Education International Research

The Unintended Consequences of Artificial Intelligence and Education

Wayne Holmes
on behalf of Education International

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Executive Summary

As has become obvious in recent months, Artificial Intelligence (AI) is increasingly impacting on many aspects of our daily lives. This is no less true in education (AI&ED). However, how AI will impact education, how it will affect teaching and learning and how it might change the roles of teachers and learners, remains uncertain. Accordingly, this report sets out to provide an analysis of the current state of AI&ED, including its potential benefits and risks, as well as the role of teachers and teacher trade unionists in ensuring that teaching with and about AI is aligned with the principles of social justice and human rights.

To provide a context for AI&ED, the report begins with an overview of AI – defining it as a field of computer science that seeks to develop machines capable of performing tasks that would typically require human intelligence. AI has been researched since the 1950s but it has made recent dramatic progress thanks to advancements in computing power, the availability of large amounts of data, and some innovative computational approaches. Today, there does not appear to be any aspect of life in which AI is not involved. AI systems underpin everything from mobile phones apps to online shopping, weather forecasts to medical diagnostics, financial and legal services to autonomous vehicles, and much more besides. However, while these developments might appear exciting, AI also raises multiple concerns, such as privacy and security risks, harmful biases, job displacement, and other potentially negative impacts of AI on society. For these reasons, there is increasingly a need for transparency and accountability in AI systems, as well as greater attention to issues of disempowerment and social inequity.

The report then moves onto AI&ED itself, discussing the connections between AI and education in term of two components: teaching and learning with AI (also known as AIED), and teaching and learning about AI (also known as AI Literacy).

AIED is itself complex. There are at least twenty different types of AIED, such that it is not possible to make general claims about its efficacy or safety. Instead, it is important to consider each application, or at least each type of application, separately, and to be clear about which of the multiple variations of AIED applications are being discussed. Accordingly, the report divides AIED into three overlapping categories: institution-focused, student-focused, and teacher-focused AIED, and having first discussed what they involve and their implications, goes on to give detailed examples (the intention being to illustrate the complexity of this space).

Student-focused AIED is where most of the excitement and the money is currently found. It has been researched for more than forty years and is now offered around the world by thousands of SMEs and large numbers of million-dollar-funded companies. This commercialisation of education has become an increasingly concerning issue, as companies seek to exploit new data-rich business models, inevitably undermining the principle of education as a public good. Examples of student-focused AIED include adaptive tutoring systems, dialogue-based tutoring systems, virtual writing assistants, automatic writing evaluation, and chatbots – each of which aims to automate one or more functions of a teacher's role.

Meanwhile, teacher-focused AIED remains mostly speculative. In other words, applications to genuinely support teachers (rather than to replace teacher functions) have not received much attention and there are only a few available examples (such as the automatic curation of learning materials, and classroom monitoring and orchestration). Finally, there is institution-focused AIED which includes AI-enabled tools designed to help with student recruitment, security, finances, and other unglamorous back-end administrative tasks that educational institutions need to do. This is probably the least visible type of AIED, although in the future it may become the most influential.

In fact, many AIED tools are questionable, whether for ethical, pedagogical, or educational reasons. In particular, they may reinforce existing biases and inequities, involve the commercial exploitation of student data, embed primitive approaches to pedagogy, and exacerbate the divide between the privileged and underprivileged, particularly in developing nations. In addition, as this report repeatedly notes, there is limited independent evidence at scale for the efficacy or safety of AI in education, or for any of the claimed benefits.

The importance of AI Literacy, teaching and learning about AI, is then discussed. Universities across Europe and beyond have been offering degrees in a range of AI subjects for years, but teaching about AI in schools remains relatively uncommon, and when it does exist it mostly focusses on the technology. However, AI Literacy comprises a human as well as a technological dimension. While the technological dimension is about how AI works, the techniques and technologies involved and how to create it, the human dimension is about the social, ethical, and rights implications of AI. In fact, teachers and teacher trade unionists play a crucial role in ensuring that teaching about AI supports human rights and social justice, empowers teachers, and supports student agency – which can only be achieved by involving all stakeholders, especially teachers, but also students, parents, and other community members.

