THE CHALLENGE OF ARTIFICIAL INTELLIGENCE

Abstract

Artificial Intelligence (AI) appears to be advancing at an ever-accelerating pace and affecting much of human life. The power of AI has already been demonstrated in various areas – from smartphone personal assistants and customer support chatbots to medical diagnoses and driverless cars. At the same time, these applications bring multiple challenges and much hyperbole. Nonetheless, of particular importance here, AI systems have also entered the classroom. However, while promising to enhance education, the design and deployment of these tools again raise particular concerns and challenges. We begin this chapter with a brief history and definition of AI outlining the evolution of AI techniques aiming to imitate or outperform human cognitive capacities. We continue by exploring what AI systems promise to deliver in educational contexts and their impact on learners, examining the interaction through the lens of three analytical categories: learning *with* AI, learning *about* AI and preparing *for* AI. We also explore the risks related to the introduction of AI into education and investigate transversal issues related to all three categories, noting that currently little attention has been paid to what is ethically acceptable for AI and education. Finally, we conclude by trying to answer two questions: how can we make better AI tools for education and how can education help address the challenges created by AI?

Introduction

Artificial Intelligence (AI) is constantly in the headlines. Almost every day, we read about another dramatic although often overhyped breakthrough, such as the use of AI to identify and counter COVID-19,[1] software agents that appear capable of fluid conversations,[2] or the creation of deep fake videos[3]. However, we know less about how AI has infiltrated our daily lives. AI helps unlock your smartphone with face ID,[4] provides personalized feeds in your social media,[5] and monitors your whereabouts as you walk about town.[6] Increasingly, while it rarely makes the headlines, AI is also being used in educational contexts, for example to automatically generate timetables,[7] to adapt tutoring technologies to individual competencies,[8] and to monitor whether students are concentrating in class.[9] Advocates, such as developers and some researchers and policymakers, argue that the introduction of AI into classrooms enhances learning and thus *de facto* benefits students. Others respond that AI in classrooms de-professionalizes teachers, ignores the social dimension of teaching and learning, and automates poor pedagogic practices.

Whichever view is more accurate, because education plays such a key role in developing and empowering the world's citizens, understanding the impact of AI on education is increasingly important. Accordingly, in this chapter, we begin that task by exploring the various connections between AI and education. We start with the context: what exactly is AI?

A brief history and definition of AI

Reflections on intelligence have been part of the philosophical project to understand the world since ancient times, and has long been accompanied by the ambition to create an artificial intelligence (history is littered with myths about master craftsmen creating artificially intelligent creatures). One more recent example is the Mechanical Turk, a machine created in 1779 that was capable of independently playing a game of chess, long thought to be the pinnacle of human intelligence – although it later turned out that the machine was a fake. A man, concealed inside the machine, was the real chess player.

However, the official beginning of today's AI project is dated to 1956, when the term was coined at a conference at Dartmouth College by the mathematician John McCarthy who was interested in developing computer programs capable of thinking intelligently (McCarthy et al., 1956). Subsequent AI researchers mainly focused their efforts on two contrasting goals. While some were interested in exploring how biological or natural intelligence works, in order to replicate those mechanisms in computer programs, others were interested in creating programs that perform tasks better than humans without worrying about whether these programs actually think as humans do.

These alternative goals, together with the interdisciplinary nature of AI research and the overlaps with ordinary computer programming, mean that it is difficult to give a universally accepted definition of AI. Nonetheless, it is the case that the history of AI is associated with the development of increasingly sophisticated algorithms and models that are applied to areas that require human cognition – such as visual perception, speech recognition and generation, decision-making or the general capacity to learn and perform cognitive tasks (Holmes et al., 2019).

Since its creation, the field of AI has experienced periods of fast progress supported by abundant funding, interspersed with so-called AI winters when progress slowed and the funding dried up, because another AI technique had failed to deliver its promise to create a machine with human-level intelligence (Marcus & Ernest, 2019). The recent dramatic developments in AI began around 2010, when a sub-field of AI, machine learning, succeeded in the automatic recognition of objects (firstly, cats!) in images and videos at closer-to-human levels. By that time, machine learning, which requires huge amounts of data to work effectively, had been researched for decades. The rapid advances were made possible thanks to significant hardware developments and the easy availability of ever-increasing amounts of data from the Internet.

