves and forcing them into sense-making.

Continuing these benefits of being the physical presence of a teacher, it can also be argued that the bodies of human teachers are an invaluable resource when engaging learners in abstract thought. There has been much interest in how teachers use their bodies to energise, orchestrate and anchor the performance of teaching (Watkins 2007). Many subtleties of teaching take place through movement, such as pacing around a room, pointing and gesturing. Teachers make use of their 'expressive body' – lowering their voice, raising an eyebrow and directing their gaze. Crucially, a human will respond to the living biological body of another human in a completely different way to even the most realistic simulation. Catching the gaze of another person 'in the flesh' is a qualitatively different experience than appearing to be looked at by even the most realistic screen-based 'virtual teacher'.

Conclusions

From a practical point of view, it is unlikely that digital technologies will soon lead to the complete disappearance of the teacher. There will still be humans employed to oversee and steward most forms of educational activity. Difficult questions remain, however, regarding the extent to which this human involvement will require professional experts in terms of content knowledge and pedagogic skills. In a world of digitally driven 'unbundling' and 'teacher-proofing', the luxury of employing expensively trained professionals is increasingly less attractive in terms of economic cost, even though it might be considered essential for educational reasons.

Rather than questioning whether digital technology will replace humans, perhaps the most interesting conclusion to these discussions is the question of how emerging forms of educational technology might prompt us to reassess the relationships between humans and technology. As Bayne et al. (2020) reason, most responses to technology use in education tend to be expressed from an anthropocentric point of view. For example, technology is usually described as a means to enhance human capabilities and human productivity, or else as a threat to the 'human-ness' of education. Alternatively, the rise of adaptive learning systems and intelligent tutors perhaps suggest a need to view teaching and technology from a 'post-human' perspective which positions technology as an equal participant – that is, simply as a non-human teacher rather than a source of assistance and/or threat to the dominant human.

Indeed, many of the discussions in this book so far have illustrated the difficulty of neatly separating 'technology' from 'humans'. One of the key points that quickly emerges in any sociotechnical discussion of technology and education is that all technology is 'human' in its origins and implementation. Any 'computer tutor' is actually a combination of people and machines, the material world, coded structures and social settings. As such, it is important to remember that personalised learning systems are designed and configured by human designers, and that algorithms are scripted by human programmers. Distinguishing between 'human teachers' and 'computer tutors' is not simply a matter of pitting the interests of people against machines. Instead, we need to think carefully about with how different sets of people (e.g. software developers, teachers and learners) are entwined with machines and software in increasingly complex and closely connected ways. These questions can certainly help us make educational sense of what is widely seen as one of the defining technological advances of the twenty-first century: AI. Chapter 7 now goes onto examine what can be learnt from this emerging area of technology and education.

Further Questions to Consider

- What can digital technologies achieve in a face-to-face classroom that a teacher on their own could not? Conversely, what can teachers achieve in a face-to-face classroom that digital technologies on their own cannot? How are these capabilities altered in fully online education?
- Think of a commonly used educational platform or application. Consider a few basic questions that you might ask if it were a

human teacher: (i) What models of pedagogy does it promote? (ii) What assumptions does it have about students and learning? (iii) What are its core values?
- To what extent does digital technology alter the nature of teachers' work? In what ways does technology genuinely 'assist' teachers and/or lead to less work? Are these benefits experienced by all teachers? Conversely, in what ways does technology make some teachers' work more difficult and/or worse?

Further Reading

There are many good discussions of how the role of the teacher might be changing in the twenty-first century. One provocative collection is:

Bayne, S., Evans, P., Ewins, R., Knox, J., Lamb, J., Macleod, H., O'Shea, C., Ross, J., Sheail, P. and Sinclair, C. (2020). *The manifesto for teaching online*. MIT Press.

The Hybrid Pedagogy online journal and website feature over ten years' discussion about alternate ways of combining digital technologies with critical pedagogy. While focused on higher education, the website remains a good source of inspiration for all types of teacher:

https://hybridpedagogy.org

A collection of Hybrid Pedagogy articles has been published in book form:

Stommel, J. and Morris, S. (2018). *An urgency of teachers: the work of critical digital pedagogy*. Hybrid Pedagogy Inc.

Chapter 4 of Seymour Papert's book remains a good overview of how the teacher's role is believed to be changing in the face of constructivist and sociocultural technology-based learning. While his writing can be polemic, Papert encapsulates how many educational technologists continue to think about teachers and teaching:

Papert, S. (1993). *The children's machine: rethinking school in the age of the computer* (pp. 57–81). Basic Books.

7

Artificial Intelligence and the Automation of Education

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Introduction

This chapter considers an area of digital technology that has developed substantially since the first edition of *Education and Technology: Key Issues and Debate*s was published at the start of the 2010s. The field of 'artificial intelligence' has been transformed over the past ten years by increasingly powerful computational techniques and data processing capacities. While interest in this area of computer science fluctuated between the 1960s and 2000s, the 2010s proved to be a time of growing belief that AI had finally come of age. As the 2020s progress, many people now consider AI technology capable of realising long-held expectations around intelligent machines, automated decision-making and perhaps even 'high level' forms of AI that can match human levels of sense-making and understanding.

We have reached a point where emerging AI technologies are being touted as impacting significantly across education. This is evident in enthusiasms for the AI-driven 'personalised learning systems' described in Chapters 5 and 6 which are designed to make key decisions about the content and topics that students should learn, and how they might learn it. This is also evident in the development of AI systems to support everything from essay grading through to institutional budgeting and system-wide governance for policymakers. More ambitiously, perhaps, AI systems are now being developed to automate creative processes – from the composition of written text and music through to visual art and design. All told, there is increasing hope that the future of education lies in this fast-changing area of technology development. As Microsoft's Dan Ayoub (2020, n.p.) speculates,

> AI is a major influence on the state of education today, and the implications are huge. AI has the potential to transform how our education system operates, heighten the competitiveness of institutions, and empower teachers and learners of all abilities.

At this stage of the book, readers will have learnt to be wary of taking such statements at face value. In the 'socially circumspect' spirit of our previous discussions, this chapter reflects on the increasing attention being paid to AI-driven applications and systems in education. What exactly is meant by 'AI', and what technical processes does it involve? What forms of AI technology are being implemented in education, and what implications do they have for students, teachers and educational institutions? How do the imagined educational benefits of AI contrast with the practical limitations of actually using these technologies? Most importantly, what are the broader consequences of the mainstream presence of AI in schools, universities and other learning environments? Even if AI-driven education is something that is possible, is this something that is desirable?

What Is Artificial Intelligence?

Before considering the claims surrounding AI and education, we should first establish some basic definitions. In simple terms, 'artificial intelligence' can be described as computer systems that take data relating to their surroundings

and past experiences, in order to make decisions and predictions that would usually require human intelligence. Crucially, these decisions and predictions allow tasks to be performed without explicit human instructions. In this sense, AI systems are developed to simulate specific forms of human logic and sense-making. Contemporary AI technologies achieve this through a capacity to process huge amounts of data relating to specific tasks that the human mind is simply not capable of processing in a similar time. For this reason, AI technologies are often described as 'algorithmic data processing' and 'automated decision-making'. Such terminology draws attention to AI as a computerised process of making bounded decisions by automated means based on large-scale data analysis.

As mentioned briefly in Chapter 4, the field of AI emerged from the initial attempts of computer scientists during the 1950s to develop 'thinking-like' qualities into computational machines. While there is a long history of automated technology in classrooms, AI technology differs in the crucial sense of not relying on preprogrammed automations. One key development in this direction was the transition in the 1970s from 'symbolic' forms of AI to 'statistical' forms of AI based on 'observational' techniques. Statistical AI allowed the application of algorithms that were designed to learn from data by following approximated understandings of how the human mind operates. Now, AI development involves automated systems that do not 'blindly' follow preprogrammed sets of rules and logics. Instead, these systems are designed to calculate odds and probabilities in humanlike ways – for example using heuristics, or through continuously repeated forms of trial and error.

In essence, then, contemporary forms of AI involve a number of different components to provide computers with an expert knowledge base and codified reasoning required to make decisions. One important aspect of this work is based around the concept of machine learning – the process of extracting information from data patterns. This sees algorithms being 'trained' to parse large amounts of data relating to real-life topics or problems in order to learn how to make informed decisions and perform tasks relating to that real-life topic. Adrian Mackenzie (2017) describes this as using data to lend a degree of 'computability', predictability and control to real-life phenomena. Until recently, machine learning required the guidance of programmers to steer an AI system towards correct calibrations. However, the 2010s saw machine learning take on a more powerful guise – what is termed 'deep learning'. This relates to the application of machine learning techniques to artificial 'neural' networks modelled on the structure of

biological brains. In theory, a deep learning system is able to train itself to refine these algorithms, until it is capable of reaching accurate conclusions.

The capacity of these 'self-correcting' systems expanded over the 2010s in light of two technological developments – the vast storage capacity of cloud computing and the growing availability of massive data sets. In particular, the early 2010s saw the advent of the so-called 'big data', with massive volumes of digital content being generated through digital sensors, social media and other commonplace technologies. For example, one early 'deep learning' breakthrough involved a team of engineers from Google working to train huge neural networks on data drawn from over ten million YouTube videos. As such, the AI systems and applications that are now entering education are capable of processing massive amounts of data to make connections and discern patterns that otherwise could not be identified by other technologies, let alone by human teachers.

Examples of Data-driven AI Developments in Education

These advances in data processing and computation are resulting in the development of AI tools, applications and systems capable of addressing many different domains of judgement and decision-making. For example, AI systems are being developed to undertake reasoning and planning tasks, make probabilistic predictions and reach informed recommendations about future actions. At the same time, AI technologies undertake incredibly complex computational tasks of perception – such as the capacity to reach a decision on what an image represents or what is being said in a text message. Even more complex is the development of creative AI systems that have the capacity to begin to create content (such as images and texts) with specific form and meaning.

Over the past ten years, these techniques have been applied across many areas of society. In the area of transportation, for example, the development of autonomous vehicles relies on various forms of AI from image recognition through to path-planning. Elsewhere, AI systems are used to model and predict complex natural systems such as climate and weather patterns, through to modelling and managing human systems such as traffic flows and financial markets. At the same time, AI now sits behind many mundane

everyday technologies – from flagging inappropriate content and abusive messages on social media, through to predicting which movies or TV shows a viewer might want to next watch.

All told, there is understandable interest in how these AI developments might be implemented in educational contexts. AI and education is an area of fast-growing commercial interest, attracting the attention of 'Big Tech' companies such as IBM and Google, alongside specialist education developers such as Pearson. It has been estimated that the global market for AI products in education will expand from $1.1 billion in 2019 to $25.7 billion by 2030. At the same time, university and commercial researchers are also exploring possible new applications of AI in education within the emerging field of 'AIEd' research which combines computer science, education, psychology and other facets of the 'learning sciences'.

Current areas of educational AI range from supporting individual students through to managing whole education systems. At a system-wide level, there is growing interest in 'automated education governance' where policymakers and education authorities use big data and AI to model processes within school districts to reach system-wide decisions (Gulson and Witzenberger 2021). One example of this is the use of supervised machine learning to identify patterns in school performance. The UK government's school inspection agency claims to have developed AI-driven systems to predict schools' 'likely future performance' (e.g. in terms of exam results or student retention), which can trigger local interventions if schools are seen to be falling below their predicted levels. This technology is seen to help the agency 'focus our efforts where they can have the greatest impact' (Ward 2018, n.p.).

Elsewhere, a number of AI-driven technologies have been adopted by school and university leaders to support managerial and administrative tasks. This includes the initial screening of job applicants, deciding on resource procurement, predicting patterns of likely student enrolment and retention, and informing other 'business decisions' faced by educational institutions (Yates and Chamberlin 2017). At the same time, AI is used for various procedural tasks around schools and universities. For example, the rise of AI in supporting campus management has seen the adoption of facial recognition systems by thousands of US schools in efforts to identify unauthorised intruders. Similar biometric systems are being used to authenticate the identity of online students – in other words, confirm that the people engaging in online learning activities are actually who they claim to be. Another growing area of development is 'online examination

proctoring' systems that authenticate the identity of students taking computer-based tests and examinations, and monitor their behaviour throughout the duration of the examination.