The report culminates in a consideration of several key issues raised by AI&ED and some recommendations. The first issue centres on intelligence: the claim that AI is intelligent, and the negative implications this can have

for society and education. While AI has the ability to process and analyse vast amounts of data at speeds beyond human capabilities, and while it may mimic intelligent behaviour and sometimes even appears intelligent, it actually lacks consciousness and any real understanding. The fact is that no AI system is capable of replicating the nuanced and complex thinking of human intelligence. Accordingly, the suggestion that AI is intelligent can lead to a devaluation of human intelligence, an over-reliance on AI systems, and a neglect of the social and emotional aspects of learning, all of which are crucial for human flourishing.

The report also questions the broad push for AI-enabled personalised learning, which has been proposed for almost a hundred years as a remedy for various educational problems, such as student disengagement, lack of motivation, and achievement gaps. However, AI-enabled personalised learning is deeply influenced by the Silicon Valley perspective, which over emphasises technology and individualism at the expense of community. One of the significant drawbacks of AI-enabled personalised learning (which is quite different to differentiated teaching) is the potential erosion of social interactions in education, critical for fostering trust, motivation, and engagement. Meanwhile, by overly emphasising individual learning paths, it can actually undermine students' self-actualisation, leading to homogenised learning outcomes. It can also downplay the crucial role of education in community-building and social skills development, ignore the holistic development of students, and potentially perpetuate socio-economic and cultural disparities.

In addition, the report considers AIED's disempowerment of teachers, reducing their role to mere technology operators while decisions about what and how students should learn are made by the commercial organisations behind the AI. This diminishes the professionalism and expertise of teachers and turns education into a commodity, where teachers are seen as service providers. Instead, AIED should be designed to support teachers rather than replace them, but many AI applications only displace teachers' time as they struggle to make the system work for their specific classroom needs. While some policymakers might see potential cost savings in automating tasks like grading, implementing AIED to replace teachers compromises classroom practices, reduces educational quality, and undermines students' rights and success.

AIED is also contributing significantly to the escalating commercialisation of education, which poses significant risks to the sector's integrity, and undermines education as a shared public good. Companies inevitably prioritise profit over efficacy and safety, human rights and social justice, all of which could lead to exclusive, inaccessible and unaccountable educational systems. Particularly concerning is the potential for AIED to reinforce existing biases and inequities, heightening the divide between privileged and underprivileged students. In addition, AIED's emphasis on standardised

testing and measurable outcomes overlooks individual student needs and stifles teacher creativity. Other concerns include the exploitation of student data (which threatens privacy and surveillance issues), the risk of a new digital divide, the potential loss of human interaction, and the possibility of a narrow, technocratic view of education. Commercialisation could also degrade the role of teachers, reducing them to service providers (the person who switches on the computers and maintains classroom behaviour), which both fundamentally misunderstands and underestimates the expertise and responsibilities of teacher professionals.

In addition, the adoption of AIED by developing nations, driven by Western or Chinese organisations, can inadvertently perpetuate neo-colonialism, reinforcing existing power imbalances and systemic inequities. AI tools, such as adaptive tutoring systems, often unintentionally incorporate inherent cultural biases favouring Global North cultures and languages, leading to cultural hegemony and marginalising local languages and cultures. This deployment of AIED is usually disconnected from local contexts, and can further marginalise underprivileged students. One potential solution is locally-led, community-driven AIED that is sensitive to local needs and contexts. Ensuring the application of AIED adheres to principles of transparency, accountability, and ethical responsibility is also crucial to prevent reinforcing existing power dynamics.

In fact, ethics is essential for responsible AI innovation in education – particularly the principles of ethics by design. This means actively embedding ethical considerations in the development of AIED from the outset, ensuring transparency, data privacy, bias mitigation, and human-centeredness throughout. Transparency enables understanding how AI decisions are made and data is used, bolstering trust. Privacy involves responsibly managing student data to maintain user trust and protect sensitive information. Addressing biases and promoting fairness prevents potential discrimination and inequities in educational settings. Maintaining human agency ensures AI supplements but does not replace human educators or decision-making. Constructivist pedagogies can be incorporated into AI systems, promoting active engagement and critical thinking. In essence, ethics by design might help harness the potential of AI while preserving human values and encouraging effective teaching and learning practices.