Inevitably, AI is complex (most AI engineers have a PhD in a related field), making its details difficult to fully understand. Nonetheless, it is worth summarizing some of the key terminology. Until recent times, most AI research adopted a rule- or knowledge-based approach (known as classical AI). The engineers encoded knowledge in models, and wrote software programs to process that knowledge. This approach led to so-called expert systems, computer software that can for example automatically diagnose failures in mechanical systems, but never achieved anything resembling human-level intelligence. On the other hand, an approach known as machine learning (which is often incorrectly assumed to be synonymous with AI), involves software, usually known as algorithms but again mostly written by humans, that typically identify patterns in huge amounts of data that can then be applied to new data. For example, a method known as supervised learning uses huge amounts of labelled data (such as photographs labelled with the names of the persons depicted), that can then automatically label new photographs (of the same people). Other machine learning techniques include unsupervised learning, self-supervised learning, and reinforcement learning The most successful machine learning approach, known as 'deep learning', is inspired by the way that neurons in animal brains work. It is one variant or another of deep learning[10] that have led to the current boom in AI technologies, including radical advances in natural language processing (NLP), translation and generation, speech recognition and generation (the application of NLP to spoken words as used by AI personal assistants such as Siri[11] or Alexa[12]), image recognition (such as facial and handwriting recognition), autonomous agents (such as game avatars and malicious software bots), affect detection (to analyze sentiment in text, behavior and faces), and artificial creativity (AI to create images, music or stories).

Despite the dramatic advances, behind the hyperbole there remain multiple limitations. For example, it has been argued that the machine learning approach is fast reaching its ceiling (doubling the data tends only to improve the outcomes by a small amount),[13] such that a new paradigm is now needed (perhaps involving a synthesis of classical AI and machine learning) (Marcus and Ernest, 2019). Another alternative is known as 'augmented intelligence' in which, rather than trying to create machines that imitate human thinking, focuses on machine-human collaboration, computational thinking combined with human creativity that might help solve more complex problems (Miao and Holmes, 2021). In any case, what is known as Moravec's paradox remains true: while AI can do many things that humans cannot do easily (such as calculate and identify patterns), it cannot do many things that humans can do easily (such as understand meaning and apply human values) (Moravec, 1988). Finally, as illustrated by the Mechanical Turk, it is important not to conflate something that *appears* intelligent with something that *is* intelligent.

The connections between AI and education

While we might imagine that the introduction of AI in education is a recent phenomenon, research about how computers could provide one-to-one tutoring first emerged in the 1970s (Guan et al., 2020). Today, the picture is more complex and the discourse often muddled, as AI is connected to education in at least three ways:

- Learning *with* AI: the application of AI tools in classrooms to support teaching and learning.
- Learning *about* AI: the teaching of AI, how it works and how to create it.
- Preparing *for* AI: the teaching of what it means to live in a world increasingly impacted by AI.

Before continuing, it is important to recognize the limitations of this categorization: the differences between the three connections are neither unambiguous nor rigid, indeed they overlap in various ways. In particular, the last two may alternatively be conceived as two aspects of the same task: preparing all citizens to understand to varying degrees the technical and human aspects of AI and their implications for our future. Nonetheless, the 'three connections' approach is still useful, if only because it helps ensure that certain subtleties are not forgotten.

Learning *with* AI

Learning *with* AI is the connection most often mentioned in the media and by policymakers. It can usefully be further divided into system-facing AI, student-facing AI, teacher-facing AI, and using AI to learn about learning. All these approaches have benefits, but many also raise serious concerns, such as those centred on data: data privacy, data security and data ownership (Holmes et al., 2021).

System-facing AI

System-facing AI does not directly support teaching or learning but is designed to administrate education processes. These include admissions, timetabling, identifying students at risk of dropping out, and attendance, behavior and homework monitoring (much of which all too often can be indistinguishable from surveillance). The data collected by AI-powered learning management systems (e.g. when a student has logged on and logged off, what activities they have accessed, and what objects they have downloaded) can be automatically analyzed to inform teachers and administrators.

