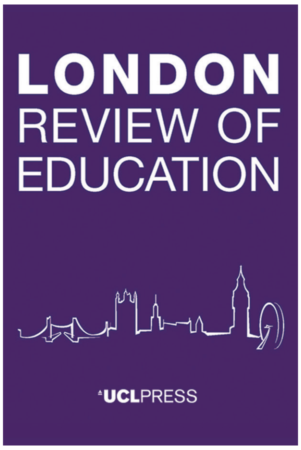

UCLPRESS

LONDON REVIEW OF EDUCATION

e-ISSN: 1474-8479

Journal homepage:
https://www.uclpress.co.uk/pages/london-review-of-education

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How to cite this article

Reiss, M.J. (2021) 'The use of AI in education: Practicalities and ethical considerations'. *London Review of Education*, 19 (1), 5, 1–14. https://doi.org/10.14324/LRE.19.1.05

Submission date: 2 January 2020
Acceptance date: 10 July 2020
Publication date: 3 February 2021

Peer review

This article has been peer-reviewed through the journal's standard double-blind peer review, where both the reviewers and authors are anonymized during review.

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LONDON
REVIEW OF
EDUCATION

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The use of AI in education: Practicalities and ethical considerations

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Abstract

There is a wide diversity of views on the potential for artificial intelligence (AI), ranging from overenthusiastic pronouncements about how it is imminently going to transform our lives to alarmist predictions about how it is going to cause everything from mass unemployment to the destruction of life as we know it. In this article, I look at the practicalities of AI in education and at the attendant ethical issues it raises. My key conclusion is that AI in the near- to medium-term future has the potential to enrich student learning and complement the work of (human) teachers without dispensing with them. In addition, AI should increasingly enable such traditional divides as 'school versus home' to be straddled with regard to learning. AI offers the hope of increasing personalization in education, but it is accompanied by risks of learning becoming less social. There is much that we can learn from previous introductions of new technologies in school to help maximize the likelihood that AI can help students both to flourish and to learn powerful knowledge. Looking further ahead, AI has the potential to be transformative in education, and it may be that such benefits will first be seen for students with special educational needs. This is to be welcomed.

Keywords: artificial intelligence, education, personalized learning, teaching, flourishing

Introduction

The use of computers in education has a history of several decades – with somewhat mixed consequences. Computers have not always helped deliver the results their proponents envisaged (McFarlane, 2019). In their review, Baker et al. (2019) found that examples of educational technology that succeeded in achieving impact at scale and making a desired difference to school systems as a whole (beyond the particular context of a small number of schools) are rarer than might be supposed. More positively, Baker et al. (2019) examined nine examples – three in Italy, three in the rest of Europe and three in the rest of the world – where technology is having beneficial impacts for large numbers of learners. One of the examples is the partnership between the Lemann Foundation and the Khan Academy in Brazil; this has been running since 2012 and has resulted in millions of students registering on the Khan Academy platform. The context is that in most Brazilian schools, students attend for just one of three daily sessions, only receiving about four hours of teaching a day. Evaluations of this partnership have been positive, for example, showing increased mathematics attainment compared to controls (Fundação Lemann, 2018).

Nowadays, talk of artificial intelligence (AI) is widespread – and there have been both overenthusiastic pronouncements about how it is imminently going to transform our lives, particularly for learners (for example, Seldon with Abidoye, 2018), and dire

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predictions about how it is going to cause everything from mass unemployment to the destruction of life as we know it (for example, Bostrom, 2014).

Precisely what is meant by AI is itself somewhat contentious (Wilks, 2019). To a biologist such as myself, intelligence is not restricted to humans. Indeed, there is an entire academic field, animal cognition, devoted to the study of the mental capacities of non-human animals, including their intelligence (Reader et al., 2011). Members of the species *Homo sapiens* are the products of something like four thousand million years of evolution. Unless one is a creationist, humans are descended from inorganic matter. If yesterday's inorganic matter gave rise to today's humans, it hardly seems remarkable that humans, acting intentionally, should be able to manufacture inorganic entities with at least the rudiments of intelligence. After all, even single-celled organisms show apparent purposiveness in their lives as they move, using information from chemical gradients, to places where they are more likely to obtain food (or the building blocks of food) and are less likely themselves to be consumed (Cooper, 2000).