Alongside these institutional forms of AI, a number of other AI-driven technologies have been developed to take on tasks that previously would have been carried out by teachers. This includes facial recognition systems to assist teachers in monitoring student attendance, alongside live facial detection systems to monitor students' attention levels and emotional states. These technologies promise to avoid mistakes and misrecognition arising from human error, and perhaps uncover instances of 'fake attendance' and 'proxies' in school systems where fraudulent attendance is commonplace (Wagh et al. 2015). Other AI tools are now used to assist teachers in identifying instances of academic malpractice and cheating. For example, essay plagiarism tools now use AI-based 'language stylometrics' to identify changes in the style (as well as content) of students' writing, thereby helping teachers identify the use of ghostwriters and contract essay services. Other applications of AI include the growing use of automated essay assessment – what is sometimes described as 'robo-grading'. These systems use machine learning techniques to process mass archives of essays already graded by humans, and then compute how these essays were graded in terms of recognising various features of the written text. These recognitions range from accuracy of spelling and grammar, through to pattern matching each essay's topic focus, sentence structure, appearance of coherent arguments and complexity of word choice. Using these calculations and learnt logics, the systems can then mark millions of other essays in a matter of seconds.

There is also growing interest in developing AI systems that can directly support students. For example, dialog systems and conversational agents (commonly known as 'chat bots') are being developed to automate general interactions between students and teachers. In particular, a few universities have begun to explore the use of chatbots to respond to student queries and provide on-demand advice and guidance. These systems are trained on large bodies of previously existing text generated from FAQ lists, website information, forum posts and online class discussions. Using these previous examples of common teacher/student interactions, chatbot systems then learn how to offer timely advice and responses to subsequent student queries. At the same time, AI-driven tools are also being used to support students in their studying and schoolwork. Applications include the use of natural language processing to provide automated writing feedback – allowing students to amend and improve the content and style of their writing in real

time, along with the live-captioning of videos, sophisticated speech-to-text transcribers, pronunciation analysis and language translation. Natural language generation tools have also been developed to support students' writing by producing machine-generated text that students can then adapt and revise.

Another growing area of educational AI is the computational techniques that underpin the 'personalised learning' systems discussed in Chapters 5 and 6, designed to direct students' engagement with online learning resources in light of their previous performance. Here, students' actions are monitored and the resulting data used to model various aspects of their performance. These learning profiles are then used to recommend the most appropriate educational resources that the student might next use. Alongside personalised learning systems, millions of students now also interact with 'pedagogical agents' – animated software characters designed to provide bespoke advice, support and guidance about an individual's learning progress and general academic well-being. Such systems are all designed to use AI-driven modelling and predictions to provide students with personalised planning, tracking, feedback and 'nudges'.

Perceived Benefits of AI in Education

Many observers see these AI applications and systems as heralding a wholesale transformation of education. Technologists have long felt justified to proclaim that 'AI will be a game changer in education' (Woolf et al. 2013, p.67). Similar enthusiasms are now being expressed by governments and official agencies. As the UNESCO (2019) 'Beijing Consensus on AI and Education' put it,

> The systematic integration of Artificial Intelligence (AI) in education has the potential to address some of the biggest challenges in education today, innovate teaching and learning practices, and ultimately accelerate the progress towards SDG 4.

These broad-brush claims are supported by a number of specific benefits that are associated with using AI in education. One popular idea is that data-driven automation can increase the efficiency of educational institutions and the individuals that work within them. Much of this enthusiasm relates to perceived data-driven advantages of scale and speed, as well as expectations

of increased accuracy and precision. As Edwards and Cheok (2018, p.5) reason,

> The ability of machines to process huge amounts of information, and utilize the output for addressing student needs underscores [a] significant area where AI surpasses humans.

From this perspective, educational AI can be justified along a number of different lines. In pragmatic terms, AI-driven systems and applications are expected to lead to long-term cost-efficiencies in comparison to training and employing human teachers and administrators to carry out the same tasks. In addition, AI offers reliable, consistent and controllable ways of delivering education, as well as providing a source of computationally precise, unambiguous decision-making. Many of the AI applications described so far in this chapter can guide actions, direct resources and generally help teachers and students be better informed and prepared. All told, AI technologies are welcomed as bringing a formal mathematical logic of 'calculability' to bear on educational situations that otherwise are dealt with through informed guesswork or speculative planning.

Alongside these promises of doing things better than humans are claims that AI technologies are capable of doing distinctly different things. For example, it is argued that AI technologies are capable of recognising patterns and making connections that humans would never consider. Indeed, one of the central claims of AI research is the capacity to identify essentially correct but completely 'unhuman' ways of doing things, as well as pointing to contentious trends and patterns that humans might ignore or prefer to overlook. In this sense, some claims surrounding education and AI convey hopes of intelligent technologies 'that can make sense of the world in ways that humans themselves cannot' (Andrejevic 2020, p.2). In theory, the combination of powerful computational techniques and massive data sets promise to transcend the limits and inefficiencies of human information processing.

It is also argued that AI brings a new sense of time and timing to education – moving beyond the fixed schedules of school days, terms and academic years. Taylor Webb and colleagues (2020, p.285) point to how AI technology introduces previously unfamiliar 'anticipatory priorities' into education thinking. For example, AI technologies are based around future-focused projections and predictive actions, continuous measurement, real-time feedback and so on. By contrast, schools and universities continue to be structured around chronological forms of time keeping. In other words,

schools and universities have entrenched understandings that time is 'something that can be counted … calendars, schedules, deadlines and performance goals are the objects and practices of chronological education' (Webb et al. 2020, p.287). By contrast, AI technologies introduce different rhythms and forms of foresight to educational activities.

A further set of perceived changes relates to the power of AI technology to exceed (and therefore enhance) the physical and mental limitations of individual human educators. These claims usually take two lines of argument. First is the idea that AI can act as a corrective to teachers' human frailties, such as fatigue, bias and scarcity of attention to individual students. As Kristin Houser (2017, n.p.) writes,

> It's easy to see the appeal of using a robotic teacher. … Digital teachers wouldn't need days off and would never be late for work … the systems would never make mistakes. If programmed correctly, they also wouldn't show any biases towards students based on gender, race, socio-economic status, personality preference, or other consideration.

As these descriptions of human bias and mistakes suggest, AI-driven systems are often imagined as capable of reaching dispassionate, objective and impartial decisions – what Edwards and Cheok (2018, p.5) describe as 'the ability of machines to … to interact with human learners without human emotions getting in the way'. A second line of argument is the more conciliatory idea that AI technologies can provide ongoing support to human teachers – 'freeing-up' teachers from routine and procedural tasks, allowing them to concentrate on higher-level pedagogic work. In this sense, AI technologies are described as taking responsibility for onerous 'routines', 'duties' and 'heavy-lifting' associated with teaching. It is commonly argued that teachers will soon have their own AI-driven 'assistants' that provide 'intelligent support' and reduce workload and stress. Such descriptions imagine 'a future in which the role of the teacher continues to evolve and is eventually transformed; one where their time is used more effectively and efficiently, and where their expertise is better deployed, leveraged, and augmented' (Luckin et al. 2016, p.11).

There are also a range of claims relating to the idea of AI-driven tools and systems helping students and teachers make better decisions, and perhaps do things that they were previously not capable of. Some of these claims relate to expectations of AI tools 'nudging' students' decision-making and actions towards more educationally advantageous outcomes. This draws on the idea from behavioural economics that individuals often act in irrational

ways and sometimes make ill-considered decisions that are not in their best interests (Thaler and Sunstein 2008). In this sense, some educational AI technologies parallel the development of behavioural economics techniques in areas such as advertising and public health. This promotes the logic that data-driven AI techniques can be used to manipulate the psychology of choice, echoing long-standing academic interest in 'computers as persuasive technologies' (Fogg 1997).

Alongside using AI technologies to manipulate individual decision-making is growing interest in the benefits of what has become termed 'AI for social good'. In educational terms, this includes ways in which AI tools might enhance education accessibility and widen participation. For example, AI-driven tools can be used to increase accessibility of learning resources for students with physical and mental disabilities. This includes the development of voice-to-text translation tools to support students with dyslexia to produce written work. Similarly, 'live' video-captioning tools make use of natural language processing to produce accessible materials for students with hearing impairments. There is also a growing number of AI applications designed for students with autism – including 'socially assistive' robots designed to help develop social skills, communication and learning (Clabaugh et al. 2019).

Finally, are various hopes that AI-infused practices might even be capable of fundamentally altering the nature of learning and knowledge production. This is illustrated by the 'assistive' AI writing tools and other forms of 'creative AI' outlined earlier in this chapter. The involvement of students in the production of AI-generated images or algorithmically assisted reading and writing, clearly alters the nature of authorship in interesting and unexpected ways. The logical implication here is that AI might also change the nature of learning itself, with new forms of learning resulting from students collaborating with AI tools in the production of work that is co-authored and co-created by machines and humans. It is suggested that this should prompt educators to fundamentally 're-imagin[e] what texts, multimodality and identity are – and do – in the age of AI' (Leander and Burriss 2020, p.1262).

The Practical Limitations of AI in Education

Given these ambitious and potentially transformative examples, it is easy to see why AI technologies are attracting considerable attention in education.

Yet, as we have found throughout this book, claims for the technological transformation of education are rarely straightforward. We therefore need to be wary of context-free enthusiasms for what are seen as essential capabilities of AI technology. As such, a useful corrective to such enthusiasms is paying closer attention to the practical limitations that are already emerging around the use of AI in education.

When examined in concrete terms, the realities of AI technology development are perhaps less all-encompassing than the hyperbole surrounding AIEd would have us believe. Indeed, increased interest and investment in AI over the past few years has led to considerable overclaiming and overselling. It was perhaps not surprising that an audit of over 2,800 AI start-up companies in Europe found that 40 per cent were not making any actual use of AI technology in their products (Ram 2019). Besides instances of outright mis-selling and 'pseudo-AI', there are a number of limitations to the AI-driven tools and applications that are currently being touted in education. For example, Les Perelman (a long-standing critic of automated grading systems) made headlines a few years ago by working with his students to develop a 'Basic Automated Bullshit Essay Language Generator'. This software demonstrated the ease with which high scores could be triggered by generating well-structured, but essentially meaningless, text. Perelman was making the point that while AI-driven essay grading software is able to discern the complex structure and correct keywords of any essay, it is unable to discern 'meaning' or even recognise accuracy of facts. Similarly, the capacity of facial recognition systems to prevent unauthorised intruders has been criticised as little more than 'security theatre', with the technology argued to 'offer only the appearance of safer schools' (Harwell 2018, n.p.) rather than somehow being able to identify or predict malintent.

Discussions over AI and education also often overlook the practicalities of accommodating these technologies in physical face-to-face classrooms. Firstly, it is important to remain mindful of the considerable amount of human work required for these technologies to function – from the human stewardship necessary to support the smooth running of an AI-driven classroom, to the human-driven 'behind-the-scenes' computational work. In a practical sense, then, it is mistaken to describe these technologies as functioning 'autonomously'. Instead, AI technologies require substantial amounts of compensatory human work to keep operational – what Astra Taylor (2018) has labelled a state of 'fauxtomation' dependent on considerable amounts of 'invisible labour'.

Of course, none of these limitations should come as a surprise. Instead, these practical issues simply reflect the types of AI that are actually being used in education, as opposed to the forms that are often speculated about. Over fifty years on from Herb Dreyfus' (1965) treatise against 'Alchemy and Artificial Intelligence', AI remains an area of considerable exaggeration and overselling. In particular, very few of the systems and applications described in this chapter make advanced use of the 'deep learning' techniques that are fuelling popular enthusiasms for the potential of AI. It remains highly debatable whether we will ever see technology that comes close to achieving the much vaunted 'human level AI' and artificial 'general' intelligence. In these ways, most of the grand promises currently being made for AI in education remain more speculative than substantial.

At best, then, the use of AI in education continues to take the form of what technologists term 'weak AI' or 'narrow AI'. These are systems that appear 'intelligent' only in terms of the specific tasks and predefined processes they are configured for. Of course, these 'narrow' forms of AI are sophisticated technological developments that are capable of playing significant roles in education. Yet the limitations of these narrow AI technologies need to be kept in mind when engaging in broader speculation of how educational forms of AI might develop in the near future. As Hilary Mason (2018, n.p.) reminds us, 'AI is not inscrutable magic – it is math and data and computer programming, made by regular humans.' In contrast to claims of AI 'taking over' education, these are technologies that are each capable only of a specific range of tasks in set circumstances. It is therefore important to maintain a sober perspective on AI in education – seeing these technologies for what they are, and making use of them accordingly.

Conceptual Concerns over AI in Education

It is also important to engage with the consequences and constraints of AI technologies above and beyond their practical limitations. Just like all of the technologies discussed previously in the book, these are not neutral tools that are used in benign ways. As such, it is also worth paying close attention to the values and logics that are implicit in educational AI, as well as the ways in which the increased use of AI might serve to alter the characteristics and nature of education. These issues are less widely acknowledged in

discussions of AI and education, but certainly need to be borne in mind when attempting to make sense of the educational implications of AI-driven technologies.