Finally, the report concludes that teachers and teacher trade unionists hold a pivotal role in ensuring that AI in education aligns with human rights, social justice, and supports teacher and student agency. This may be achieved by continuing to advocate for democratic control over education and the ethical use of AIED, underpinned by human-centric AI Literacy (that includes the human dimension as well as the technological dimension of AI). Empowering teachers with AI training and inclusion in AI decision-making processes can help them effectively support their students' AI Literacy, while enabling them to decide whether and which AI tools to use in their classrooms. In

addition, advocating for transparency, accountability, and regulation of AI in education is paramount. Involving all stakeholders – teachers, students, parents, and community members - can reinforce the alignment of AI with human rights and social justice. Lastly, teachers and trade unionists need to critically engage with the narrative around AI in education, questioning unsubstantiated claims, demanding evidence of efficacy and safety, ensuring that key decisions about AI in teaching are collectively made by educators, and avoiding the unintended consequences of AIED.

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Introduction

1. Introduction to the report

As Artificial Intelligence (AI) continues to permeate various aspects of our lives, its impact on education (AI&ED) is rapidly increasingly. However, the extent of this impact and its implications for teaching, learning, and the roles of educators and learners remain uncertain. This report discusses the current state of AI&ED, exploring its potential benefits and risks, while also examining the vital role of teachers and teacher trade unionists in ensuring that the application and teaching of AI in education upholds principles of social justice and human rights.

2. Outline of the report

- **Artificial Intelligence: a brief introduction**
  To contextualise AI&ED, the report starts with an overview of AI. This is followed by a consideration of various concerns raised by AI, such as those around privacy, biases, job displacement, and social inequities.
- **AI and education**
  The report then discusses AI&ED, distinguishing between teaching and learning with AI (AIED) and teaching and learning about AI (AI Literacy).
- **Teaching and learning with AI (AIED)**
  AIED includes diverse applications, divided into student-focused, and teacher-focused, and institution-focused, categories, each with its own implications.
- **Teaching and learning about AI (AI Literacy)**
  AI Literacy encompasses not only the technological dimension but also human dimension of AI – the social justice, ethical, and human rights implications.
- **AIED in practice**
  Drawing on a taxonomy, in this section 24 different types of AIED (as developed for six educational sectors, from early years to tertiary education and professional learning) are discussed. Examples of each

are given, while the potential benefits, the (all too often non-existent) evidenced benefits, and the risks and challenges are identified.

- **Unintended consequences**
  In this penultimate section, the report considers four critical issues raised by AI&ED: the misconceptions about artificial intelligence, the drawbacks of AI-enabled personalised learning, and the escalating commercialisation of education.

- **Recommendations**
  The report concludes with a call for an ethics by design approach, to ensure responsible AI innovation, and highlights the potential of teachers and trade unionists in shaping AI's role in education with a focus on human values and effective teaching practices.

3. Methodology

This report draws upon a range of publications, including UNESCO's *AI and Education. Guidance for Policy-makers* (Miao & Holmes, 2021); UNESCO's Global Education Monitoring Report (UNESCO GEM, 2023); UNESCO's International Forum on AI and Education: Ensuring AI as a Common Good to Transform Education, synthesis report (Miao & Holmes, 2022); UNESCO's *K-12 AI curricula. A mapping of government-endorsed AI curricula* (Miao & Shiohira, 2022); UNESCO's *Understanding the Impact of Artificial Intelligence on Skills Development. Education 2030* (Shiohira et al., 2021); the Council of Europe's *Artificial Intelligence and Education. A Critical View Through the Lens of Human Rights, Democracy and the Rule of Law* (Holmes et al., 2022); the EU's *DigComp 2.2. Annex 2. Citizens Interacting with AI Systems* (Vuorikari & Holmes, 2022); the EU's *Ethics Guidelines for Trustworthy AI* (European Commission et al., 2019); the EU's *The Impact of Artificial Intelligence on Learning, Teaching, and Education* (Tuomi, 2018); the Centre for Curriculum Redesign's *AI in Education. Promise and Implications for Teaching and Learning* (Holmes et al., 2019); the *Ethics of AI in Education. Practices, Challenges and Debaters* (Holmes & Porayska-Pomsta, 2023); and *State of the Art and Practice in AI in Education* (Holmes & Tuomi, 2022).

In Section 4 of this report, more than 150 individual AI-enabled AIED applications are named – the aim of including such a broad range of AIED applications being to illustrate to the reader the complexity of the space and why it is not possible to evaluate the efficacy and safety of AIED as a whole, but only in terms of the various types of AIED and specific applications. Identifying those applications involved snowball searching (drawing on the reports cited above) supported by extensive academic literature searches and general web searches. Inevitably, the results are limited to applications

that have been reported in English (the language spoken by the report's author) and those that have been developed in high income countries (because the search revealed very few applications developed in low-income countries, presumably partly because of language but also because rarely are the resources available to potential developers of AIED applications in low-income countries). Only those AIED applications for which there were accessible descriptions were included in this report; however, as repeatedly noted, there is very limited evidence for any of the claimed benefits.