Without endorsing the *Scala Naturae*, still less the Great Chain of Being, it is clear that many species have their own intelligence. This is most obvious to us in the other great apes – gorillas, bonobos, chimpanzees and orangutans – but evolutionary biologists and some philosophers are wary of binary classifications (humans versus all other species, or great apes versus all other species), preferring to see intelligence as an emergent property found in different manifestations and to varying extents (Spencer-Smith, 1995; Kaplan and Robson, 2002). For example, some species have much better spatial memories than we do – in bird species such as chickadees, tits, jays, nutcrackers and nuthatches, individuals scatter hoard sometimes thousands of nuts and other edible items as food stores, each in a different location (Crystal and Shettleworth, 1994). Their memories allow them to retrieve the great majority of such items, sometimes many months later.

None of this is to diminish the exceptional and distinctive nature of human intelligence. To give just one example, the way that we use language, while clearly related to the simple modes of communication used by non-human animals, is of a different order (Scruton, 2017). From our birth, before we begin to learn from our parents and others, we have – without going into the nature–nurture debate in detail – an innate capacity to relate to others and to take in information (Nicoglou, 2018). As the newborn infant takes in this information, it begins to process this, just as it takes in milk and emulates walking. As has long been noted, 4-year-olds can do things (recognize faces, manifest a theory of mind, use conditional probabilistic reasoning) that even the most sophisticated AI struggles to do. Furthermore, it is the same 4-year-old who does all this, whereas we still employ different AI systems to cope (or attempt to cope) with each of these, highlighting the point that AI is still quite narrow, whereas human cognition is far broader in comparison (Boden, 2016).

There is no need here to get into a detailed discussion about the relationship between robots and AI – although there are interesting questions on the extent to which the materiality that robots possess and that software does not makes, or will make, a difference to the capacity to manifest high levels of intelligence (Reiss, 2020). It is worth noting that our criteria for AI seem to change over time (see Wang, 2019). Every time there is a substantial advance in machine performance, the bar for 'true AI' gets raised. The reality is that there are now not only machines that can play games such as chess and go better than any of us can, but also machines (admittedly not the same machines) that can make certain diagnoses (for example, breast cancer, diabetic retinopathy) at least as accurately as experienced doctors.

It should be remembered, however, that within every AI system there are the fruits of countless hours of human thinking. When AlphaGo beat 18-times world go champion Lee Sedol in 2016 by four games to one, in a sense it was not AlphaGo alone but also all the programmers and go experts who worked to produce the software. Indeed, the same point holds for all technologies and all human activities. Human intelligence, demonstrated through such things as teaching the next generation and the invention of long-lasting records (writing, for example), has meant that the abilities manifested by each of us or our products (such as software) are the results of a long history of human thought and action.

There are endless debates as to whether or not machines can yet pass the Turing test. The reality is that the internet is filled with bots that regularly convince humans that they are other humans (Ishowo-Oloko et al., 2019). Some of the saddest instances are the bots that appear on dating websites. Worryingly, the standard advice as to how to spot them (messages look scripted, grammar is poor, they ask for money, they respond too rapidly) will presumably soon become dated as technology 'improves' and would also disqualify quite a few humans.

So, AI is here – it is already making a huge impact on almost every aspect of manufacturing, and there are sensible predictions that it will be used increasingly in a large number of professions, including medicine, law and social care (Frey and Osborne, 2013; POST, 2018). What are its effects likely to be in education, and should we welcome it or not?