Student-facing AI

Student-facing AI has been the focus of research for more than fifty years and has received by far the most funding[14]. More recently, from about 2010, this type of AI 'escaped' from the research lab and is now offered by innumerable private companies around the world (at least thirty of which are multi-million dollar funded). Student-facing AI typically involves using machine learning algorithms to process large amounts of student data to recommend learning pathways adapted to the individual student.

Student-facing AI includes the so-called 'intelligent tutoring systems'[15] which provide step-by-step instructions adapted to individual student accomplishments, 'dialogue-based tutoring systems'[16] which are underpinned by the Socratic method and use natural language processing to guide students in solving learning problems; 'exploratory learning environments'[17] which adopt a constructivist model and facilitate discovery learning guided by the AI, educational chatbots which provide students with anytime support[18], and automated writing evaluation which might provide formative or summative assessment (Holmes et al., 2019).

The most common, most researched, and most funded of these applications are the so-called intelligent tutoring systems (ITS). These work by providing step-by-step one-to-one tutoring (instructions and activities), detecting student behavior patterns, and providing continuous assessment and feedback. Although sophisticated and the result of years of research, ITS all too often only automate existing poor pedagogic practices, usually naïve instructionism, rather than bringing anything new to pedagogy (Holmes et al., 2021). In any case, ITS tend to be limited to well-defined and structured subjects such as mathematics, physics and computer science. They are far less effective in complex, dynamic and uncertain learning environments, and cannot address ill-defined problems that do not have a clear solution path, such as in the humanities and language arts (Holmes et al., 2019). They also inevitably reduce student agency, because of the way in which they provide their step-by-step instructions towards predetermined outcomes, 'nudge' student decisions and actions, and reduce the opportunity to learn from failure (Selwyn, 2019). Despite being limited and not as effective as human teachers, they also replace teacher functions and thus effectively de-professionalize teachers. For example, while probably every teacher would like an AI system to do their marking for them, delegating marking to an automated system takes away key opportunities for teachers to learn about their students' skills and challenges. In any case, there is little evidence that automated marking systems actually work.

Teacher-facing AI

Teacher-facing AI has received far less attention. Usually, teachers have to make do with the ubiquitous data dashboards incorporated in most student-facing AI that allow them to monitor 'data-fied' progress (Williamson et al., 2020). But there exists few AI tools that are expressly designed to support teachers – to provide, what you might think of as, an AI-powered virtual exoskeleton that helps teachers to become super teachers. In fact, the only true teacher-facing AI examples of which we are aware are designed to help teachers easily identify resources to support their teaching.[19] Perhaps the reason is that student-facing AI is the low-hanging fruit which has received decades of research attention, while true teacher-facing AI is more challenging.

AI to learn about learning

This final 'learning *with* AI' topic uses a loose interpretation of AI. Nonetheless, it involves using machine learning techniques and statistics to analyze data collected during students' online learning. It is because AI is an extremely interdisciplinary area, enriched by psychology, neuroscience, linguistics and cognitive science, that it has potential to provide insights into the process of learning (Holmes et al., 2019). In any case, over recent years, due to the increased availability of data from distance and hybrid learning modes, two closely related fields (what distinguishes them is increasingly unclear) have emerged: educational data mining (EDM) and learning analytics (LA). Both involve the collection and processing of large amounts of student interaction and other data to discern patterns, often to predict which students are at risk of failure so that they might be given additional support.[20] On the other hand, although there is relatively little research in this direction, EDM and LA do have potential to help us better understand how learning happens, and which of the learning theories taught to pre-service teachers are closer to the truth.

Learning *about* AI

As noted earlier, by 'learning *about* AI' we mean learning how it works and how to create it. In other words, in this connection we are talking only about AI from a technical perspective. However, although for analysis we have separated 'preparing *for* AI' from 'learning *about* AI', in practice it is critical that any teaching about the technical aspects of AI should be *interwoven* with teaching about the human aspects of AI (rather than tagging a brief consideration of 'ethics' onto the end of an otherwise wholly technical course, as is usually the case). That said, 'learning *about* AI' involves teaching about the AI techniques and technologies that we mentioned earlier (classical AI, machine learning, deep learning, NLP, facial recognition, autonomous agents and so on).