Artificial Intelligence: a brief introduction

For some, "Artificial Intelligence" conjures up images of a dystopian future ruled by emotionless humanoid machines. However, the reality is that Artificial Intelligence (AI) is already among us, as many have begun to realise following the recent launch and the rapid take-up of the AI tool ChatGPT[1]. Increasingly every day in most countries, we all engage with AI in almost every aspect of our daily lives: whether we are using our mobile phones, reading an article in a newspaper, buying something online, checking the weather forecast, playing a computer game, being injected with a vaccine – the list is endless.

So, what exactly is AI? AI is a field of computer science that emerged from the field of cybernetics (the study of control and communication in living organisms and machines) and that seeks to develop intelligent machines. This is usually taken to mean machines that are capable of performing tasks that would typically require human intelligence. AI was named by the computer scientist John McCarthy at a workshop held in 1956 at Dartmouth College (a US Ivy League research university). However, since then, AI has been defined in multiple ways, often by and for computer scientists in ways that are challenging for non-experts to understand. A simple definition for non-experts is provided by the online Oxford English Dictionary:

> *The capacity of computers or other machines to exhibit or simulate intelligent behaviour.*

This definition is helpful because it does not depend entirely on data (Holmes & Porayska-Pomsta, 2023). While it does accommodate the data-driven AI techniques that have led to the dramatic recent developments, it can also include symbolic AI (an earlier knowledge-based approach that is still used in many AI applications in education) and any new paradigm of AI that might emerge in future years. However, it does not reference the role of humans, which is important given the critical role of humans at all stages of the AI development pipeline (including setting the objectives, collating and cleaning the data, choosing the algorithms, evaluating the outputs, aligning with human values, and so on). Finally, while it does distinguish by omission between intelligent behaviour and intelligence, it does not do so clearly – which is important because no AI systems are in any meaningful sense actually intelligent. Nonetheless, this definition can easily be extended for the

1 https://chat.openai.com

application of AI in education.

In recent months, at least partly because of the field's name, the media have often debated whether one AI system or another is conscious, sentient or intelligent. It is true that some AI systems might appear to be intelligent, or at least their output might appear to be the output of an intelligence (much like the eighteenth-century Mechanical Turk which fooled many into believing it was autonomously playing chess, Schaffer, 1999). However, despite the ambitions of the field, and despite any convincing appearances, it is important to recognise that no AI system today is intelligent (or conscious or sentient). For all these reasons, some have argued that (much to the consternation of some sub-editors) the words Artificial Intelligence should always be capitalised, "to highlight that it is a specific field of inquiry and development, and not simply a type of intelligence that is artificial" (Holmes & Tuomi, 2022). In any case, there remains little prospect of any genuinely intelligent AI system (what is known as Artificial General Intelligence) in the foreseeable future. In fact, AI might more properly be known as "Automatic Statistical-, Probability- or Rule-based Analysis, Prediction, Control or Generation Systems" or at least as a subfield of cybernetics, despite the limited opportunities these give for a memorable acronym. AI remains the most common shorthand.

Much of the hype and speculation surrounding AI focuses on hypothetical futures inspired by science fiction. In fact, from the 1960s, AI developed in fits and starts with periods of rapid progress (for example, the period during which the field focused on rule-based symbolic AI or knowledge-based expert systems) interspaced with periods known as AI winters where confidence in the field and funding all but evaporated (partly because of the over-promising and under-delivery of advancements by the AI researchers). The dramatic progress that we have seen over the past decade are due to three key developments: faster computer processors (it has been suggested that computer processing power is currently doubling every four months), the availability of large amounts of big data (thanks to the Internet), and advances in computational approaches.

Meanwhile, the dramatic developments that we have seen over the past few months have less to do with the underlying technology (which has been available for years) and more to do with an arms race between the big technology companies (the desire to be first to market in order to inflate their profit line and share value), and the controversial decision to make easily available to the public what is a powerful technology with unknown consequences.