AI and its use in non-teaching aspects of education

The main concern of this article is with the use of AI for teaching. However, schools are complex organizations and there is little doubt that AI will play an increasing role in what might be termed the non-teaching aspects of education. Some of these have little or nothing to do with the classroom teacher – for example, the allocation of students to schools in places where such decisions are still made outside individual schools, improved recruitment procedures for teachers and other staff, better procurement systems for materials used in schools and more accurate registration of students. Other aspects do involve the teacher – for example, improved design and marking of terminal assessments, more valid provision of information about students to their parents/guardians (reports) and so on. The importance of these for the lives of teachers should not be underestimated. Many teachers would be delighted if AI could reduce what they often characterize as bureaucracy that wears them down (see, for example, Towers, 2017; Skinner et al., 2019).

A range of software tools to help with some of these aspects of school life already exists – for example, for timetabling (FET, Lantiv Timetabler, among others) – and there is a burgeoning market for the development of AI for assessment purposes by Pearson and other commercial organizations (Jiao and Lissitz, 2020). Obviously, automated systems can be used (and have been for many years) in 'objective marking' (as in a multiple choice test). The deeper question is about the efficacy and occurrence of any unintended consequences when automated systems are used for more open-ended assignments. The research literature is cautiously optimistic, for both summative and formative assessment purposes (for example, Shute and Rahimi, 2017; van Groen and Eggen, 2020). At the same time, it should not be presumed that the use of AI for such purposes will necessarily be unproblematic. Enough is now known about bias in AI (for example, unintended racial profiling) for us to be cautious (Burbidge et al., 2020).

Some of the benefits that schools can provide for students are not covered by the term 'teaching', and AI may prove useful here. For example, a number of schools in England, both independent and state, are using an AI tool which is designed to predict self-harm, drug abuse and eating disorders. It has been claimed that this is already decreasing self-harm incidents (Manthorpe, 2019), although Carly Kind, Director of the Ada Lovelace Institute (a research and deliberative body with a mission to ensure that data and AI work for people and society), points out that 'With these types of technologies there is a concern that they are implemented for one reason and later used for other reasons' (Manthorpe, 2019).

AI and the personalization of education

Some of the claims made for AI in education are extremely unlikely to be realized. For example, Nikolas Kairinos, founder and CEO of Fountech.ai, has been quoted as saying that within 20 years, our heads will be boosted with special implants, so 'you won't need to memorise anything' (White, 2019). The reasons why this is unlikely ever to be the case, let alone within 20 years, are discussed by Aldridge (2018), who examines the possibility of such knowledge 'insertion' (see Gibson, 1984). Aldridge (2018) draws on a phenomenological account of knowledge to reject such a possibility. Puddifoot and O'Donnell (2018) argue that too great a reliance on technologies to store information for us – information that in previous times we would have had to remember – may be counterproductive, resulting in missed opportunities for the memory systems of students to form abstractions and generate insights from newly learned information.

Moving to a more conceivable, although still very optimistic, instance of the potential of AI for education, Anthony Seldon writes:

> Two of the most important variants are the quality of teaching and class sizes. In proverbial terms, AI offers the prospect of 'an Eton quality teacher for all'. Class sizes for those children fortunate enough to attend a school will be reduced from 30 or more, where the individual student's needs are often lost, down to 1 on 1 instruction. Students will still be grouped into classes which may well have 10, 20, 30 or more children in them, but each student will enjoy a personalised learning programme. They will spend part of the day in front of a screen or headsets, and in time a surface on to which a hologram will be projected. There will be little need for stand-alone robots for teaching itself. The 'face' on the screen or hologram will be that of an individualised teacher, which will know the mind of the student, and will deliver lessons individually to them, moving at the student's optimal pace, know how to motivate them, understand when they are tired or distracted and be adept at bringing them back onto task. The 'teacher' themselves will be as effective as the most gifted teacher in any class in any school in the world, with the added benefit of having a finely honed understanding of each student, their learning difficulties and psychologies whose accumulated knowledge will not evaporate at the end of the school year. (Seldon with Abidoye, 2018: Chapter 9: 2)

For all that this passage seems to have been written in a rush ('in front of a screen or headsets', 'on to which', 'onto task'), it is worth examining, both because it manifests some of the hyperbole that attends AI in education and because it is written by someone who is not only a vice chancellor of a university and a former headteacher, but also (according to his website, www.anthonyseldon.co.uk) one of Britain's leading educationalists.