AI curricula

Many countries have integrated ICT and digital skills curricula into formal education systems over recent years, and a few are also now introducing AI curricula into schools. At the same time, in the United States, the AI4K12[21] curriculum is being independently developed for use across all educational settings, while most of the world's largest technology companies have also developed their own AI curricula. Nonetheless, whatever the mechanism, across the world – albeit currently in limited ways – students as young as five years' old are being introduced to AI, how it works and how to create it, helping them to understand what it can do, even if they have no intention of ever becoming an AI engineer. Nonetheless, this integration of AI curricula in school education should over time help develop a more diverse pool of AI experts, a better gender balance, and a mix of cultural values, which hopefully will filter down in positive ways to the AI tools that are developed.[22] At the other end of the education journey, most Higher Education institutions around the world offer one or more courses teaching the AI techniques and technologies mentioned earlier, all designed to train the AI engineers and developers of tomorrow (while helping countries establish their AI competitive edge).

The role of teachers

Finally, the successful implementation of AI curricula will not be possible without teachers – which means that teachers need to be trained. This training should include content knowledge for teachers who will teach about AI (including teachers who might usefully teach about the use of AI in music, writing and the other arts), as well as appropriate pedagogies for those who will use student-facing AI tools in the classroom. In particular, teachers and schools administrators, who might not possess specific technical knowledge, need to be able to evaluate properly the AI tools that they are considering using (Holmes et al., 2018), so that they might decide if and how they might be used to augment the learning process, or if they might have any negative consequences.

Preparing *for* AI

As noted earlier, by 'preparing *for* AI' we mean the teaching of what it means to live in a world increasingly impacted by AI. In other words, in this connection we are talking about AI from a human perspective – which as we have mentioned should be interwoven with 'learning *about* AI'. To begin with, preparing *for* AI means focusing school curricula on the essentially human skills that AI is unlikely to be any good at for many years to come (such as creativity, collaboration, critical thinking, communication, value judgements, and social and emotional learning), rather than continuing to teach what AI can already do better than humans. It also means addressing the fact that learners are increasingly interacting not only with other learners but also with non-human intelligence or technologies, a new dimension of relationships that will have profound social and ethical implications (Facer, 2021). And it also means a focus on the human issues, such as the fairness, accountability and trustworthiness of AI. For example, when teaching how facial recognition works and how it can be created, students should also consider at the same time, or at least in the same session, the ethical consequences of facial recognition (e.g.

the inability of current facial recognition systems to recognize women of color as accurately as they recognize white men, and the impact of facial recognition when used in CCTV systems in public spaces). The reality is that this rarely happens, and when it does the ethics tends to be 'taught' by computer scientists who, although experts in their own field, usually do not have any ethics training. In short, while university courses in AI are beginning to look seriously at what it means for their AI to be ethical, it is key that the AI engineers and developers of tomorrow are at least capable of considering the complex implications of their work for wider society.

The ethics of AI in general has been addressed by innumerable governments and institutes around the world, leading to a vast array of principles and regulations (Jobin et al., 2019). However, the ethics of AI for education (which is likely to be different from, for example, the ethics of AI for health or transportation) is yet to be fully worked out (Holmes et al., 2021). As we have noted, almost all contemporary AI tools require the collection and analysis of data, which is why most ethical principles focus heavily on that data (addressing issues such as privacy, security and ownership). Most AI for education also involve data, but, while addressing the ethics of that data is necessary, it is not sufficient: for AI and education, it is important also to consider the ethics of education. Issues such as the ethics of teacher expectations, teacher roles and relations between teachers and students, and particular approaches to pedagogy, all also need to be considered (Holmes et al., 2021). In fact, it might be more challenging to determine what is ethically acceptable for AI and education than in any other area, as the consequences might be witnessed only in the long-term (Selwyn, 2019).

What else does it mean to prepare for AI? What are the other transversal issues that need to be properly considered by students, indeed all citizens, around the world? Here we mention briefly just a few, firstly some data-related issues: bias, privacy, consent and ownership; then some education-related issues: value alignment, autonomy, agency, empowerment, pedagogy, and the future of work.