Problems of 'decontextualisation'

First are concerns relating to the limitations of using statistical modelling and computation to represent complex educational contexts. While the computational modelling, re-weighting and continual refinement of millions of data points sound impressive, it arguably remains incapable of approximating the social nuance and complexity of even the most basic educational situation. This leaves AI researchers (and data scientists in general) at a distinct disadvantage when trying to model any 'real world' educational issues. This limitation was illustrated in a Princeton University study that challenged hundreds of statisticians, data scientists, AI and machine learning researchers to predict six life outcomes for children, parents and households. These outcomes included common educational data points such as the children's 'grade point average' at school and their self-reported perseverance (the so-called 'grit') with regard to schoolwork. While the resulting computational systems were given nearly 13,000 data points on over 4,000 families stretching back over fifteen years, it was concluded that 'despite using a rich dataset and applying machine learning methods optimized for prediction, the best predictions were not very accurate and were only slightly better than those from a simple benchmark model' (Salganik et al. 2020, p.1). As media coverage of this research put it, 'AI can't predict how a child's life will turn out even with a ton of data' (Hao 2020).

From a social science perspective, this shortfall is of little surprise. As illustrated in Chapter 2, the contextual layers implicit in any area of education are impossible to fully capture. Any educational application of AI therefore faces inevitable problems of representativeness, reductiveness and explainability. For example, in terms of the 'representativeness' of educational data, it is often argued that sophisticated computational processes are only as good as their 'input' data (a phenomenon termed 'Garbage In, Garbage Out'). There are plenty of instances where educational data might be inaccurate, incomplete, poorly chosen or simply a weak indicator of what it supposedly represents. Such gaps and omissions are especially important when modelling what human teachers and students do. Even the most complex models of 'teaching' and 'learning' contain significant areas of

uncertainty. Yet, as Louisa Amoore (2019, p.151) reasons, machine learning processes are not designed to accommodate doubt, or acknowledge the idea that some 'variables' might be incalculable:

> The machine learning algorithm must reduce the vast multiplicity of possible pathways to a single output. At the instant of the actualization of an output signal, the multiplicity of potentials is rendered as one, that moment of decision is placed beyond doubt.

In this sense, it can be argued that there are many elements of education that cannot be fully captured and expressed through data processing – even if technically sophisticated approximations are possible. Of course, AI (as with any instance of data science) relies on the use of proxy indicators, as well as clearly defined outcome variables, predictive variables and validation data. As such, effective data-driven systems need to be designed with sophisticated understandings of how these variables relate to the social problem at hand (Eubanks 2017). However, there are perhaps many factors integral to understanding what goes on in education that may never be adequately measured and quantified in reduced form. For example, how could one construct a genuinely nuanced and sensitive computation of a student's mental health, or a realistic sense of family 'poverty'? These are social issues that are important elements of making sense of education, but not necessarily reducible into neat datafied forms and the process of what Amoore (2019, p.151) terms, the 'condensing of multiplicity to a single output'.

Alongside these issues are concerns over how educational AI applications suffer from an inevitable lack of explainability and 'black boxing'. In short, as AI systems become more complicated, it is increasingly difficult to work out the rationales behind any decisions that these systems produce. It is often noted that even programmers and engineers who design machine learning systems struggle to isolate and explain the reasons why their system has chosen any particular action (Ivarsson 2017). This lack of explainability sits uneasily with established ways of doing things in education. Most educators consider themselves to be well-informed 'reflexive' practitioners. Teaching and learning are understood to be processes where people need to know why, as well as what, they are doing. Simply being directed or guided what to do next does not constitute 'teaching' or 'studying' in its fullest sense.

These concerns stretch well beyond conventional notions of data validity and instead question the appropriateness of using data to model educational processes and practices adequately. One common criticism is that AI suffers from an inevitable lack of 'common-sense' understanding and nuanced

awareness of even basic social contexts. As Fei-Fei Li (2017, n.p.) observes, 'The definition of today's AI is a machine that can make a perfect chess move while the room is on fire'. Considerable doubts remain over the extent to which AI systems are able to appropriate what is going on in 'real world' educational contexts. In particular, it can be argued that data-driven approaches substantially underestimate the social complexity of classrooms, schools and the complicated lives that students and teachers lead. Echoing Murray Goulden's (2018) distinction between 'technologically smart' but 'socially stupid' AI systems, concerns persist that even massive amounts of data points cannot adequately capture the complexities and nuances of who a student is, or how a school or university functions. As Meredith Broussard (2019, p.61) argues,

> Math works beautifully on well-defined problems in well-defined situations with well-defined parameters. School is the opposite of well-defined. School is one of the most gorgeously complex systems humankind has built.

Of course, these arguments are based upon differences in ontology – in other words, how one sees the existence of the social world. As implied in our earlier discussions, there are plenty of data scientists and software developers who consider the world to be broadly quantifiable, calculable and subject to statistical control. Judy Wajcman (2019) describes this as an 'engineering' mindset that conceives social systems as essentially programmable machines that can be engineered to operate effectively given the correct inputs. Elsewhere, however, are many others who feel that these assumptions do not extend to social contexts such as classrooms or online learning environments. In this sense, it is important to remember that knowledge is always situated. In this sense, we need to move away from seeing educational implementations of AI technologies in terms of what Donna Haraway (1988) terms the 'God-Trick' (the pretence of providing a detached objective God's-eye view of the world). Instead, we need to see AI techniques as just offering one of many possible perspectives. This is not to conclude that AI technologies have no place in education at all, but does imply that AI can never provide a definite analysis, account or answer.

Problems of 'diminishment'

Second are concerns relating to the diminishment of teaching and learning as human-focused and human-centred processes. Of course, this decentring of human concerns might be welcomed as a part of a productive shift to

'post-human' or 'trans-human' forms of education where teachers and students embrace AI technology to overcome their cognitive limitations and become 'more-than-human' beings (Lipowicz 2019). Yet, the increased use of AI in education mostly gives rise to a set of social concerns over the possible de-humanisation of education. These concerns take different forms. For example, it is argued that AI technologies evoke a constant state of monitoring, measurement and manipulation of students' behaviour that constitutes unacceptable forms of 'pervasive surveillance' (Vanolo 2019, s.951). In a practical sense, this also raises the inadequacy of any promise of 'informed consent' regarding the use of AI technologies in classrooms. The systems being deployed in schools and universities rely on continuous and comprehensive data collection in order to operate. In this sense, allowing students to 'opt-in' or 'opt-out' of having their data collected does not fit with the basic design of any system.

In a more esoteric sense, it can also be argued that this constant 'dataveillance' is likely to alter the behaviour of students and teachers. For example, one practical consequence of facial detection technologies is students and teachers having to contort their facial expressions in 'unnatural' ways that allow the technology to 'detect' and/or 'recognise' them. Similarly, one of the practical consequences of speech detection technologies is some students and teachers having to reconfigure their accent, vocabulary and cadence in more 'standard' ways to allow the technology to parse the speech. If the algorithmic gaze of the system is not triggered, then the onus tends to fall onto the individual to present a more 'readable' face or voice. In this way, automated systems result in narrow definitions of human subjectivity, thereby running the risk of 'diminishing our subjectivity in order to comply with digital systems' (Andrejevic 2020, p.133).

Regardless of how complex they might appear, sustained engagement with AI-driven classroom technologies is invariably reduced to getting to know the system and being able to interpret and work with its coded logic – what could be termed a form of 'algorithmic conformity'. This certainly raises questions over the forms of learning that are most readily supported through AI technologies. Even the 'chattiest' pedagogic agent interface could be said to facilitate little more than an elaborate form of information delivery and ultimately a 'behaviourist' model of training. As Audrey Watters (2017, n.p.) reasons, these are technologies built upon the principle of 'manipulat[ing] and influenc[ing] users, encouraging certain actions or behaviours and discouraging others and cultivating a kind of addiction or conditioned response'. This might offer an acceptable way of supporting

some types of skills development, but clearly is a poor means of supporting many other forms of understanding, knowledge and sense-making.

It might also be reasoned that these systems narrow the nature and conditions of any 'learning' they are involved in. For example, one widely used algorithm in educational software development during the 2010s was the off-the-shelf 'Elo' algorithm (originally designed for calculating the relative skills of chess players). This algorithm inevitably frames classroom interactions through the lens of playing zero-sum games such as chess, with individuals conceived as motivated by winning games, gaining points and competing against others. This points to an important ontological tension between models of 'education' that circulate within computer science and the understandings of 'education' that many educators hold dear. For example, if a learning episode is designed to progress along similar adversarial and competitive lines to playing chess, then it may well result in very different outcomes than supporting learning through a collaborative community of inquiry. Of course, some education professionals place value on competition and performance above broader notions of collaborative learning. Nevertheless, as Francois Chollet (2019, p.1) observes, 'The contemporary AI community still gravitates towards benchmarking intelligence by comparing the skill exhibited by AIs and humans at specific tasks such as board games and video games.'

Another recurring concern relates to the diminishment of the teacher's role. As far as some critics are concerned, the ultimate goal of AI in classrooms is 'automating and displacing the most expensive element of schooling: teacher labour' (Saltman 2020, p.203). Continuing our discussions from Chapter 6, while teachers are unlikely to be replaced outright by AI technologies, they might well be displaced in a number of less obvious ways. All told, we cannot presume that increased classroom automation will result in increased teacher autonomy. Instead, it could be argued that these technologies reframe the teacher's role to one of primarily shepherding the activities of students in ways that are decided and determined by machines. Many of the educational AI technologies described in this chapter separate teaching tasks into different components, and thereby risk diminishing the ability of human teachers to exercise professional judgement and expertise over the overall process of 'educating'. At best, the teacher is reduced to interpreting and enacting the judgements of various automated elements of classroom. This might result in teachers having to explain why a student has received a particular grade on their 'robograded' essay while not being responsible for determining that grade. Teachers may have to support

students to progress through learning tasks that have been 'recommended' without a clear sense why this is an appropriate course of action. In essence, many AI-driven classroom systems are technologies designed to organise teaching and set the parameters of what can (and what cannot) be done. These are not technologies designed to give teachers increased control over the content and direction of their work.

In short, many of the technologies outlined in this chapter seem most likely to control, deskill and demean the teachers that they are supposedly 'assisting'. As Judy Wajcman (2017, p.124) contends, the 'proverbial elephant in the room' when talking about AI-led automation is that these technologies are not facilitating less work, but are actually facilitating worse jobs. From this perspective, there is good reason to anticipate that AI will not lead to a majority of teachers enjoying more meaningful work or more fulfilling interactions with their students and colleagues. While few people anticipate these technologies doing away with the need for human supervision altogether, there is a growing feeling that highly trained, well-salaried professional teachers might no longer be required to oversee these processes. Instead, AI-driven classroom technology could well usher in an era of deprofessionalisation. Whereas teachers being replaced by robots remains highly unlikely, teachers having to work like robots is perhaps a much more likely prospect.

Problems of 'disadvantaging'

Finally are concerns over the ways in which AI technologies might exacerbate inequalities and injustices in education, rather than acting as a force for 'social good'. It can be strongly argued that the increased presence of AI in education works to (dis)advantage some groups of students and teachers over others. A central concern here relates to the reproduction of existing social inequalities (as well as the generation of new forms of inequality) through data-driven processes. Above all, it is now increasingly recognised that AI and algorithmic systems exacerbate discriminatory decision-making in favour of those social groups most represented in the systems' data sets (Noble 2018, Eubanks 2017). These inequalities can be perpetuated by educational AI in a number of subtle (and not-so-subtle) ways. For example, the AI-assisted writing technologies described earlier tend to be trained on large text collections often taken from limited sources such as online discussion forums. This can therefore perpetuate the limited

modes of knowing and writing that tend to prevail on such forums, and are normalised in the outputs of the resulting AI applications:

> In the same way that the assemblage of training data congeals into an ideal user-subject – based on the sources of data collection: a white, middle-class, able-bodied, native English speaker – it also yields an ideal model of writing. (Dixon-Román et al. 2020, p.246)

It is also increasingly argued that AI systems work to contrast fixed attributions of race and gender in informing education decision-making. For example, AI systems such as facial and speech recognition place disproportionate emphasis on 'detecting' the gender and race of the individuals that they identify. In other instances, the emphasis placed on categorisation and labelling within AI systems renders some individuals (who do not fit easily into norms) 'hypervisible' to education systems oriented towards discipline. Conversely, the same individuals are rendered invisible to education systems oriented towards reward and progression (see Reddy 1998). Mary Madden (2019) points to the 'double-down effect' that marginalised groups can experience in datafied systems. These groups not only endure intense scrutiny from systems designed for surveillance and behavioural monitoring, but also remain marginalised by systems that may provide them with opportunities to alleviate their situation (e.g. being shortlisted when applying for a scholarship or job promotion).