I agree with Seldon that personalization of teaching is likely to be one of the principal benefits of AI in education, but I do not have quite the unbounded enthusiasm for one-to-one teaching of school students that he does. There are times when one-to-one teaching is ideal – indeed, most of my own teaching since I took up my present post in 2001 has been one-to-one (doctoral students). However, there are two principal reasons why one-to-one teaching, on its own, is less ideal for younger students – one is concerned with the nature of what is to be learnt; the other is concerned with how it is to be learnt (see Baines et al., 2007). With younger students, quite a high proportion of what is to be learnt is not distinctive to the learner, in contrast to doctoral teaching, where most of it is. When what is to be learnt is common to a number of learners, they can learn from each other, as well as from the official teacher. When I spent quite a bit of time giving one-to-one tutorials in mathematics to teenagers desperately trying to pass their school examinations, the experience convinced me that, while there is much to be said for one-to-one tuition, there is also a vital role for group discussion. Indeed, there is no reason to pit AI and group learning in opposition: the two can complement one another (Bursali and Yilmaz, 2019).

Then there is the fact that Seldon seems to have an interesting notion of quality school teaching, in which the teacher does not need to have any individualized knowledge of their students: 'The "teacher" themselves will be as effective as the most gifted teacher in any class in any school in the world, *with the added benefit of having a finely honed understanding of each student*' (Seldon with Abidoye, 2018: Chapter 9: 2, my emphasis). This seems to be an extreme version of transmission ('banking') education (Freire, 2017), in which what is to be taught is independent of the learner. Freire argued that it was this notion of transmission education that prevents critical thinking ('conscientization') and so enables oppression to continue. A naive assumption that AI can be 'efficient' by enabling learners to learn rapidly could therefore lead to the same lack of criticality and ownership of their learning.

I am also a bit more sceptical than Seldon about the presumption that 'The "face" on the screen or hologram will … know how to motivate them' (Seldon with Abidoye, 2018: Chapter 9: 2). Perhaps he and I taught in rather different sorts of schools, but my memory of my schoolteaching days was that motivation was all too often about using every ounce of my social skills to know when to be firm and when to banter, when to stay on task and when to make a leap from the subject matter at hand to aspects of the lives of my students (see Wentzel and Miele, 2016). It is not impossible that AI could manage this – but I suspect that this will be a very considerable time in the future.

There is also a somewhat disembodied model of teaching apparent in Seldon's vision ('The "face" on the screen or hologram'). To a certain extent, this may work better for some subjects (such as mathematics) than others. As a science teacher, I suspect that the actuality of some 'thing' (I grant that this could in principle be a robot) moving around the classroom or school laboratory, interacting with students as it teaches, particularly during practical activities, is valuable (see Abrahams and Reiss, 2012). I also note that there is a growing literature – some, but not all, of it centred on science education – on the importance of gesture and other material manifestations of the teacher (for example, Kress et al., 2001; Roth, 2010).