Bias

Technology is never neutral; instead it reflects the cultural norms and values of the humans who create and process it. For example, machine learning models can all too easily be biased if the data that informs it is biased (which is often the case for data scraped from the Internet), or because the developers encode (albeit unintentionally) their own cultural values in the algorithms. In other words, while AI developers position AI tools as less biased than humans, biases in AI do still exist – which may lead to the colonization of knowledge and learning with AI tools that are not culturally appropriate. For example, if the model used by a student-facing AI tool is trained on data generated by young people in Europe or the US, this might have negative consequences for young people in Asia or Africa.

Privacy, consent, and ownership

Every citizen should be able to understand the implications of data sharing and how AI algorithms can affect privacy, equity and sustainability. When young people in schools are asked to engage with a student-facing AI tool, they will generate large amounts of personal interaction data that is aggregated by the system. This raises multiple questions. To begin with, have the young people genuinely given their informed consent for this data to be collected, processed and re-used? Indeed, are they legally competent to give such consent, or have their legal guardians given consent on their behalf? Developers might reply: if the teacher is happy to use the system, why do we need the consent of the students? We do not ask for student consent when a teacher decides to use a particular textbook or non-AI classroom tool. However, introducing the AI changes things. In particular, the data generated by the student almost always leaves the classroom, to be appropriated by the company who developed the tool, and re-used to enhance that company's algorithms.

We also need to consider how the generated data is processed, whether it is stored securely, and who holds the ownership (Renz et al., 2020). If the student were to write an essay, draw a design, or compose some music, they would own what they have produced. Why then does not the student (or, indeed, people in general) own the data that they create by means of their interaction with an AI system? Data is valuable – indeed, it is data that drives most AI companies' business models. The collection of such a wide range of personal data also raises issues of privacy and surveillance. Where is the moral case for external companies to know what a student clicked and when, for how long they watched a video, or where they are on campus? Many student-facing AI systems even aim to infer the student's affective state, with the laudable intention of helping move them from a negative to a positive affective state in order to enhance their learning, but doing so represents an unprecedented at-scale invasion of personal space.

Value alignment

One of the main concerns related to the design and deployment of AI, especially in education, is that while trying to imitate human cognition it cannot understand human goals – if only because humans do not all share universal goals. If we cannot define human objectives completely and correctly, it means that we cannot code them in AI (Russell, 2019). This leads to the core problem of value alignment. If we allow AI tools to make informed decisions on our behalf, how do we ensure that the values incorporated in these decisions are the ones that we want? This is specifically important in the area of education, which is an extremely complex environment that does not always include clear definitions and rules.

Autonomy, agency and empowerment

Quality education is not only about cognitive knowledge, but also collaboration, empathy and respect for the diversity of human beings and ideas. Teacher-student relations can empower and motivate: a single glance or word of encouragement at the right moment can have a big impact on a student. But can student-facing AI do the same, or do those tools risk undermining learner's agency, autonomy and curiosity? For example, ITS, while adapting pathways for students, promote only a certain 'right' type of action and aim to prevent students failing, which prevents them learning from such an experience. This might cause learners and teachers to over-rely on AI decision-making, leading to an inability to act independently (Selwyn, 2019), much like how GPS technologies have impacted our ability to self-navigate around town (Dahmani and Bohbot, 2020). In particular, the personalization of learning, which is entirely based on statistical averages, effectively deprives learners of their own individualities (Koenig, 2019) and the opportunity to self-actualize.

Pedagogy

As noted earlier, most student-facing AI can be accused of automating poor pedagogic practices (essentially didactic instructionism with no opportunities to collaborate or learn from failure). This reflects many developers' naïve understanding of what actually constitutes good quality education (after all, they went to school, so they understand education). Spoiler alert: education is not just about memorization and recall, and it is particularly not just about memorizing and recalling facts and procedures. Nonetheless, where are the AI tools that challenge existing pedagogy or that add to the lexicon? For example, it has been argued that for too long education systems have depended on end-of-course no-talking examinations to assess and accredit student achievements. However, while there is a great deal of research in e-proctoring (i.e. automating a practice that is questionable with techniques indistinguishable from surveillance), where is the research into AI-powered alternative approaches to assessment and accreditation? There are many possibilities, some that de-professionalize and some that empower teachers, but so far few funding opportunities.