While not introducing racist or gendered practices into schools and universities for the first time, AI technologies certainly foreground issues of race and gender within educational contexts, and therefore exacerbate pre-existing discriminatory practices. The same might be said for any marginalised group. This is illustrated in Os Keyes' (2019) argument that 'data science is a profound threat for queer people'. Defining 'queer' primarily in terms of fluidity, autonomy, a distinct lack of definition and 'the freedom to set one's own path', Keyes argues that data-driven AI technology designed to 'recognise' students and their behaviours is fundamentally set in opposition to these qualities (given that data science is grounded in ideas of statistical norms, discrete categories, precise definitions and assumptions of predicable futures). Any gaps, omissions and blanks in non-binary and non-conforming students' data profiles will invariably lead to diminished calculations and a limited range of diagnoses, predictions and decisions being made about them. Significant issues are likely to be ignored, and additional unwarranted assumptions are likely to be made. All told, the chances of these students being mis-represented are high.

All these outcomes seem to contradict enthusiasms over the use of 'AI for social good' outlined earlier as justifying the educational adoption of these technologies. Indeed, critics such as Ben Green argue that any idea of using AI for social good is hampered by the generally vague and unarticulated assumptions about what 'social good' might constitute. This lack of grounding principles means that the 'social goods' being pursued by educational AI developers can cover a wide (and sometimes conflicting) range of political characteristics. This can result in simplifying issues that are actually politically complex, as well as failing to reach any clear consensus over what is desirable. As such, proponents of educational AI run the risk of blithely 'wading into hotly contested political territory' and acting in unhelpful and perhaps harmful ways (Green 2018, p.19).

Such tensions are illustrated by the claims outlined earlier regarding the use of AI technologies to support students with mental disabilities. These perceived benefits of AI could be argued to perpetuate common ableist tropes of helping disabled people 'pass' as normal, gain 'independence' and better 'fit into' social settings such as classrooms. This can be seen in enthusiasms for students with dyslexia being able to author essays using AI-driven talk-to-text applications, or children with autism being supported to learn appropriate 'social skills' through interacting with a social robot. In terms of the latter technology, for example, Os Keyes (2020) contends that the increased use of AI to 'support' students with autism reinforces cultural understandings of autists as asocial, overly rational and preferring communication with machines rather than humans. Predominantly designed by those without autism, such AI technologies are based around ideas of 'repair' and normalisation – that is, '"fixing" autistic people, rather than attempting to meet autistic people in the middle' (Keyes 2020, p.16). Returning to our discussions from Chapter 2, these applications of AI could be critiqued along 'techno-ableist' lines. As Ashley Shew (2020, pp.47–8) puts it,

> The latest set of technological solutions to the perceived problems of disabled people is Artificial Intelligence and machine learning. … AI designers are clearly focused on changing the individual to fit the environment rather than the other way around.

Conclusions

Regardless of any criticisms and concerns, support for AI technologies in education will undoubtedly grow over the 2020s and beyond. Indeed,

whether or not educational AI 'works' as promised by its developers and vendors, this technology looks set to be integrated increasingly into school and university settings. As Adam Greenfield (2018, p.243) contends, 'The meaningful question isn't whether these technologies work as advertised. It's whether someone believes that they do, and acts on that belief.' From this perspective, we need to treat the continued integration of AI technologies into educational settings as a serious proposition with specific politics. It is therefore important to ask questions about the distinct social order that is being built up around AI and education – that is, likely reconfigurations of power, (dis)advantage and relations within school and university settings. When seen in these terms, there is much about the deployment of AI technology in education that merits further consideration.

In particular, the politics of AI and education tends to get overshadowed in most discussions. Yet, as argued throughout the latter sections of this chapter, educational AI is not a matter of developing neutral technologies that are capable of being used for either good or bad ends. To return to Langdon Winner's (1980) argument that every technology artefact 'has politics', it seems clear that all AI systems, processes and procedures are based on design-related decisions that have impacts that are determinative for society. This is not to 'blame' educational AI practitioners for any negative consequences of their work in designing and developing technologies. Yet it is important for the field to assume a greater degree of responsibility – especially with regard to how AI developers, designers and vendors choose to interact with the aspects of education that their tools and techniques interact with.

This is not to argue that the presence of AI in education needs to be rejected altogether. Yet it is important to recognise that the digital automation of education is not simply a technical matter of how to most effectively design, program and implement systems. Instead, we need to get to grips with questions relating to the nature of education as a profoundly social (and therefore human) process. These are questions about the sociology and psychology of education, about relationships and emotions, about education cultures and education politics. As Judy Wajcman (2017, p.126), contends, it is important that non-technologists get involved in shaping conversations around AI and automated systems, and take a leading role in 'crafting the future … gaze fixed on the horizon, alert to the winds of change'.

This chapter has touched upon some obvious ways in which AI technologies can play a valuable role in education – for example, eliminating the repetitive administration and bureaucracy that persists in many schools

and universities. There are many logistical and procedural tasks where 'keeping humans in the loop' might well slow things down. In these instances, as Luciano Floridi (2016, n.p.) puts it, 'We should make AI's stupidity work for human intelligence'. There might also be benefit in the field of educational AI striving to be more experimental and decidedly non-human in its ambitions – pursuing 'new creative possibilities, and new kinds of usefulness to our students' (Bayne et al. 2020, p.83). Indeed, the most fruitful instances of AI-based education might not lie in seeking to replicate biological and human ways of doing things. Instead, the greatest potential of AI might be realised in attempting to apply totally new sets of engineering principles to education. At the same time, it is important to take seriously the contention that there are a number of fundamental ways in which AI should be *not* be applied in education. As stated at the beginning of this chapter, even if AI-driven education is something that can be done, this might not always be something that we necessarily want.

Further Questions to Consider

- This chapter has covered a range of different forms and types of AI-driven technology currently being developed for use in education. Which of these technologies can you see being taken up in education? Why do you think that these particular technologies will find a place in schools, universities or other education settings? Conversely, which AI technologies are you more sceptical about? Why might these eventually prove to be less successful?
- It is often claimed that AI technology will act as a useful source of support and assistance for teachers. Teachers can be freed up from onerous tasks and concentrate on higher-level teaching work. To what extent do you think this will happen? Alternately, might AI technologies begin to marginalise teacher expertise and decision-making in some aspects of their work? Either way, how might the teacher's role change when working alongside AI technologies in the classroom?
- Who is ultimately responsible for the outcomes of having an AI-driven technology in a classroom? A range of people are implicated in the deployment of any technology. These include the

system designers, developers and programmers; the software vendors; the school authorities who purchased the software; the teacher overseeing its use and the students themselves. To what extent should any (or all) of these people share responsibility for what results from the use of AI technology in a classroom? To what extent can the technology itself be deemed responsible?

Further Reading

There are many insightful books from the 1970s that reflect on philosophical implications of AI and society. These often remain pertinent to current discussions of AI in the 2020s:

Dreyfus, H. (1972). *What computers can't do*. MIT Press.
Dreyfus, H. (1979). *What computers still can't do*. MIT Press.
Witzenbaum, J. (1975). *Computer power and human reason*. WH Freeman.

Frank Pasquale provides a thorough discussion of how teachers – alongside other professions in medicine, design and law – can take control of how AI and automated technologies are developed in ways that can enhance (rather than diminish) their work:

Pasquale, F. (2021). *New laws of robotics: defending human expertise in the age of AI*. Harvard University Press.

8

Education and Technology Looking to the Future

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Introduction

This book has tackled a number of key issues and debates that currently underpin the ever-changing topic of education and technology. Of course, the scope of our discussions has been limited to what can be fitted into a couple of hundred pages. As such, it has not been possible to provide a complete analysis of every aspect of education and technology. In focusing this book around eight substantive areas of debate, there are inevitable gaps and issues that merit further consideration elsewhere. For example, we have not addressed psychology-inflected issues such as 'screen-time'

or 'cyberbullying'. There is certainly more to be said on topics such as 'digital literacies' and 'digital citizenship'. We have not explored 'low-tech' educational innovation in low-income and middle-income regions that involves creative uses of radio, television and mobile phones. Indeed, there are many variations between national education systems in terms of technology implementation, as is also the case between different sectors of education. For example, the technological issues implicit in 'early childhood' education are vastly different from those in work-based training. Much more needs to be written about how education and technology come together with issues of gender, race, dis/ability and intersections therein. The book has also said little about the 'instructional design' of educational technologies. These are all discussions that are well worth seeking out elsewhere.

Some omissions in this book have been deliberate. We have tried to not spend too long discussing current 'hot topics' that may be of little relevance in years to come. Readers in the early 2020s might expect to see more discussion of 'flipped classrooms', 'Edu-Twitter', 'learning analytics' and so on. However, readers in the late 2020s might be struggling to remember what these concepts were. Similarly, there has been relatively little reference to debates that are primarily of academic concern. In sociological terms, for example, preoccupations of identity, power, materiality and so on have only been addressed on occasion. There has been relatively little attention given to the role of social and philosophical theories in explaining some of the fundamental issues covered in this book. All of these deficits can be addressed by engaging with the specialist academic literatures on technology, new media and society.

Such omissions notwithstanding, this book has still addressed many of the fundamental issues and tensions that lie at the heart of technology use in education. We have paid due attention to the recent histories as well as current realities of technology use in education. In particular we have taken account of the 'wider picture' beyond the immediate technical and practical concerns of how technologies are used. Based on these more 'holistic' understandings, it has been possible to make better sense of why technologies are used (and not used) in the ways that they are in education. More importantly, this approach also makes it possible to gain a better idea of how technologies might be used in the future.

The past seven chapters have covered a great deal of ground, and challenged some common assumptions that persist in discussions of education and technology. For example, from Chapter 1 onwards we have established that technological devices, tools and gadgets are perhaps the

least important aspects of education and technology to think about. While it is understandable that people who are interested in technology tend to pay close attention to educational technology 'artefacts' (i.e. hardware devices, software applications and services), it is equally important to try to make sense of what people do with technologies (i.e. the activities and practices). It is also important to engage with the wider contexts, social structures and relationships that envelop these activities and practices. To fully understand how digital technologies are used in education, we need to consider a multitude of factors – what we have referred to as 'the milieu' of education and technology.

Of course, any 'warts and all' approach to education and technology bumps up against many of the common-sense ways that people tend to think about technology. For instance, we have deliberately attempted to look beyond the widely presumed 'transformative' qualities of digital technologies, and the belief that anything 'digital' automatically provides more efficient, effective and/or elegant ways of doing things than was previously possible. We have also stressed the need to resist approaching education and technology solely in terms of learning. Hopefully, anyone having read this book will be well able to think about education and technology in ways that stretch beyond narrow concerns of 'technology' and 'learning' that tend to dominate how the topic is discussed.

Taking this broad approach is unlikely to result in straightforward conclusions and easy answers. That said, most of this book's chapters have identified a range of reasons why technology use does not inevitably result in a 'change for the better'. Moreover, we have seen how many of the changes associated with digital technologies are not essential properties of the technology per se. While these observations can be made of technology in any aspect of society, this seems to be an issue that is especially relevant to educational contexts. Many of the 'outcomes' and 'effects' of technologies in education are influenced heavily by local educational contexts that these technologies are used in. In this sense, any outcomes of technology use in education are certainly not consistent, and often result in unacknowledged consequences and subtle side effects.

Against this background, the past seven chapters have pointed to a few recurring sociotechnical 'tensions' that underpin the use of digital technologies in education. In brief, these tensions (and their corresponding challenges) include:

#1. **Tensions between personalisation and collectivity:** the use of digital technologies in education has become increasingly imbued with values

of personalisation and the 'hyper-individualisation' of engagement. How can we reimagine forms of technology engagement in education that are based around alternate values of collectivity, community and conviviality?

#2. Tensions between inclusivity and exclusivity: the use of digital technologies in education seem to persistently advantage those who are already relatively well resourced, well educated and otherwise advantaged. Technologies are also designed in ways that predominantly advantage those who are able-bodied and neurotypical. How can we reimagine forms of technology use in education that are explicitly designed to address issues of equity, diversity and overcoming disadvantage?

#3. Tensions between autonomy and automation: emerging forms of digital technology in education are based increasingly around the standardised automation of key teaching and learning processes. How can we imagine forms of educational technology that do not limit the agency and autonomy of teachers and students?

#4. Tensions between the commercial and the commons: the use of digital technologies in education is increasingly led by commercial interests, values and agendas of private sector corporations. How can these be reconciled with the design, development and production of educational technologies that are based around values of the public good?