Finally, the present reality of any learning innovation that makes use of technology, including AI, is that one of its first effects is to widen inequalities, particularly those based on financial capital, but often also with respect to other variables such as gender and geography (for example, differential access to broadband in rural versus urban communities) (Ansong et al., 2020). In addition, for all that AI may promise increasing personalization, Selwyn (2017) points out that digital provision often results in 'more of the same'. Furthermore, such digital provision is accompanied by increasing commercialization:

> Technology is already allowing big businesses and for-profit organisations to provide education, and this trend will increase over the next fifty years. Whatever companies are the equivalent of Pearson and Kaplan in 2065 will be running schools, and we will not think twice about it. (Selwyn, 2017: 178–9)

Nevertheless, personalization does seem likely to represent a major route by which AI will be influential in education. I can remember designing with colleagues (Angela Hall took the lead, with Anne Scott and myself supporting her) software packages ('interactive tutorials') for 16–19-year-old biology students in 2002–3 (Hall et al., 2003). The key point of these packages was that, depending on students' responses to early questions, the students were directed along different paths, in an attempt to ensure that the material with which they were presented was personally suitable. By today's standards, it would seem rather clunky, but it constituted an early version of personalization (that is, 'differentiation').

Neil Selwyn (2019) traces this approach back to the beginnings of computer-aided instruction in the 1960s. Many of the systems are based on a 'mastery' approach (as in many computer games), where one only progresses to the next level having succeeded at the present one. Selwyn is generally regarded as something of a sceptic about many of the claims for computers in education, so his comment that 'these software tutors are certainly seen to be as good as the teaching that most people are likely to experience in their lifetime' (Selwyn, 2019: 56) is notable.

As these systems improve – not least as a result of machine learning, as well as increases in processing capacity – it seems likely that their value in education will increase considerably. For example, the Chinese company Squirrel (which attained 'unicorn' status at the end of 2018, with a valuation of US$1 billion) has teams of engineers that break down the subjects it teaches into the smallest possible conceptual units. Middle school mathematics, for example, is broken into a large number of atomic elements or 'knowledge points' (Hao, 2019). Once the knowledge points have been determined, how they build on each other and relate to each other are encoded in a 'knowledge graph'. Video lectures, notes, worked examples and practice problems are then used to help teach knowledge points through software – Squirrel students do not meet any human teachers:

> A student begins a course of study with a short diagnostic test to assess how well she understands key concepts. If she correctly answers an early question, the system will assume she knows related concepts and skip ahead. Within 10 questions, the system has a rough sketch of what she needs to work on, and uses it to build a curriculum. As she studies, the system updates its model of her understanding and adjusts the curriculum accordingly. As more students use the system, it spots previously unrealized connections between concepts. The machine-learning algorithms then update the relationships in the knowledge graph to take these new connections into account. (Hao, 2019: n.p.)

What remains unclear is the extent to which such systems will replace teachers. I suspect that what is more likely is that in schools they will increasingly be seen as another pedagogical instrument that is useful to teachers. One area where AI is likely to prove of increasing value is the provision of 'real-time' ('just-in-time') formative assessment. Luckin et al. (2016: 35) envisage that 'AIEd [Artificial Intelligence in Education] will enable learning analytics to identify changes in learner confidence and motivation while learning a foreign language, say, or a tricky equation'. Indeed, while some students will no doubt respond better to humans as teachers, there is considerable anecdotal evidence that some prefer software – after all, software is available for us whenever we want it, and it does not get irritated if we take far longer than most students to get to grips with simultaneous equations, the causes of the First World War or irregular French verbs.

It has also been suggested that AI will lead to a time when there is no (well, let us say 'less') need for terminal assessment in education, on the grounds that such assessment provides just a snapshot, and typically covers only a small proportion of a curriculum, whereas AI has far more relevant data to hand. It is a bit like very high-quality teacher assessment, but without the problem that teachers often find it difficult to be dispassionate in their assessments of students that they have taught and know.

I will return to the issue of personalized learning in the section on 'Special educational needs' below.

AI and the home–school divide in education

Traditionally, schools are places to which adults send children for whom they are responsible, so that the children can learn. One not infrequently reads denouncements of schools on the grounds that their selection of subjects and their model of learning date mainly from the nineteenth century and are outdated for today's societies (see, for example, White, 2003). Even in the case of science, where there have clearly been substantial changes in what we know about the material world, changes in how science is taught in schools over the last hundred years have been modest (see, for example, Jenkins, 2019). Furthermore, science courses typically assume that there is little or no valid knowledge of the subject that children can learn away from school. Outside-the-classroom learning is generally viewed as a source of misconceptions more than anything else.