The future of work.

Given that AI-powered tools can perform many routine tasks, potentially allowing humans to focus on complex work that also requires empathy or common sense, the introduction of AI is likely to affect most professions in all sectors, especially in middle-skills jobs. On the other hand, there is likely to be a growing demand for high-skilled jobs that will require both technical digital and transversal socio-emotional and communication skills. However, a closer look shows that AI and related technologies can automate not only manual tasks but also some cognitive tasks, which might drastically change the nature of human involvement in, and the quality of, work (Buchanan et al., 2020). Consequently, education will have an increasingly important role to play, preparing citizens for a world in which job roles are constantly shifting, and helping to re-skill people as needed throughout their lives. In addition, education and regulations are key to ensure that AI applications do not negatively affect workers' well-being, but instead empower and augment them. They are also key to ensure that the developers (those who drive AI research, design and deployment) promote sustainable development, advance universal human rights and pursue social equity and economic prosperity for all (Shiohira, 2021).

What's next?

Disruptive technologies, climate change, widening inequalities and global crises such as the COVID-19 pandemic have all emphasized the need to re-think the consequences of human actions and the role of education in shaping our future societies (Appadurai, 2020) – if only because, besides being one of the key factors for social and economic development, education is also a vehicle for transmitting and building shared purposes and values. This is why we need a collective effort to re-imagine both education that empowers teachers and students, and how AI can open up avenues for innovation, creativity and self-actualization. Here, this raises two questions: How can we make better AI tools, and how can education help address the challenges created by AI?

How can we make better AI tools for education?

The design and development of future student-facing, teacher-facing and system-facing AI tools should adopt a human-centred approach (Mitchell, 2019) and be problem-oriented. They should start with the definition of challenges and root causes. Although the dominant narrative suggests otherwise, AI technologies cannot provide solutions to all education problems (and just because an AI system *can* do something does not mean that we *should*). For example, putting an ITS into a rural context because there are insufficient qualified teachers may be of benefit to one cohort of learners but this Silicon Valley-inspired techno-solutionism does not solve the actual problem – instead, we probably need to focus on increasing the numbers of qualified teachers by means of professional development. In short, AI technologies for use in education should *by design* be underpinned by educational values, should address real educational big problems, should not be driven by the private sector, but should be developed in cooperation with all actors (from learners and teachers, to policy-makers and civil society).

Any learning *with* AI tool should also by its very nature be designed to augment a teacher's work and not de-professionalize them (replace or degrade their status or dignity). Instead, developers need to recognize that the pedagogical process is always under construction and can be unpredictable, while AI tools (at least for the foreseeable future) lack common sense and nuanced understanding of educational contexts. For example, even if the learning content is adapted to the individual, it does not necessarily mean that it is delivered by means of the most effective pedagogical approach or towards helping the student to self-actualize (rather than just pass the same superficial examinations as everyone else).

A human-centered approach should be at the heart of all AI tools and initiatives. AI might be able to identify learning patterns in the huge amounts of data that it collects that otherwise would have never been discovered and thus provide some useful insights, but it cannot create embodied social interactions between students or between students and teachers, nor can it express the whole richness of human experiences. In short, the reality is that not all that is worth knowing and learning can be incorporated into digital devices and reduced to algorithms – which is why AI classroom tools should be designed to support not replace teachers.

How can education help address the challenges created by AI?

Finally, education as a site for critical study (i.e. both learning *about* AI and preparing *for* AI) can enable people to handle the challenges arising from AI from both a technical and humanistic perspective. It can provide the underpinning for new professions, but also raise awareness of the emerging impact of AI on humanity and inform philosophical debates on potential human-machine relationships. Informed citizens should be able to establish regulatory and monitoring mechanisms to ensure that AI technologies – especially those used in educational contexts – do not amplify existing inequalities, but instead benefit the most vulnerable or marginalized and contribute to the common good. Indeed, AI and its impact on education create challenges and opportunities, but ultimately it is social and political choices – not just the technologies or the technologists – that will determine how AI contributes to education and the outcomes for all.