These issues, tensions and arguments relating to the current state of education and technology provide a good basis from which to now turn our attention to questions about the future. Despite the present 'messy realities' of education and technology, many educators and technologists remain optimistic – expecting that the next ten years or so will finally see widespread technology-led changes in education. In this respect, it is sensible to remain open to the possibility that future forms of education and technology might be notably different to now. So, before reaching any final conclusions it is worth considering a few future issues and debates. Could it be that there will be something intrinsically different about emerging digital technologies and the conditions that will surround their use? Alternatively, are we about to see radical shifts in the world that might recast our current concerns with education and technology in completely new light? If so, what future forms of education and technology might we anticipate? Now that we have considered all that has come before, what might be coming next?

Looking towards the Future of Education and Technology

This concluding chapter is an apt place to give some thought to how these concerns might play out over the next decade or so. How will questions of learning, teaching, institutionalism and automation develop over the next few years? What new issues might arise? For example, are we justified in presuming the continued centrality of human cognition in the ways that knowledge is produced? What are the implications of digital technologies gaining increased social agency? Questions such as these push us to engage with the future in imaginative and open-minded ways. As John Urry (2016, p.187) puts it, 'In order to operate in the world … we must peer into the future – there is no choice.'

At first glance, it might seem that extrapolating the technological future is relatively straightforward. After all, we have a fairly good sense of what areas of current 'emerging' technology development are likely to thrive over the next few decades. For example, it seems reasonable to expect that the years up to 2050 will see continued innovation in areas such as AI, automated decision-making, big data analytics, platformed personalisation, smart sensors and the 'Internet of Things'. The next thirty years will likely see significant advances in areas such as 'biotechnology' and 'nanotechnology'. It might also be the case that continued work in neuroscience and pharmaceutical technology leads to significant development of 'smart drugs' and other cognitive enhancements.

Yet even if these areas of technology development continue as broadly expected, this tells us little about what impacts such technologies might have in education. As has been highlighted throughout this book, educational technology needs to be understood in sociotechnical terms. This reminds us to not think about the future of educational technology simply in terms of technology. Instead, future uses of digital technologies in education need to be seen as entwined with the social, economic, political, cultural and historical conditions that they will be developed, produced and used within. This is where discussions of the future of education and technology perhaps become even more complicated than discussions of the present or the past.

As such, it makes sense to be wary of anyone who is too confident in their claims about the future of education and technology. The most bold and assured visions of technology-driven education tend to be made by people

with something to sell. The CEO of an online education company is understandably eager to predict that only ten higher educational institutions will remain in the United States by the 2060s (Anders 2013). A real-estate developer planning a futuristic city state in the Saudi desert has a vested interest in pushing visions of schools staffed by holographic teachers (Scheck et al., 2019). As Audrey Watters (2019) observes, we need to stay alert to the promises and predictions of people looking to profit from the sale of technology in education. A lot of different interest groups have much to gain from peddling what Watters derides as 'a steady stream of EdTech propaganda'.

Different Perspectives on 'knowing' the Future of Education and Technology

Looking beyond such huckerism, there are plenty of other educational commentators who are producing more considered accounts of future forms of education and technology. In this sense, a number of different traditions have emerged that offer interesting ways of imagining the future of technology-focused education.

Predictions and Forecasting

Education and technology has long been a focus for people wanting to make predictions and forecasts. While the 1970s and 1980s saw a succession of predictions around the theme of schools and classrooms 'in the year 2000', more recent efforts have tended to focus on forecasting the 'near future' of five years or so. During the 2000s and 2010s, one influential source of such predictions was the annually compiled 'Horizons' report. Starting in 2004, these reports have asked various panels of experts to identify technologies that are likely to be integrated into education settings in the short term, medium term and long term (the reports define 'long term' as a time frame of 'five years or more').

Looking back over the past twenty years of Horizon reporting reveals much about the difficulties of predicting how education and technology progress. For example, the 2004 report anticipated the educational potential

of 'knowledge webs' and 'context aware computing'. While the former prediction has certainly come to pass in various forms of networked and social education described throughout this book, the latter technology has yet to be implemented in any significant way. During the mid-2010s, Horizon reports focused on developments in areas such as 'adaptive learning technologies' and the 'Internet of Things'. This former technology is now used widely in some areas of education, while the latter remains largely conceptual. More recently, the 2020 Horizon report highlighted the emergence of 'AI/machine learning education applications', 'analytics for student success' and 'XR' (cross-reality) technologies', alongside repeated support for 'adaptive learning technologies'.

As well as identifying likely technologies, the Horizon reports have also attempted to second-guess what new practices might be associated with these new technologies. These predictions are usually more tentative in nature. For example, during the 2010s, the Horizon reports shifted from predicting the 'end' of schools and universities, and instead began to talk of 'rethinking how institutions work' (Educause 2019). This involved suggestions that schools and universities might develop 'agile' and 'entrepreneurial' characteristics (NMC 2015), amid 'advancing cultures of innovation' (Educause 2019). The most recent reports have been more tentative, talking of 'gradual evolution rather than a disruption of current practices'.

As these examples illustrate, such forecasting is best taken with a degree of scepticism. While still considered by many educationalists as a credible source of ideas, the Horizon reports have only ever shown a limited ability to rise above the hyperbole of emerging technologies and trends, with many of their forecasted shifts failing to impact significantly on actual classrooms. As the publishers of the most recent Horizon reports concede, these predictions have only ever had a modest level of success:

> The Horizon Report has provided ample documentation of predictions, from educational technology experts, of the future impact of technology on teaching, learning, and creative inquiry. Unfortunately, its track record has been described as fair to middling. (Educause 2020a, p.13).

Foresight and Scenarios

While many people still see value in exercises such as the Horizon forecasts, the past few years have seen various other ways of engaging with futures thinking around education and technology. Indeed, even the successful

Horizon predictions of the 2000s and 2010s tended to tell us little about the contexts, arrangements and cultures of education – that is, what 'education' is likely to look like in light of these altered technological conditions. As such, in the early 2020s the Horizon reports dropped their framework of predicting technology impact within one, three and five years. Instead, the Horizon expert panels began to construct 'scenarios' to explore various ways that new technologies might impact on education systems (detailing diverse scenarios of 'growth' and 'transformation', through to scenarios of 'constraint' and 'collapse').

This shift from prediction to speculation reflects a growing trend for people to think about 'futures' in a plural sense. This emphasis on 'futures' acknowledges that there is unlikely to be just one linear future that can be predicted and forecasted. Instead, foresight approaches attempt to imagine how we might prepare for possible different futures which may (or may not) occur. The emphasis here is on preparedness rather than prediction. As John Urry (2016, p.1) put it, 'Futures are unpredictable, uncertain and often unknowable.' The foresight approach therefore remains open to imagining different variations and directions that may well unfold in different ways over the next few years.

The emphasis on thinking about possible futures also reflects an interest in speculating on what might be ahead of us in technologically plausible (rather than fantastical) terms. These are not usually exercises in speculating wildly about holographic teachers or colonising the moon. This idea of plausible futures encourages speculation that is grounded in present technological conditions. It also encourages us to take account of educational technologies being embedded within social institutions, practices, processes and other contextual factors.

Various foresight approaches can help develop understandings of possible futures of education and technology. For example, it can be revealing to undertake historical analysis of past visions of futures – such as the spate of 'classroom of 2000' visions produced since the 1960s (e.g. Stonier and Conlin 1985, Young et al. 1988). Another interesting approach is what Ruth Levitas (2013) describes as 'open' utopianism – involving imaginative exploration of future emancipatory possibilities. All these approaches can be brought to life through methods such as 'strategic foresight methods' that extrapolate various current trends, and 'horizon-scanning' that attempts to detect early signs of potentially important developments. By contrast, 'backcasting' involves starting with defining a desirable future in detail, and then working backwards to identify how we might have arrived at that point.

Another common foresight activity is the construction of scenarios. The aim here is to construct vignettes of different ways that education might develop, and then identify key factors that would be capable of driving change in this particular direction. In a meta-analysis of fifty foresight studies from across the 2000s and 2010s, Dhoya Snijders and colleagues (2018) identified four common scenarios that detail possible future forms of education and technology:

- **Scenario 1 – 'De-schooling'**: Plentiful access to technology allows people to engage in self-directed personalised learning provided by a diversity of sources. Traditional forms of schools, teachers and classes of students are replaced by temporary online networks of learners, diverse types of education professionals, and a dynamic marketplace for short courses and educational experiences.
- **Scenario 2 – 'ICT education for everyone'**: The widespread availability of powerful technology, high-speed connectivity and standardised software platforms means that people can access high-quality education regardless of their circumstances. Schools and universities provide devices to all students. A few multinational companies cooperate with public education systems to provide standardised educational software and serious games for all.
- **Scenario 3 – 'Everyone for themselves'**: Digital technology supports highly personalised engagements with informal education. Individuals learn what they like, when and where they choose. Face-to-face classrooms are rare, and variations in the quality of people's access to technology means that there are inevitable gaps between rich and poor.
- **Scenario 4 – 'Learning to live together'**: Public education systems are well funded and well resourced in order to fulfil a publicly recognised role as the principal provider of education for all. Schools are central hubs of every local community, and teachers facilitate learning communities with a strong emphasis on social and cultural skills. There is a distrust of the IT industry, and excessive use of technology in education is discouraged.

While concerned broadly with the same types of technologies, these different scenarios highlight the contested nature of what might be considered as plausible education futures. Clearly, each of these scenarios fits with different forms of society, shared values and political philosophies – for example, a preference for social democracy as opposed to libertarianism. These scenarios also presume different relationships between government and

commercial actors, and different cultural understandings about community, family, schools and other institutions. As such, these contrasting scenarios raise the broader point that envisioning future forms of education and technology is also an exercise in envisioning preferred forms of society.

Speculative Fictions

Scenario-planning and other foresight methods offer neat ways of thinking about the organisational and societal contexts that future forms of educational technology might be embedded within. However, they tend to describe events at a broad level – for example, across a whole education system or even a whole society. As such, scenario-planning tends to tell us little about individual experiences of using these technologies – for example, how it feels to be a student or an educator experiencing these future forms of education. Recasting such scenarios through personal narratives can draw out different perspectives on educational technology futures. This is reflected in the recent rise in speculative fiction as a method of addressing the future of education and technology. As Mark Graham describes,

> Speculative fiction … is a powerful and engaging medium because it uses extrapolation and speculation to explore possible worlds and to encourage readers to reflect on how these worlds came into being, how they operate, and how they are different from our present world. As such, they use the tactics of estrangement (pushing a reader outside of what they comfortably know) and defamilarisation (making the familiar strange) as a way of creating a distancing mirror on society and to offer cognitive spaces to reconsider assumptions, rationales and viewpoints. (Graham et al. 2019, s10–s11)

A good example of this genre is Graham and colleagues' (2019) edited collection of sixty-four stories describing cities in the near future. Each city is imagined as organised, and runs along the lines of various current 'big tech' companies, with a few stories detailing how the logics of 'platformatised' education might play out. For example, one story describes education as reframed through the logics of the 'Acxiom' database marketing company. This includes the mandated use of fitness trackers by teachers as part of their contracts. These trackers are justified as a key component of Acxiom's ability to run predictive analytics to monitor teaching effectiveness, and therefore calculate teachers' performance-related salaries in a fair manner. As the tagline to this story puts it, 'people are entitled to what the data say they deserve.' Other stories describe how the logics of Sony's PlayStation gaming

console might result in the gamified school, with students being awarded points for good behaviours such as recycling and politeness. Alternatively, a Tinder-governed city would include an education system where parents can 'swipe left' or 'swipe right' to choose who they would like to next teach their children.

Perhaps the most chilling story in this collection describes a speculative future for data-dependent education running along the lines of Cambridge Analytica's business model of profiting from people's capacity to produce personal data. For example, in a society based on gauging everyone's affect and emotions, classroom decisions are increasingly reliant on biometric monitoring. Students with appropriate expressive and neurotypical characteristics fit well into these conditions. By contrast, students lacking in 'readable' socioemotional skills remain 'unseen' and are reassigned to study in online schools. This is a society also riven by fears of breaching the information privacy of minors. As such, all students have their internet access limited to schoolwork only, and require 'homework' codes for any educational use outside of school. Stories such as these certainly contrast with the optimistic and empowering stories that are usually told about education and technology. Yet why should we consider these dystopian accounts any less plausible, or less likely to come to fruition?

Approaching the Future of Education and Technology as Unknowable

While no forecast, scenario or story can ever claim to be 'correct' or 'right', engaging in these different forms of futures thinking is a useful way of sharpening our thoughts and actions regarding current forms of education and technology. That said, it could be argued that these established ways of engaging with futures all suffer from a major blind spot. In short, nearly all these discussions of possible futures of education and technology stick to expected parameters of the continuation of current conditions. Regardless of their thrust, all these scenarios and stories tend to presume that fundamental elements of current society, economy and politics will continue. In short, it is presumed that some form of the status quo will ensure, even if we cannot be sure exactly in what form.