Nowadays, however, and even without the benefits of AI, there is a range of ways of learning science away from school. For example, when I type 'learning astronomy' into Google, I get a wonderful array of websites. I remember the satisfaction I felt when, in about 2004, a student who was ill and had to spend two terms (eight months) away from school while studying an A-level biology course for 16–18-year-olds that I helped develop (Salters-Nuffield Advanced Biology), as well as two other A levels, was able to continue with her biology course because of its large, online component, whereas she had to give up her other two A levels. It seems clear that one of the things that AI in education will do is help to break down the home–school divide in education. The implications for schooling may be profound – for all that a cynical analysis might conclude that schools provide a relatively affordable child-minding system while both parents go out to work.

Having said that, the near-worldwide disruption to conventional schooling caused by COVID-19, including the widespread closure of schools, indicates how far any distance-learning educational technology is from supplanting humans, for which millions of harassed parents, carers and teachers doing their best at a distance can vouch. Even when the technology works perfectly (and is not overloaded), and there has been plenty of time to prepare, home schooling is demanding (Lees, 2013).

Nor should it be presumed that learners away from school must necessarily work on their own. Most of us are already familiar with online forums that permit (near) real-time conversations. Luckin et al. (2016) argue that AI can be used to facilitate high-quality collaborative learning. For instance, AI can bring together (virtually) individuals with complementary knowledge and skills, and it can identify effective collaborative problem-solving strategies, mediate online student interactions, moderate groups and summarize group discussions.

Ethical issues of AI in education

The aims of education

The use of AI to facilitate learning emphasizes the need to look fundamentally at the aims of education. With John White (Reiss and White, 2013), I have argued that education should aim to promote flourishing – principally human flourishing, although a broader application of the concept would widen the notion to the non-human environment. Such a broadening is especially important at a time when there is increasing realization of the accelerating impact that our species is having on habitat destruction, global climate change and the extinction of species.

Establishing that human flourishing is the aim of education does not contradict the aim of enabling students to acquire powerful knowledge (Young, 2008) – the sort of knowledge that in the absence of schools, students would not learn – but it is not to be equated with it. Human flourishing is a broader conceptualization of the aim of education (Reiss, 2018). The argument that education should promote human flourishing begins with the assertion that this aim has two sub-aims: to enable each learner to lead a life that is personally flourishing and to enable each learner to help others lead such lives too. Specifically, it can be argued that a central aim of a school should be to prepare students for a life of autonomous, wholehearted and successful engagement in worthwhile relationships, activities and experiences. This aim involves acquainting students with possible options from which to choose, although it needs to be recognized that students vary in the extent to which they are able to make such 'choices'. With students' development towards autonomous adulthood in mind, schools should provide their students with increasing opportunities to decide between the pursuits that best suit them. Young children are likely to need greater guidance from their teachers, just as they do from their parents. Part of the function of schooling, and indeed parenting, is to prepare children for the time when they will need, and be able, to make decisions more independently.

The idea that humans should (can) lead flourishing lives is among the oldest of ethical principles, one that is emphasized particularly by Aristotle in his *Nicomachean Ethics* and *Politics*. There are many accounts as to what precisely constitutes a flourishing life. A Benthamite hedonist sees it in terms of maximizing pleasurable feelings and minimizing painful ones. More everyday perspectives may tie it to wealth, fame, consumption or, more generally, satisfying one's major desires, whatever these may be. There are difficulties with all of these accounts. For example, a problem with desire satisfaction is that it allows ways of life that virtually all of us would deny were flourishing – a life wholly devoted to tidying one's bedroom, for instance.