In fact, while the potential benefits of AI may be significant, there are also concerns about its impact on society. One concern is the risk of job displacement as AI systems become increasingly capable of automating tasks that were previously done by humans. There are also serious concerns about privacy and security, as AI systems can collect and process vast amounts of

personal data. In addition, there is the risk of harmful biases in AI systems, as they can perpetuate existing societal biases present in the data they were trained on. It is interesting that such a futuristic technology as AI is firmly rooted in the past, from which all the data it uses is derived. This means that AI systems rely on data sets that most often reflect social and cultural biases, leading to discriminatory outcomes. For example, facial recognition technology has been shown to be less accurate for people of colour and women due to biased or incomplete training data. Algorithms can also perpetuate and amplify existing inequities, such as through discriminatory hiring or lending practices. Another issue is the lack of transparency and accountability in AI systems – as many AI models are opaque, making it difficult for individuals to challenge or appeal decisions made by such systems. This is especially important in areas such as criminal justice or healthcare and increasingly education where such decisions can have significant consequences.

To address these concerns, increasing numbers of researchers (such as Emily Bender, Timnit Gebru, Gary Marcus, Mel Mitchell, and Meredith Whittaker) are calling for increased transparency and accountability in AI systems, as well as greater attention to issues of bias and social inequity. This could include measures such as mandatory auditing of AI systems, greater diversity and inclusion in the development and deployment of AI systems, and increased public awareness and education about the potential impacts of AI.

1. Generative AI

Following the launch in November 2022 of the automatic text generation tool ChatGPT, generative AI has captured everyone's attention. Although ChatGPT is probably the best-known text generative AI tool, there are already many similar tools from other BigTech organisations (as well as generative tools for images, videos, and music). The text generation tools all work like the autocomplete you find in some email and word processing programmes, but taken to an order of magnitude much higher. In response to a prompt, they identify in their database of billions of words the word that is most likely to be a good start to a relevant sentence. Then they identify the most likely next word, and the next, and so on. Because of its access to billions of previous sentences, its output can look impressively human-like. It is usually fluent and can be convincing. However, just like human-written texts, text GenAI outputs can be superficial, inaccurate, untrustworthy, and full of errors. Most importantly, despite appearances, no GenAI tool understands the text it is trained on, the prompt it is given, or the output it generates.

As the University of Oxford Associate Professor Carissa Véliz writes:

> *"Large language models [which is the technology behind text GenAI] are the ultimate bullshitters because they are designed to be plausible (and therefore convincing) with no regard for the truth."* [2]

Inevitably, generative AI raises multiple ethical concerns. The text that ChatGPT and other generative AI tools output looks accurate but often it is not. If it is used to generate text about something in which you are an expert, you will notice immediately its superficiality, what it misses, and what it makes up. However, novices (such as learners) in the topic are unlikely to notice such issues. To them, the output can look definitive, which can lead to various misunderstandings.

A second problem is that generative AI only generates the most likely text that emerges from the Internet. In other words, it reproduces the opinions that are most common or dominant (to give a metaphor, if ChatGPT had been developed in the 1950s, it would be outputting confident statements that smoking cigarettes is good for our health). This means that it inevitably further marginalises voices that are already marginalised, such as those from minority cultures. It also inevitably makes writing more homogeneous, as its suggestions by definition reproduce standard ways of expressing ideas and normative values – the voices and values that dominate the Internet, especially those from high-income countries in general, and from Silicon Valley in particular. It also might undermine innovation, as innovation always begins as a minority voice.

A final problem for text generative AI also stems from the fact that it scrapes all its data from the Internet, which means that its data is full of disturbing materials and biases. To address this, the company that created ChatGPT employed thousands of workers (many in low- income countries for a payment of as little as $2 an hour), to identify and prevent offensive ideas appearing in its output. The same is true for the other generative AI developers. This process is known as setting up guardrails; and the fact that it is necessary undermines GenAI's fundamental approach.

Image, music and computer code generative AI are similarly impressive and problematic. While they are capable of generating some extraordinary images, human-like music, and working programming code, they are based on images, music and computer code taken from the Internet with no consideration for the Intellectual Property (IP) of the creators. Various court cases that are in progress will determine how this is addressed.