Approaching the future of education and technology through this lens of what seems 'probable', 'likely' or 'familiar' might seem sensible in comparison

to wildly predicting holographic teachers and schools-on-the-moon. Yet, it could be argued that this remains a limited starting point – foreclosing alternative ways of doing things that could prove necessary in light of unforeseeable circumstances, crises and catastrophe.

Such shortfalls certainly came to the fore at the start of the 2020s and the global Covid-19 pandemic. In the previous thirty years or so of horizon-scanning and future-scoping about education and technology, few people foresaw a global pandemic shutting down nearly every country around the world, and sending 85 per cent of the world's students into emergency remote schooling. In a practical sense, the impact of the pandemic will continue to resonate across education systems throughout the 2020s and beyond. Yet, it also exposes the limitations of how the future of education and technology tends to be talked about. Take these reflections from an author of a set of educational technology scenarios published a few weeks before the pandemic came to the world's attention:

> We wrote a paper imagining three futures of EdTech, and in none of these scenarios did we imagine some sort of crisis. I look back now and think, how did we not think about some sort of rupture? Instead, we had three possible futures that flowed in different directions from what we have today. … So COVID showed us that crises are what make change. Maybe the pandemic was just one crisis. So, we can imagine a future where further crises are coming – ecological crises, other crises – and each crises is going to have its own unexpected leap. (Macgilchrist 2020)

The Covid pandemic certainly proved a stark reminder that we live in uncertain and vulnerable times. It also demonstrated how the fortunes of different countries and regions around the world are inexorably interconnected and dependent with each other. At the same time, Covid was also a reminder that exceptional shifts in the status quo can take place. As Steve Matthewman (2020) reflected a few months into the pandemic, this was a global event when 'the unthinkable happened'. Governments temporarily suspended entire economies and education systems, international travel was halted, unemployed workers were paid basic state incomes and homeless populations housed in hotels. As Matthewman (2020, n.p.) reasoned,

> Disasters are social laboratories. They give us the opportunity to think the world anew. The Coronavirus pandemic t[old] us that the impossible happens, and that other ways of living are within our grasp.

Bringing these sentiments to bear on the topic of education and technology, Covid soon prompted people to argue that it made little sense to envisage

possible futures that simply involved a return to a 'new normal' that was only a slight variation on the pre-pandemic status quo. Instead, Covid was taken as a prompt to think more radically about education futures along lines of further possible crises – incorporating what is unforeseeable alongside what is foreseeable.

This spirit of hopeful (re)imagining in the face of unknown crises is reflected in the growing interest in 'anticipatory' approaches in imagining education futures (see Amsler and Facer 2017). This contends that viewing the future through the lens of what seems 'probable', 'likely' and 'predictable' is an inherently repressive starting point – foreclosing alternative ways of acting and divergent forms of knowledge. Instead, the prospect of 'unknowable' futures requires us to imagine how we would like to be living – particularly from the perspectives of marginalised interests and non-powerful groups. The anticipatory approach raises a host of challenging questions that might be asked of educational technology in the 2020s. For example, how might alternate approaches to education and technology be established that do not presume the continuation of dominant 'big tech' industry, global capitalist modes of production, the 'global middle class' or other ways in which society tends to be imagined by policymakers, corporate reformers and other powerful interests? The focus here is on using these radically different imagined futures to inform 'anticipatory behaviours' – that is, changes in present approaches to education and technology that are rooted in our imagined and desired futures (Poli 2017).

Anticipating Forms of Education and Technology Fit for an Age of Climate Crisis

So, how might we anticipate desirable forms of education and technology in light of the risks associated with future unknown planetary crises and catastrophes? There are various interconnected risks that we might usefully start from. For example, we might anticipate disruption caused by future pandemics, increased militarisation or geopolitical destabilisation due to the rise of popularist authoritarian governments. However, one prevailing uncertainty of our current times is the multiple, interconnected crises associated with ongoing environmental instabilities. This encompasses a

range of issues: from the depletion of non-renewable natural resources through to the deleterious human and ecological consequences of anthropogenic climate change. It is clear that these issues represent one of the most urgent areas of uncertainty over the next few decades. As such, it seems sensible that these prevailing risks are anticipated in any talk of the 'futures' of education and technology.

Education and technology is rarely discussed in relation to environmental risks, ecological instability and eco-justice. When environmental connotations are considered, this is usually framed in terms of possible environmental benefits of expanded digital technology use in schools, universities and other education settings. For example, commentators will occasionally speculate on how environmental benefits already accrue from reduced paper use, videoconferencing and installing 'green tech' such as smart lighting and smart metering across 'carbon neutral' campuses. It is also reasoned that online teaching reduces the carbon footprint of schools and colleges, not least by reducing on-campus power consumption (Caird et al. 2015) and lowering emissions of students who would otherwise be travelling to classes (Versteijlen et al. 2017).

Indeed, most forms of emerging technology in education attract sporadic claims of environmental benefit. At the beginning of the 2010s, 'massive open online courses' were praised for 'reconceptualising' higher education along the lines of reduced carbon emissions and low environmental impact (Lane et al. 2014). As the 2010s progressed, various other educational technologies attracted similar praise – from the sustainable qualities of augmented reality (Alahmari et al. 2019), through to the role of blended learning in 'protect[ing] global environmental resources' (Caird and Roy 2019, p.107). If educational technology is considered at all in terms of its environmental impact, this has tended to be in wholly positive terms.

This confidence spills over into imagined future forms of technology use in education. As mentioned earlier, the 2020 edition of the 'Horizon' report developed a 'Collapse' scenario shaped by 'climate-related catastrophes' and associated 'political destabilisation'. Here, higher education systems of the late 2020s were imagined to have been 'dramatically transformed' by 'two primary forces: the dangers posed by climate change and the advances in digital technology' (Educause 2020, n.p.). In this scenario, digitally driven universities were imagined as vital tools in helping societies 'address the climate-related challenges'. It was imagined that global networks of universities had been formed to 'focus on online learning as a sustainable educational model'. Online courses allowed

students to have 'time-delimited enrolments' and monthly subscriptions to access learning and micro-credentials when needed. While the authors of this scenario acknowledged that 'extreme global weather events and droughts would impact negatively on students' well-being', technology was again expected to offer a range of solutions. For example, the report imagined students having personal 'AI companions' capable of significantly decreasing 'rates of depression and other markers of mental distress' associated with climate-related anxiety.

Despite anticipating political destabilisation and climate catastrophes, this 'Collapse' scenario was notable in presuming the continuation of the status quo – not least the construction of institutionalised and credentialed education, and the ongoing expansion of digital infrastructures. Digital technologies were framed as a solution to problems arising from climate catastrophes – the need for more flexible scheduling, constrained geographic mobility and impacts on mental health. Of course, we have learnt throughout this book to question claims of technology being a quick 'fix' or ready solution. So, in what ways might this framing of 'green tech' in education miss some fundamental issues and possible problems?

First, this idea of technology as a means of addressing climate change presumes the continuation of an 'abundant' mode of digital technology that might well not be environmentally viable in years to come. Instead, we also need to consider the possibility that the ways in which digital technologies are currently being produced, consumed and discarded might soon prove unsustainable. Key concerns here include the energy demands and natural resource depletion involved in the production of digital hardware, alongside the energy demands of 'cloud' data storage and processing, the damaging effects of 'e-waste' and digital disposal. Of course, the conundrum of what to do after the world passes the point of 'peak IT' is not unique to education (Lambert et al. 2015). Nevertheless, educational technologists might soon be facing the stark fact that 'the finite-ness of our planet sets hard non-negotiable limits' (Mann et al. 2018).

Second, these digitally centred scenarios assume that climate change will take the form of ultimately solvable problems that can be overcome through different and more innovative uses of technology. By contrast, John Michael Greer (2008) reasons that environmental degradation is not a problem that can ever be solved, but instead is a predicament that needs to be lived with as best we can. Rather than waiting for 'technical fixes' to somehow overcome these issues, it falls to everyone involved in education to adjust their technology-related approaches and ambitions. In crude terms, we might

have little option but develop future forms of education in ways that are not dependent on continuous and plentiful technology use.

This suggests imagining a range of alternate approaches to climate change inflected futures of education. For example, if we persist with the idea that digital technologies should be a central element of education, then one radical alternative might be rediscovering modes of technology use that are fit for a resource-constrained world – as Pargman and Wallsten (2017) put it, forms of educational technology that are capable of 'coping with finiteness'. This involves rethinking any assumptions we might have that digital technologies are essentially limitless, infinite and replicable. What if we cannot expect to personally own and frequently upgrade multiple devices? What if we cannot presume instantaneous and continuous access, unlimited and eternal storage, high-bandwidth connections and high-definition content that is stored in multiple versions and shared repeatedly across many different platforms?

Instead, what would it mean to reorient the use of digital technology in education around a limited mode of use that acknowledges its impending environmental constraints? This might involve moving away from privileging the individual user, and instead re-establishing technology use in education as a collective, shared and communal practice. Reimagined along these constrained lines, it seems sensible that any digital resources being used in education are repairable, refurbishable and durable. In addition, the use of digital technology in education might be rationed to what is really necessary and/or of genuine 'added value'. In short, we might want to establish a prevailing culture of sustainable, appropriately limited technology use in education.

Alternately, we might choose to develop forms of educational engagement and provision that explicitly resist the ways in which digital technologies currently contribute to 'amped-up' cultures of learning (Greenwood and Hougham 2015, p.98). This might involve moving away from 'hyper-intense' modes of digital learning, and instead rediscovering modes of 'simple learning' (Håkansson and Sengers 2014), or what Payne and Wattchow (2009) describe as 'slow pedagogy'. All of these alternate approaches would demand different intensities of technology use. For example, we might want to establish autonomous learning collectives that are located in ideals of the commons – 'autonomous, anti-colonial projects and institutions of learning located outside state and market educational systems, which are grounded precisely in a critique of the anticipatory underpinnings of modern 'education' itself' (Amsler and Facer 2017, p.11). These examples illustrate

alternate forms of educational technology that might be extrapolated from anticipating our climate futures in more radically catastrophic ways. This is not an exercise in doom-mongering. Instead, all of these possibilities are intended to prompt hopeful thinking and positive change. Indeed, the anticipatory futures approach is intended as a stimulus to start working in these alternate ways from now onwards.

Lessons Learnt about Education and Technology

How we choose to make sense of the futures of education and technology depends upon how unknowable we concede these futures to be. Clearly, in this current era of global instability, pandemics and climate change, it seems sensible to concede that the future is never wholly predicable and not set simply to unfold in broadly similar ways to what has come before. Clearly, the future should not be seen as a straightforward extrapolation of present predicaments. Instead, we should remain open to the idea that education and technology might unfold in ways that are essentially uncertain, multifactorial and non-linear in nature. The futures of education and technology are embedded within various complex predicaments and challenges – a fact that should prompt us to think about 'futures [as] made up of unstable, complex and interdependent adaptive systems' (Urry 2016, p.188).

Of course, the main goal of addressing these possible futures of education and technology is to make better sense of how we might want to act in the present. As Keri Facer (2020) puts it, ideas of the future are primarily ideas to be used in the present – as prompts to see new possibilities, ask different questions and establish new practices. As Richard Barbrook (2007, p.8) concludes, 'the future illuminates the potential of the present'. Thinking about future forms of education and technology should also prompt us to move on from old ideas and assumptions. In the words of John Marnard Keynes (1936), 'the difficulty lies, not in the new ideas, but in escaping from the old ones.' As such, we need to 'think about how different ideas of the future create new possibilities and resources to stimulate, challenge and inform what we are doing in the present' (Facer 2020, n.p.).

One important lesson that can therefore be taken from this chapter is the largely unknowable nature of most aspects of education and technology – past, present or future. This 'unknowable-ness' of education and technology

has been an important theme throughout this book. While the certainty, precision and control associated with the use of digital technologies in education can be understandably reassuring, the fact remains that any 'outcomes' that arise from technology will always vary wildly. Moreover, any intended outcomes will always have a variety of associated unacknowledged, unexpected and unintended consequences. These 'unknown' aspects remind us that we cannot simply see technology use in education as somehow disconnected from broader societal contexts. This also reminds us that we need to look beyond 'cause-and-effect' conceptions of technology and education change, as well as moving beyond presumptions that digital technologies will inevitably lead to 'new' forms of teaching and learning.