A richer conceptualization of flourishing in an educational context is provided by the concept of *Bildung*. This German term refers to a process of maturation in which an individual grows so that they develop their identity and, without surrendering their individuality, learns to be a member of society. The extensive literary tradition of *Bildungsroman* (sometimes described in English as 'coming-of-age' stories), in which an individual grows psychologically and morally from youth to adulthood, illustrates the concept (examples include *Candide*, *The Red and the Black*, *Jane Eyre*, *Great Expectations*, *Sons and Lovers*, *A Portrait of the Artist as a Young Man* and *The Magic Mountain*).

The relevance of this for a future where AI plays an increasing role in education is that, while any teacher needs to reflect on their aims, there is a greater risk of such reflection not taking place when the teacher lacks self-awareness and the capacity for reflexivity and questioning, as is currently manifestly the case when AI provides the teaching. Furthermore, given the emphasis to date on subjects such as mathematics in computer-based learning, there is a danger that AI education systems will focus on a narrow conceptualization of education in which the acquisition of knowledge or a narrow set of skills come to dominate. Even without presuming a *Dead Poets Society* view of the subject, it is likely to be harder to devise AI packages to teach literature well than to teach physics. Looking across the curriculum, we want students to become informed and active citizens. This means encouraging them to take an interest in political affairs at local, national and global levels from the standpoint of a concern for the general good, and to do this with due regard to values such as freedom, individual autonomy, equal consideration and cooperation. Young people also need to possess whatever sorts of understanding these dispositions entail, for example, an understanding of the nature of democracy, of divergences of opinion about it and of its application to the circumstances of their own society (Reiss, 2018).

The possible effect of AI on the lives of teachers and teaching assistants

It is not only students whose lives will increasingly be affected by the use of AI in education. It is difficult to predict what the consequences will be for (human) teachers. It might be that AI leads to more motivated students – something that just about every teacher wants, if only because it means they can spend less time and effort on classroom management issues and more on enabling learning. On the other hand, the same concerns I discuss below about student tracking – with risks to privacy and an increasing culture of surveillance – might apply to teachers too. There was a time when a classroom was a teacher's sanctuary. The walls have already got thinner, but with increasing data on student performance and attainment, teachers may find that they are observed as much as their students. Even if it transpires that AI has little or no effect on the number of teachers who are needed, teaching might become an even more stressful occupation than it is already.

The position of teaching assistants seems more precarious than that of teachers. In a landmark study that evaluated a major expansion of teaching assistants in classrooms in England – an expansion costed at about £1 billion – Blatchford et al. (2012) reached the surprising conclusion, well supported by statistical analysis, that children who received the most support from teaching assistants made significantly less progress in their learning than did similar children who received less support. Much subsequent work has been undertaken which demonstrates that this finding can be reversed if teaching assistants are given careful support and training (Webster et al., 2013). Nevertheless, the arguments as to why large numbers of teaching assistants will be needed in an AI future seem shakier than the arguments as to why large numbers of teachers will still be needed.

Special educational needs

The potential for AI to tailor the educational offer more precisely to a student's needs and wishes (the 'personalization' argument considered above) should prove to have special benefits for students with special educational needs (SEN) – a broad category that includes attention deficit hyperactivity disorder, autistic spectrum disorder, dyslexia, dyscalculia and specific language impairment, as well as such poorly defined categories as moderate learning difficulties and profound and multiple learning disabilities (see Astle et al., 2019). If we consider a typical class with, say, 25 students, almost by definition, SEN students are likely to find that a smaller percentage of any lesson is directly relevant to them compared to other students. This point, of course, holds as well for students sometimes described as gifted and talented (G&T) as for students who find learning (either in general or for a particular subject) much harder than most, taking substantially longer to make progress.