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ENDNOTES

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[1] e.g. “Hundreds of AI tools have been built to catch covid. None of them helped.” (Douglas Heaven, 2021) (https://www.technologyreview.com/2021/07/30/1030329/machine-learning-ai-failed-covid-hospital-diagnosis-pandemic).
[2] e.g. “ The race to understand the exhilarating, dangerous world of language AI (Hao, 2021) (https://www.technologyreview.com/2021/05/20/1025135/ai-large-language-models-bigscience-project).
[3] e.g. “Deepfakes Are Going To Wreak Havoc On Society. We Are Not Prepared.” (Toews, 2020) (https://www.forbes.com/sites/robtoews/2020/05/25/deepfakes-are-going-to-wreak-havoc-on-society-we-are-not-prepared/?sh=7dfbdd9e7494).
[4] For a helpful explanation, see “About Face ID advanced technology” (https://support.apple.com/en-gb/HT208108)
[5] For a helpful explanation, see “The Impact of Artificial Intelligence On Social Media” (https://medium.com/humansforai/the-impact-of-artificial-intelligence-on-social-media-579345b6f751).
[6] e.g. “Colleges are turning students’ phones into surveillance machines, tracking the locations of hundreds of thousands.” (Harwell, 2019) (https://www.washingtonpost.com/technology/2019/12/24/colleges-are-turning-students-phones-into-surveillance-machines-tracking-locations-hundreds-thousands).
[7] e.g. Unitime (https://www.unitime.org).
[8] See Endnote 15.
[9] e.g. see “Using AI to measure student engagement” (https://www.educationmattersmag.com.au/using-ai-to-measure-student-engagement).
[10] For a helpful explanation of deep learning, see “Top 10 Deep Learning Algorithms You Should Know in 2021” (https://www.simplilearn.com/tutorials/deep-learning-tutorial/deep-learning-algorithm)
[11] https://www.apple.com/uk/siri
[12] https://www.digitaltrends.com/home/what-is-amazons-alexa-and-what-can-it-do
[13] At the beginning of 2021, Google announced Google Brain, an artificial intelligence language model that uses 1.6 trillion parameters (units of data). Nonetheless, although in many ways impressive, Google Brain still does not understand language as a human does.
[14] For one perspective on the funding of student-facing AI, see: “The Next Wave of Edtech Will Be Very, Very Big — and Global” (Corcoran, 2021) (https://www.edsurge.com/news/2021-07-30-the-next-wave-of-edtech-will-be-very-very-big-and-global).
[15] Commercial examples of ITS include Mathia (https://www.carnegielearning.com/solutions/math/mathia), alta (https://www.knewton.com/what-is-alta), Alef (https://alefeducation.com), ALEKS (https://www.aleks.com), Byjus (https://byjus.com), Eshuri (https://eshuri.rw), M-Shule (https://m-shule.com), and Squirrel AI (http://squirrelai.com). Non-commercial examples include ViLLE (https://www.learninganalytics.fi/en) and Assistments (https://new.assistments.org).
[16] Examples of DBTS include AutoTutor (http://ace.autotutor.org/IISAutotutor/index.html) and Watson Tutor (https://www.ibm.com/blogs/watson/2018/06/using-ai-to-close-learning-gap).
[17] Examples include ECHOES (https://sites.google.com/site/echoesproject), Fractions Lab (https://www.italk2learn.com), and Betty’s Brain (https://wp0.vanderbilt.edu/oele/bettys-brain).
[18] Examples include Ada (https://www.jisc.ac.uk/news/chatbot-talks-up-a-storm-for-bolton-college-26-mar-2019), Eneza (https://enezaeducation.com), and Deakin Genie (http://genie.deakin.edu.au).
[19] The two true teacher-facing AI examples, both of which curate learning resources, are X5GON (https://www.x5gon.org) and IBM’s Teacher Advisor (https://teacheradvisor.org).
[20] One example is OUAnalyse (https://analyse.kmi.open.ac.uk).
[21] https://ai4k12.org
[22] For example, see “Black in AI” (https://blackinai.github.io/#) and “Women in AI” (https://www.womeninai.co).