From the opening chapter onwards, this book has considered how digital technologies are often instinctively associated with expectations of significant improvement of existing educational processes, or perhaps even the transformation of education into new forms. Yet, we have also seen how digital technologies are often linked to the continuation and perpetuation of existing and deeply entrenched patterns. In fact, it might be concluded that educational technology is usually a prompt for 'more of the same' rather than a force for radical change and improvement. Despite the excitement and hyperbole that surrounds it, there is often little that is truly 'new' about new technology. Even the unprecedented disruption of the Covid pandemic school and university shutdowns at the start of the 2020s saw the rapid reappropriation of digital technologies to replicate face-to-face classes, lectures and examinations. Looking back to the challenges posed by Neil Postman in Chapter 2, one of the key questions that needs to be continuously asked of education and technology is the simple question of 'what is new here?'. In other words, what is technology making possible that was not possible before?

This reappraisal of what we might consider as constituting 'new' chimes with another theme that has recurred throughout this book – that is, the highly symbolic and often ideologically driven claims that are made about educational technologies. Across these eight chapters, we have seen how discussions about education and technology are never completely neutral and disinterested. When thinking about education and technology, we cannot overlook the fact that many of the enthusiasms and concerns expressed for digital technology in education are driven by people's wider beliefs, values and agendas. Indeed, most chapters in this book have noted that 'educational technology' often acts as a site for wider debates, contests and struggles over education. Discussions about education and technology are never solely about technology. Moreover, discussions about education

and technology are never wholly objective and clear-cut. It certainly seems reasonable to conclude that many of the claims made around digital technology use in education are more a matter of faith than a matter of fact.

Given this, when talking about education and technology, it is important to have a clear sense of our own ideologies, values and agendas. It is also important to remain mindful that other people can perceive the same technologies and technology-based practices from very different perspectives and ideological positions. For example, it is easy for learning-focused educators to presume that everyone shares their framing of technology in terms of improving 'learning outcomes' and supporting learner decision-making. Yet, as we have seen throughout this book, a range of other interests are also promoting alternate versions of educational technology for very different reasons – from Thomas Edison through to Tucker Carlston. In particular, the past twenty years has seen technology use increasingly associated with efforts to promote a 'corporate reform' of education systems, and driven by ambitions to improve institutional efficiencies and bring market forces to bear on how education is organised. Elsewhere, other promotions of technology use have strong social justice components, driven by concerns over inclusivity, democracy, participation and care. Conversely, we should not ignore connections between the rise of AI and analytic-driven systems in education and far-right 'neo-reactionist' ideologies in Silicon Valley that stand in opposition to progressive and democratic values (Means and Slater 2019).

While people might ostensibly be talking about the same technologies, their underpinning values and politics can be very different, if not wholly at odds with each other. As such, we need to ground our engagements with education and technology in terms of our own values. As Tressie McMillan Cottom (2019, p.29) puts it, 'We must be sure that we do not confuse the technology tools themselves with the purpose of our work. EdTech is not a set of tools; rather, it is a set of practices that further a greater good.' In this sense, the normative challenge that faces each reader of this book is straightforward. What do *you* consider to constitute 'a greater good'? In your opinion, what should educational technology look like so that it might be able to stimulate this 'good' for all?

Conclusions

As the 2020s progress, there is greater need than ever to develop and promote sophisticated discussions of education and technology. It would be foolhardy

to deny the educational potentials of digital technologies altogether – digital technology is obviously having a major influence across a range of educational contexts. Yet, any changes or improvements are never consistent or straightforward, and rarely result in the wholesale 'transformations' that many people would like to believe. In this sense we need to develop and promote better understandings of the realities of education and technology. Why is it that digital technology has not yet made a radical difference to the quality and reach of education in the ways that we are sometimes told that it will? What is it that digital technology cannot do in education? What are the full wider consequences of refashioning education in technology's image? Given the challenges that might lie ahead in terms of environmental instability and other crises, do we need to quickly reassess our future expectations of 'digital education' altogether?

In order to address such issues, there is a clear need to develop more realistic understandings of education and technology. This involves paying close attention to the social, cultural, political, economic and historical aspects of education and technology. Of course, we should not lose sight of the fact that current digital technologies have obvious educational potentials and 'advantages'. Undoubtedly, the next wave of emerging digital technologies will also provide compelling reasons to get excited about their educational application. Yet any reckoning of these technologies must take into account the long history of incremental and often unpredictable changes in education that tend to result from technology implementation and use. At the same time, more efforts should also be made to scrutinise what actually takes place when these digital technologies meet educational settings, and how the outcomes relate to what has taken place in the past. This points to three basic areas of questioning:

- What is the use of this technology in educational settings actually like?
- Why is this use of technology in educational settings the way it is?
- What are the consequences of this use of technology in educational settings?

As these deceptively simple questions suggest, education and technology is perhaps best approached as a site of ongoing negotiation, struggle and conflict. Tackling these questions requires a deliberate focus on what has been described throughout this book as the 'messy realities' of education technology use. This requires exploring instances where digital technologies are not being used, or where digital technologies are being used in ways that suppress and disadvantage. This requires asking questions about emotional and affective aspects of education and technology – what Schirmer and Apple

(2014) describe as matters of 'love, care and solidarity' that define education as more than just a process of knowledge transfer. In all these ways and more, we need to pose questions that are perhaps more ambiguous and awkward than are usually found in discussions of educational technology. This involves developing lines of enquiry that are perhaps less focused on issues of innovation of potential improvement, but certainly no less far-reaching.

All these questions imply the establishment of critical outlooks on education and technology. Of course, being critical of technology is not a natural position for many people to adopt – especially in the face of presumed digital 'progress' and 'innovation'. As Max Read (2020, n.p.) observes,

> Among the unspoken foundational tenets of Silicon Valley is the idea that technological change is not just good, but inevitable, and that anything done to hinder (or even control) development of certain kinds of technology is somewhere between backwards and morally wrong.

Hopefully our discussions throughout this book demonstrate that being critical of technology is not the same as being 'anti-technology'. One cannot be 'anti-technology' any more than one can be 'anti-food', or opposed to any other essential element of modern society. Approaching education and technology in a spirit of critique does not involve stubbornly denying the benefits of digital technology, or engaging in relentless criticism with no sense of hope. Neither does being critical involve giving up altogether on the potential of digital technology to support better forms of education.

Instead, being critical of education and technology involves being prepared to push back against current ways of doing things and offering alternatives. As Sara Watson (2016, n.p.) suggests, we should strive towards 'constructive technology criticism' that seeks to 'assemble new insights and interpretations' and thereby point to alternate possibilities. This involves being realistic, objective, and sceptical (rather than cynical). This involves continuing to ask awkward questions along the lines of Neil Postman's seven critical challenges listed in Chapter 2. Our key concerns about education and technology are not the usual ones of 'What works?', but concerns of 'What is education for?' and 'What should education be like?'.

Above all, serious and sustained critical debate about education and technology needs to provoke action and change. The lack of easy solutions or clear-cut answers is no reason to give up on the possibility of improving education and technology. Just as there is little sense in being excessively optimistic about technology, neither is there sense in being completely defeatist. As has been reiterated throughout this book, technology does not

have a predestined impact on education. It is crucial to remember that we are all as much capable of shaping the technologies we use as these technologies are capable of shaping us. In this spirit, continuing to engage with the ideas and debates raised in this book will provide a powerful foundation for better things to come. Whatever problems and challenges might lie ahead, we need to continue making sense of education and technology in hopeful and constructive ways.

Further Questions to Consider

- This chapter has stressed the importance of reflecting on our own personal values, and how these shape our thinking around education and technology. Think about what you consider to be 'good' or 'best' uses of technology in education. How do these ideas reflect broader values and orientations that you hold? What forms of technology use in education might be preferred by someone with opposing values and perspectives?
- Dhoya Snijders and colleagues (2018) identify four scenarios that commonly arise when people think about the possible futures of technology and education. (i) 'De-schooling', (ii) 'ICT education for everyone', (iii) 'Everyone for themselves' and (iv) 'Learning to live together'. Which of these scenarios do you see as more plausible, or perhaps more preferable? What would have to happen for this possible future to come to fruition?
- What future(s) do you envisage for education and technology given the challenges that might lie ahead in terms of environmental instability and climate change? To what extent might 'green' forms of technology use in education play a positive role in mitigating these environmental challenges? To what extent does education (along with the rest of society) need to radically change its consumption of digital technologies?

Further Reading

The book remains an interesting and provocative overview of the role of 'futures thinking' in understanding educational change:

Facer, K. (2011). *Learning futures: education, technology and social change*. Routledge.

Finally, here are three books that continue many of the discussions pursued throughout the eight chapters of this book. Each of these books focuses on key ideas and debates about technology at different levels of education provision:

Christodoulou, D. (2020) *Teachers vs tech?: The case for an EdTech revolution*. Oxford University Press.

Selwyn, N., Nemorin, S., Bulfin, S. and Johnson, N. (2018). *Everyday schooling in the digital age: high school, high tech?* Routledge .

Nichols, M. (2020). *Transforming universities with digital distance education: the future of formal learning*. Routledge.

Glossary

Artificial Intelligence (AI) In simple terms, 'artificial intelligence' refers to computer systems that take data relating to their surroundings and past experiences, in order to make decisions and predictions that would usually require human intelligence. These decisions and predictions allow tasks to be performed without explicit human instructions. In this sense, AI systems are developed to simulate specific forms of human logic and sense-making. This is achieved through the capacity of current AI technologies to process huge amounts of data relating to specific tasks that the human mind is simply not capable of processing in a similar time. As such, AI technologies are sometimes also described as 'algorithmic data processing' and 'automated decision-making'. Such terms draw attention to AI as a computerised process of making bounded decisions by automated means based on large-scale data analysis

Behaviourist theory Behaviourist theories (such as those advanced by B. F. Skinner) describe how people's behaviour is 'conditioned' by reactions and responses to various stimuli in their environment. Behaviourist approaches often focus on modifying how an individual responds (i.e. behaves) when faced with a stimulus. It is reasoned that the consequences of responding to a stimulus are likely to influence how an individual subsequently responds when next faced with the same stimulus. If the consequence of the initial behaviour is reinforced by a reward, then it is likely to be repeated (i.e. reinforced). If the consequence of this behaviour is suppressed through a punishment, then it is likely to be curtailed (i.e. modified). Despite being developed in the early twentieth century, behaviourist principles (e.g. programmed instruction, frequent testing and immediate feedback) continue to influence many aspects of contemporary education.

Blended learning Any situation where formal, face-to-face education provision is combined with an element of technology-mediated learning. In a blended learning situation, digital technology is used to provide students with self-directed and/or a-synchronous learning experiences. The 'blend' between face-to-face and technology-mediated education will vary according to the type of learning and level of the students. This is sometimes referred to as 'hybrid', 'flexible' or 'hyflex' learning.

Bring Your Own Device (BYOD) The idea that all students in a class can make free use of the personal digital devices rather than these devices being restricted or banned altogether. The pluralised version 'Bring Your Own Devices' acknowledges the increased use of 'second screens' (e.g. using a smartphone at the same time as a laptop), while 'Bring Your Own Technology' extends the concept to personal internet connections, applications and other aspects of digital technology beyond the actual devices. All of these conditions extend the original '1-to-1' concept where every student has a device to use for themselves.

Code/Space The idea that physical places such as a 'school' or a 'university' is now an assortment of material spaces that is entwined with (and increasingly defined by) digital code. As such, a 'school' is defined by its software systems, code and data, in a similar way that it is defined by its physical buildings and spaces. This raises the idea that digital systems are no longer simply layered 'on top' of schools. Instead, computation is interwoven around the built environment and everyday experiences of many schools to the extent that computation is a crucial component of what the school is. As such, student in her bedroom with a laptop using the school network can still be considered to be 'at school'. Conversely, if a school's network, Wi-Fi and LMS is taken away, then it would soon be difficult for that school to remain functioning.

Cognitivist theory Theories of learning that have emerged from the field of cognitive science, seeking to describe learning in terms of the thought processes that lie behind any observable behaviour. Cognitivist theories tend to describe learning as an internal process of mental action. Learning is seen primarily as a matter of symbolic manipulation, with an individual's mind processing goals, intentions, plans, mental representations and logical computations.

Computing Within Limits The 'Computing Within Limits' movement stems from discussions within academic computer science concerned with how to develop sustainable modes of computing that might be fit for a resource-constrained and environmentally unstable world. This approach raises the need to plan future education technology use with a primary aim of 'coping with finiteness'. This implies a complete rethinking of many of the fundamental presumptions of limitless, infinite and replicable technology use that most discussions about digital education are currently built upon. From a 'Computing Within Limits' perspective, these forms of technology use are not appropriate for a constrained future. Instead, we need to develop radically leaner and ecologically mindful approaches to rethinking how digital technologies might be best deployed (and not deployed) in education in the near future.