2 https://t.co/xdDXttibQG

AI and education (AI&ED)

It is easy to find many enthusiasts (including many well-funded corporations) who will tell you all about how AI will revolutionise education. To give one example:

> *A classroom today still resembles a classroom one hundred years ago. We know the flaws of today's education – it is one-size-fits-all yet we know each student is different, and it is expensive and cannot be scaled to poorer countries and regions with a reasonable student-to-teacher ratio. AI can play a major part in fixing these flaws and transform education [...] With AI taking over significant aspects of education, basic costs will be lowered, which will allow more people to access education. It can truly equalize education by liberating course content and top teachers from the confines of elite institutions and delivering AI teachers that have near-zero marginal cost. [...] I believe this symbiotic and flexible new education model can dramatically improve accessibility of education, and also help every student realize his or her potential in the Age of AI. (Lee & Qiufan, 2021, p. 118)*

There may well be some extraordinary possibilities (again, as suggested by ChatGPT), but it is important to try to get behind the hyperbole and to think about the very many challenges– in other words, to bring a critical studies perspective. To begin this project, it is first important to recognise that the connections between AI and education are more complex than many acknowledge – and there are a lot of misunderstandings and little robust independent research at scale (Miao & Holmes, 2021). To help navigate the complexity, it can be useful to think of AI and education in two independent but complementary components: the application of AI in education (also known as teaching and learning with AI, or AIED), and teaching and learning about AI (also known as AI Literacy).

1. Teaching and Learning with AI (AIED)

AI is applied in education, in countries around the world, to support teaching and learning (AIED) in multiple ways. Accordingly, it is not possible either to draw simple inferences or to make grand claims about AIED's efficacy or otherwise. Instead, we need to be clear about which of the multiple

variations of AIED applications are being discussed – especially as many remain speculative while some are questionable for ethical, pedagogical, or educational reasons. Recently, the range of AIED has been summarised in a taxonomy of more than twenty different types, for most of which there are many examples, subdivided in three overlapping yet still expedient categories: institution-focused, student-focused, and teacher-focused AIED (Holmes & Tuomi, 2022). We build on this taxonomy in Section 4; here, we briefly introduce the categories.

1.1. Student-focused AIED

Student-focused AIED is where you find most of the AIED excitement and money. This has been researched for more than forty years and has now "escaped" from the lab to be offered by large numbers of million dollar-funded corporations around the world. There are many types of student-focused AI, each of which aims to improve upon (which usually means replace) certain teacher functions – with potentially major impacts on teachers.

The most prominent (researched, funded, and available) student-focused AIED are the adaptive tutoring systems (or, as they are often misleadingly called, intelligent tutoring systems). With these, the student engages with an online system that delivers some information, an activity and possibly a quiz. The student's individual responses (where they click and what they answer) then determines the next piece of information, activity, and quiz they are given. In this way, each student follows their own adapted pathway through the material to be learned. A free example adaptive tutoring system is Assistments.[3]

Other student-supporting AI includes dialogue-based tutoring systems (which use a dialogic Socratic-approach to teaching and learning – an example is AutoTutor[4]), automatic writing evaluation (examples of which, such as e-Rater[5], are increasingly being used in standardised assessments, especially in the USA), and chatbots (which use natural language processing to provide on-demand responses to student queries – an example is Ada[6]). Additional examples of student-focused AIED, designed for different education sectors, are explored in Section 4.1.

3 https://new.assistments.org
4 https://www.memphis.edu/iis/projects/autotutor.php
5 https://www.ets.org/erater.html
6 https://www.jisc.ac.uk/news/national-centre-for-ai-in-tertiary-education-launches-chatbot-pilot-14-dec-2021

1.2. Teacher-focused AIED

Teacher-focused AIED aims to help or support teachers, rather than replace teacher functions (see student-focused AIED, section 3.1.1). However, there are currently very few genuinely teacher-focused AIED available (the many student-focused AIED tools that include data dashboards for teachers do not really count) – and the ones that are available still have a way to go before they are genuinely useful. Those that do exist include automatic resource-curation (AI tools that scan the Internet in response to a teacher's query to identify quality resources that they can use in their teaching – an example is X5GON[7]), teacher coaching (essentially, ITS for teachers), assessment support (i.e., AI tools that support teachers as they assess, rather than claim to assess on behalf of teachers – an example is GRAIDE[8]), and lesson and materials generation (an example is Education Copilot[9]). Additional examples of teacher-focused AIED, designed for different education sectors, are explored in Section 4.2.