To clarify, for all that some school students may require a binary determination as to whether they are SEN or not, or G&T or not, in reality these are not dichotomous variables – they lie on continua. Indeed, one of the advantages of the use of AI is precisely that it need not make the sort of crude classifications that conventional education sometimes requires (for reasons of funding decisions and allocation of specialist staff). If it turns out (which is the case) that when learning chemistry, I am well above average in my capacity to use mathematics, but below average in my spatial awareness, any decent educational software should soon be aware of this and adjust itself accordingly – roughly speaking, in the case of chemistry, by going over material that requires spatial awareness (for example, stereoisomers) more slowly and incrementally, but making bigger jumps and going further in such areas as chemical calculations.

Estimates of the percentage of students who have SEN vary. In England, definitions have changed over the years, but a figure of about 15 per cent is typical. The percentage of students who are G&T is usually stated to be considerably smaller – 2 per cent to 5 per cent are the figures sometimes cited – but it is clear that even using this crude classification, about one in five or one in six students fit into the SEN or G&T categories. And there are many other students with what any parent would regard as special needs, even if they do not fit into the official categories. I am a long-standing trustee of Red Balloon, a charity that supports young people who self-exclude from school, and who are missing education because of bullying or other trauma. One of the most successful of our initiatives has been Red Balloon of the Air; teaching is not (yet) done with AI, but it is provided online by qualified teachers, with students working either on their own or in small groups. It is easy to envisage AI coming to play a role in such teaching, without removing the need for humans as teachers. Indeed, AI seems likely to be of particular value when it complements human teachers by providing access to topics (even whole subjects) that individual teachers are not able to, thereby broadening the educational offer.

Student tracking

In the West, we often shake our heads at some of the ways in which the confluence of biometrics and AI in some countries is leading to ever tighter tracking of people. Betty Li is a 22-year-old student at a university in north-west China. To enter her dormitory, she needs to get through scanners, and in class, facial recognition cameras above the blackboards keep an eye on her and her fellow students' attentiveness (Xie, 2019). In some Chinese high schools, such cameras are being used to categorize each student at each moment in time as happy, sad, disappointed, angry, scared, surprised or neutral. At present, it seems that little use is really being made of such data, but that could change, particularly as the technology advances.

Sandra Leaton Gray (2019) has written about how the convergence of AI and biometrics in education keeps her awake at night. She points out that the proliferation of online school textbooks means that publishers already have data on how long students spend on each page and which pages they skip. She goes on:

> In the future, they might even be able to watch facial expressions as pupils read the material, or track the relationship between how they answer questions online during their course with their final GCSE or A Level results, especially if the pupil sits an exam produced by the assessment arm of the same parent company. This doesn't happen at the moment, but it is technically possible already. (Leaton Gray, 2019: n.p.)

It is a standard trope of technology studies to maintain that technologies are rarely good or bad in themselves: what matters is how they are used. Leaton Gray (2019) is right to question the confluence of AI and biometrics. While this has the potential to advance learning, it is all too easy to see how a panopticon-like surveillance could have dystopian consequences (see books such as *We* and *Nineteen Eighty-Four* and films such as *Das Leben der Anderen*, *Brazil* and *Minority Report*).

Conclusions

There is no doubt that AI is here to stay in education. It is possible that in the short- to medium-term (roughly, the next decade) it will have only modest effects – whereas its effects in many other areas of our lives will almost certainly be very substantial. At some point, however, AI is likely to have profound effects on education. It is possible that these will not all be positive, and it is more than possible that the early days of AI in education will see a widening of educational inequality (in the way that almost any important new technology widens inequality until penetration approaches 100 per cent). In time, though, AI has the potential to make major positive contributions to learning, both in school and out of school. It should increase personalization in learning, for all students, including those not well served by current schooling. The consequences for teachers are harder to predict, although there may be reductions in the number of teaching assistants who work in classrooms.

Acknowledgements

I am very grateful to the editors of this special issue, to the editor of the journal and to two reviewers for extremely helpful feedback which led to considerable improvements to this article.

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