Connected Learning A model of learning that seeks to describe the increased influence of digital technologies on everyday learning. Connected Learning highlights the learning that occurs when using technologies to design, make, create and produce various forms of digital content. It also considers the role of digital technologies in supporting online communication and interaction between remote individuals. Connected Learning recognises the links between formal and informal learning, especially interest-driven learning that is supported by peers and knowledgeable mentors.

Connectivism The idea that learning now relates primarily to the ability to access and use distributed information on a 'just-in-time' basis. Rather than knowing and retaining information on a long-term basis, connectivism describes how individuals develop personal, meaningful networks of learning. From this perspective, 'learning' can be seen as an individual's ability to connect to specialised information nodes and sources when required. Similarly, being 'knowledgeable' can be seen as the ability to nurture and maintain these connections.

Constructionist theory An extension of constructivist theories of learning, associated primarily with the work of Seymour Papert. Constructionism describes how learning takes place through the exploratory building of objects that are themselves capable of doing something. By building an object and then manipulating it to do something, individuals are able to learn from the process of thinking about how to get something else to think. Constructionists talk of supporting individuals' conversations with artefacts, thereby framing technology as a tool to learn *with* rather than learn *from*.

Constructivist theory Theories of learning associated primarily with the work of psychologists such as Jean Piaget and Jerome Bruner. Constructivist theories describe learning that is problem-based and building upon an individual's previous experience and knowledge. In this sense, learning is rooted in processes of exploration, inquiry, interpretation and meaning-making. Constructivist theories portray learning as an active process where individuals construct their own perspective of the world through personal experiences.

Context The social arrangements and organisational forms that surround the use of technology. This can include institutions (such as the family or workplace), social structures (such as race, gender, social class) and cultures (such as national cultures or youth subcultures). These broader social contexts are seen to influence the specific activities and practices that people undertake with technologies. Acknowledging the importance of social context highlights the need to not only see digital technology in terms of artefacts and devices.

Datafication 'Datafication' is a term that describes the ways that digital technologies are associated with the generation of 'big data' sets that can be analysed to make predictions, identify trends and generally inform what takes place in society. Crucially, a key part of this datafication is the ways that digital technologies produce masses of 'trace' data during their use. This digital data is generated at scale, circulated at speed and processed on a real-time basis. In educational terms, then, datafication describes the ways in which any school or university is now a place where massive amounts of data are being generated and systematically collected in order to make sense of the people within it, and the things that they are doing. In this sense, datafication refers the recent trend in education to turn vast amounts of activity and human behaviour into data points that can be tracked, collected and analysed.

Deschooling The idea that education can be arranged and provided outside of the confines of education institutions such as schools and universities. Deschooling describes how learning can take place through temporary, autonomous and non-hierarchical networks. Deschooling was popularised through the work of the philosopher Ivan Illich. Illich reasoned that individuals in educational institutions are discouraged from taking responsibility for their own self-development, and also from engaging with other potential opportunities for learning within their immediate communities.

Design (teaching as design) The view that a teacher's job is primarily one of setting up the conditions of learning and making sure that opportunities to learn arise over the course of any educational episode. This involves an ongoing process of planning, interacting, evaluating and reflecting. It is important to note that it is not possible for a teacher to 'design' learning – learning is not something that can be controlled or forced to occur. Instead, the role of a teacher is to design *for* learning. This can include establishing suitable learning tasks, supportive environments and conducive forms of social relations between students and teachers.

Deskilling The idea that technology contributes to a fragmentation of the teaching process, with different elements of a teacher's work shared between different people and/or automated through technology. While this breaking down of work might seem helpful, deskilling highlights the problem of individuals losing sight of the whole process and therefore losing control over their own labour. In this way, some digital technologies are seen to lead to a deprofessionalisation of teaching – fragmenting jobs into disconnected work processes that require little conceptual ability. Ultimately this can lead to a sense of disengagement and alienation amongst teachers.

Digital In a basic sense, 'digital' refers to discontinuous data, based on the two distinct states of 'off' or 'on' (or 0 and 1) with no value in-between. Digital technologies are only capable of distinguishing between these two values of 0 and 1, but use binary codes to combine these zeros and ones into large numbers and other practical forms of information. Most people consider the processing of data in this way to be hugely advantageous in terms of the scale, speed and control of what can be done. For example, digital information is far easier to store and distribute electronically, easier to manipulate accurately than 'real-world' analogue data, and infinitely replicable.

Disruptive innovation A view of technology and social change deriving from the economist Clay Christensen. 'Disruptive innovation' refers to relatively ordinary technologies that are combined to address emerging values, needs and desires that are not being catered for elsewhere. Often these simple applications and ideas might seem counter-intuitive or inferior in comparison to current ways of doing things. Nevertheless, these innovations successfully make a product or service available to new populations who previously had not been able to access it. Over time these new ways of doing things then force existing providers to either change their ways or go out of business. Wikipedia is often cited as an example of an innovation that disrupted the printed encyclopaedia business.

Education In a basic sense, 'education' can be understood as the conditions and arrangements where learning takes place. Yet education is not simply a technical matter of facilitating people's learning. In addition, education also involves broader functions of 'qualification', 'socialisation' and 'subjectification'. Education is therefore concerned with helping people gain a sense of who they are, and to act autonomously and critically in the world. These broader concerns tend to be overlooked in many discussions of technology and education.

External imperatives The sense that the increased use of digital technology elsewhere in society necessitates the increased use of technology in education. Commonly cited 'external' imperatives include the workforce demands of business and industry, as well as the increasing requirement for people to be able to use digital technology in order to participate in society and act as citizens.

Flipped classroom The use of digital technologies to allow students to engage with instructive materials (such as lectures, set readings, tests) outside of the classroom. Most common is the use of digital video and digital readings. Teachers are then free to use face-to-face classes to focus on student-centred activities such as problem-solving, group-work, discussion, discovery-led research and personalised support and guidance.

Formal learning The institutionally sponsored provision of learning – that is, learning that is structured and often assessed and credentialised. There is a wide range of formal education, most obviously the compulsory forms of school-based learning for children and young people. Similar types of formal post-compulsory learning also exist through colleges, universities and various types of distance education. Formal education can also be found outside of schools and universities, in adult education and work-based training settings.

Informal learning Learning that occurs during the course of everyday life. Informal learning usually is not classroom based, and has no curriculum, assessment or formal 'teacher'. Informal learning is unstructured and controlled by the individual learner. Common forms of informal learning include work-based 'learning on the job' as well as learning that is stimulated by general interests, pursuits and hobbies.

Internal imperatives The idea that digital technology has a clear capacity to improve many aspects of education. Common forms of 'internal' imperative for the increased use of digital technology within schools and universities include supporting better forms of teaching and learning, supporting the administrative and bureaucratic work of educators, making education institutions more efficient and productive.

Learning The acquisition of new skills and new forms of knowledge and understanding. Many theories of learning developed during the first decades of the twentieth century conceptualised learning as an end product or outcome – for example, a distinct change in behaviour or thinking. More recently, learning is understood to also involve individuals making sense of who they are and developing an understanding of the world in which they live. From this perspective, learning can be seen as a continuing process of 'participation' rather than a discrete instance of 'acquisition'.

Learning management systems (LMS) Online platforms for information and resource sharing, as well as the organisation of curriculum and pedagogy. In essence, these systems replicate the main functions of the classroom and school/university in digital form. These systems support the provision of learning content and other resources, communication between students, teachers and administrators, the submission and assessment of coursework, and the monitoring of learning progress.

Lifelong learning The idea that education encompasses not only the compulsory phases of schooling but also education and training throughout the life course. Lifelong learning describes the different forms and modes of learning that individuals engage in during distinct stages of their life (ranging from workplace training requirements through to hobby-related learning

in older age). A related concept is 'life wide learning' – describing how an individual's learning is likely to be situated across a number of contexts at any time, such as employment, formal education, community and family.

Massive Open Online Course (MOOC) MOOCs are courses provided to masses of online students for little or no cost. These often involve the use of video lectures accompanied by online quizzes and discussion spaces. Through the rise of providers such as Udacity, edX, Coursera and Futurelearn, MOOCs offer university-affiliated courses to classes of thousands of students at a time.

Open Educational Resources (OER) The open education resource movement supports free access to information in the form of web-based digital resources for learning, teaching and research. These resources are usually placed in the public domain at no cost for free use or repurposing by others. These resources can range from full courses to individual lessons or sessions. The idea of OERs relates to the broader philosophies of 'open source' software development, as well as philosophies of 'open education' and 'open society'.

Personalised learning Using digital technology to arrange education around the needs, interests and circumstances of individuals. Efforts to support personalisation of education through technology tend to focus either on issues of decision-making or customisation of content. Whereas many technologies support individuals in making decisions about their learning, other recent developments have explored the possibility that these decisions might be best made by the technology itself. For example, analytics and adaptive systems have been developed to adapt individuals' engagement with learning content according to their specific needs, capabilities and past performance.

Platformatisation Educational institutions are increasingly reliant on large software systems and platforms – such as 'learning management systems' – which are used to act as intermediaries between students, their teachers and the broader official institution. These platforms are used to host access to resources, as a site for communication and social exchange, to support monitoring of attendance and engagement of work, as well as uploading and grading of assignments. These platforms are integral to the long-term organisation and planning of a school or university, as well as a key determinant of day-to-day decisions within every classroom. This raises interesting questions regarding how 'platform logics' are coming to shape the nature of what is done in education – from the types of work and interactions that students and teachers engage in, through to the ways in which educational processes are made more visible to 'outside' interests.

Reschooling The idea that digital technology necessitates the reconfiguration and reinvention of what 'school' is. Attempts at 'reschooling' often involve remodelling dominant institutional structures and organisational processes within the existing physical and spatial environments of schools and universities. In other words, while new schools and universities may look the same from the outside, what goes on within them is substantially different from before.

Social media Online platforms and applications that depend on the collective efforts of their users. These technologies are distinguished by their capacity to support forms of 'mass socialisation'. Many of the most popular social media platforms and applications rely on openly shared 'user generated' content that is authored, curated, critiqued and reconfigured by a mass of users. In this way, social media bring an interactive and participatory ethos to the way that digitals are used.

Social shaping of technology A way of understanding the relationship between social change and technology. From this perspective, the nature and form of any technology is subjected to continual interactions and 'negotiations' with the social, economic, political and cultural contexts that it emerges into. Understanding technology as 'socially shaped' allows us to ask questions about the large number of factors that influence the design, development, production, marketing, implementation and 'end use' of technology.

Sociocultural theories of learning Theories of learning that are rooted in the work of psychologists such as Lev Vygotsky. Sociocultural accounts tend to focus on the social and cultural nature of learning. Vygotsky saw most human action as involving what he called 'cultural tools' and resources (such as language or writing). Sociocultural accounts describe learning with cultural tools as being highly social and often informal in nature. The act of learning a particular skill or understanding specific cultural and social practices is seen to be a largely tacit process, involving an individual imitating what is observed from the actions of others.

Technological determinism The commonplace assumption that technology is a primary force that determines the nature of society. Technology is seen as an autonomous force that drives social progress and changes in society. Whatever we do, we cannot stop technology having a certain and inevitable effect on our lives. Despite its popularity, technological determinism is felt by some critical commentators to be a reductive way of understanding technology and society.

Technological essentialism The commonplace idea that digital technologies have consistent, durable qualities regardless of when, where and for what

purposes they are being used. This can lead to three erroneous ways of thinking about technology. First is seeing technologies as distinct from the social and historical conditions from which they emerged ('ahistoricism'). Second is the idea that technology somehow has qualities and characteristics that come from beyond the humans that develop and use it – in other words, technologies function in an autonomous manner that is outside of human control ('substantivism'). Third is the belief that all technological devices express the same essence ('one-dimensionalism'). Approaching technology in these terms usually results in either uncritical enthusiasm for digital technology or a 'technophobic' rejection of digital technology.

Technological solutionism The commonplace idea that digital technologies offer ready solutions, correctives and 'fixes' to existing education problems. This way of thinking is evident in the transformative ways that emerging technologies such as AI and 'big data' are currently being imagined as impacting on education – echoing similar claims for previous educational technologies such as computers, television and radio. Of course, attempts to use the 'power' of technology in order to solve problems that are non-technological in nature often come up against a number of recurring issues. For example, technologies tend to produce uneven results, rarely ending in similar outcomes for all of the population and often replacing one social problem with another. At best technology-based interventions tend to deal only with the surface manifestations of a problem rather than its roots

Technology In a basic sense technology is the process by which humans modify nature to meet their needs and wants. Usually technology is described in terms of humans' ongoing use of tools to adapt and control their environment, and also to improve existing forms of living. This emphasis on 'doing things better' implies that the term 'technology' refers to more than just material tools and artefacts that are used to do something. In this sense, the term 'technology' has also encompassed the processes and practices of doing things, understanding things and developing knowledge.

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