1.3. Institution-focused AIED

Institution-focused AIED includes AI tools designed to help with student recruitment, security, finances, and all the other unglamorous back-end administrative tasks that educational institutions all need to do. There are also a few more education-specific examples, including lesson timetabling, identifying students at risk, and e-proctoring; as well as some innovative applications, such as using AI to identify trends in competencies required by businesses, so that universities and Adult Education institutions know which courses they ought to consider offering. In fact, institution-focused AIED are probably the least visible, least researched and least funded type of AIED – although, because they have such wide potential, in the future they may become the most influential and so might lead to the greatest benefits and the greatest harms. Additional examples of institution-focused AIED, designed for different education sectors, are explored in Section 4.3.

2. Teaching and Learning about AI (AI Literacy)

The second, independent but complementary, component of AI and education is teaching and learning about AI, or AI Literacy. AI Literacy itself comprises both a technological and a human dimension.

7 https://www.x5gon.org
8 https://www.graide.co.uk
9 https://educationcopilot.com

2.1. The technological dimension of AI literacy

The technological dimension of AI Literacy is what most people (appear to) think of when they consider teaching and learning about AI (perhaps because AI has been developed by computer scientists – see, for example, AI4K12). It comprises learning how AI works, the techniques, and technologies, and how to create it. For years, universities across Europe and beyond have offered degrees in a range of AI subjects (including topics such as data analytics, machine learning, neural networks, and so on), enabling many graduates to take up extremely well-paid jobs as data scientists or AI engineers. In schools, the situation is quite different, as shown by a recent publication from UNESCO which maps AI school curricula from around the world (Miao & Shiohira, 2022). This revealed that the teaching of AI in schools remains relatively uncommon.

Finally, however, there are an enormous variety of online AI courses and tutorials that anyone may choose to take, most often for free. One that is extremely popular, that introduces the technologies of AI and is available to all learners, is Elements of AI, from the University of Helsinki. Another one, from France, is ClassCode.

2.2. The human dimension of AI literacy

A second finding of UNESCO's AI school curriculum mapping project was that the human impact of AI currently plays only a small part in the teaching of AI. While the ethics of AI is dutifully mentioned in most courses on AI, it is usually only a small part or it is tagged on at the end of the course after the more 'interesting' technical topics have been considered (for examples, see AI4K12 and Elements of AI, mentioned earlier). In any case, including only the ethics of AI is a very limited approach, given that the ethics is only one critical aspect of the human impact of AI on humans. The UNESCO mapping project also revealed that mostly teaching about AI remains the preserve of computer science teachers. Rarely are teachers from the arts, humanities or social sciences involved – despite the impact of AI on their particular subjects, and the need for voices from outside of computer science to investigate and better understand the impact of AI on all humans and the natural world.

In short, while the technological dimension of AI is important, in other words while all students should have an appropriate level of understanding of how AI works (appropriate to their age and/or level of education, and their context), the human dimension is equally important. The human dimension of AI means preparing everyone for the impact of AI on all our lives. It includes helping everyone deal with issues such as AI hype, AI biases, fake news, and the impact on privacy and on jobs.

While these issues are gaining increasing attention in academia and the media (usually only thanks to scandals such as those involving the big tech corporations), they are rarely embedded in any AI curriculum, whether for school students or for adults.

Finally, it is true that the human dimension of AI is not always ignored. The EU's latest version of its DigComp Digital Competence Framework specifically looks at the impact of AI on humans and the competences that all citizens should have to enable them to deal with the growing issues (Vuorikari & Holmes, 2022). Meanwhile, the Council of Europe has also investigated the impact of using AI in education on human rights, democracy, and the rule of law:

> With regard to human rights, we examine the impact of AI&ED on a child's rights to education, to human dignity, to autonomy, to be heard, to not suffer from discrimination, to privacy and data protection, to transparency and explainability, to be protected from economic exploitation and to withhold or withdraw consent for their involvement with any technology. With regard to democracy, we consider how AI&ED might both support and undermine democratic values, how democratic education, which depends on open access and equity, may be compromised by the dominance of commercial AIED applications, how certain tools promote individualism at the expense of the collaborative and social aspects of teaching and learning and the impact of AI models representing the world as a function of the past. With regard to the rule of law, we identify and examine several cases in which the use of AI algorithms in education have been subject to legal challenge – the use of historical school-level data to grade individual learners, learning data traces and biometric data. (Holmes et al., 2022, p. 9)

It is also true that neither teachers nor their professional colleagues have been given the support or the professional development that they need in order to properly understand either the human or technological dimension of AI. If teachers are to decide which AIED tools may be appropriate for their classrooms (whether for technical, pedagogical, or ethical reasons), or if they are to be able to teach their students about the possible human consequences of AI, or if students are to be taught how to critically approach AI in order to understand not only how it works but also its potential negative and positive impact, high quality support and professional development opportunities must be provided for all teachers (including teachers of literature and the visual arts, as well as teachers of the human sciences, and teachers of the natural and applied sciences).

AIED in practice

As noted in Section 3.1, AI is increasingly being widely used in schools and other educational settings. In this section, we discuss the various ways in which AI is being used in schools, drawing on the taxonomy mentioned earlier (Holmes & Tuomi, 2022), and name more than 150 individual AI-enabled AIED applications.

Note that Education International is not endorsing any of the featured tools. Instead, as mentioned earlier, the aim of including such a broad range of AIED applications is to illustrate to the reader the complexity of the AIED space and why it is not possible to evaluate the efficacy and safety of AIED as a whole, but only in terms of the various types of AIED and specific applications.

For each type of AIED, we discuss the potential benefits (i.e., the benefits that the developers claim), the evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale), and the risks and challenges. It is worth pointing out here that in fact there is actually very little evidence of benefits for almost all the types of AIED. Researchers have conducted thousands of studies on tools that they have developed, but there remains little independent evidence at scale, such that educators and policymakers should adopt a healthily sceptical approach when reading the marketing blurb for any particular commercial AIED application, and should require robust evidence before deciding whether to use it in their classrooms.[10]

The types of AIED detailed in this section are:

Student-focused AIED

- Adaptive Tutoring Systems
- AI-enabled Apps (e.g., maths, text-to-speech, language learning)
- AI-enabled Simulations (e.g., games-based learning, VR, AR)
- AI to Support Learners with Disabilities
- Virtual Writing Assistants
- Generative AI
- Chatbots

10 A useful resource for educators, which explores the evaluation of AI-enabled EdTech, is the publication "*Technology-enhanced Personalised Learning. Untangling the Evidence*" (Holmes et al., 2018) available at https://www.bosch-stiftung.de/sites/default/files/publications/pdf/2018-08/Study_Technology-enhanced%20Personalised%20Learning.pdf

- Automatic Formative Assessment
- Learning Network Orchestrators
- Dialogue-based Tutoring Systems
- Exploratory Learning Environments
- Health
- AI-enabled Lifelong Learning Assistant

Teacher-focused AIED

- Plagiarism detection
- Automatic Curation of Learning Materials
- Classroom Monitoring
- Automatic Summative Assessment
- AI-enabled Teaching Assistant (including assessment assistant)
- Classroom Orchestration
- Professional Development

Institution-focused AIED

- Admissions (e.g., student selection)
- Course-planning, Scheduling, Timetabling
- School Security
- Identifying Dropouts and Students at Risk
- e-Proctoring

1. Student-focused AIED

Adaptive tutoring systems ('Intelligent Tutoring Systems' or 'ITS')

Adaptive tutoring, first introduced in the 1970s, is the most researched, the most funded, and the most commercialised domain of AIED. Adaptive tutoring systems (also known as 'Intelligent Tutoring Systems' or 'ITS') are AI-enabled computer programmes that provide step-by-step tutorials (information, activities, and quizzes), mainly in structured subjects such as mathematics and physics (although this is now beginning to be extended to other subjects). They automatically adapt the learning content, learning pace, and level of difficulty, and provide individualised real-time guidance and feedback, all based on the learner's performance (their successes and misconceptions) as they engage with the learning materials.

For example, if a learner appears to be struggling with a particular concept, the system can provide additional explanations or resources to help them better understand the topic. Similarly, if a learner shows mastery of a particular concept, the system can skip ahead to more advanced content. This approach, offering each learner their own pathway through the learning materials, is often known as 'personalisation'.

Typically, adaptive tutoring systems draw on three algorithmic models: a domain model (knowledge about the subject), a pedagogy model (knowledge about effective teaching and learning), and a learner model (a representation of the learner's knowledge state). They also sometimes include an 'open learner model' which is designed to allow learners to monitor their achievements and teachers to better understand an individual's learning.

According to many researchers and commercial developers, adaptive tutoring systems offer numerous benefits, such as increased learner engagement, improved knowledge retention, and greater learner achievement. For these reasons, such systems are increasingly being adopted by schools worldwide. However, in fact there is little robust independent evidence at scale to support those claims.

In any case, adaptive tutoring systems pose various ethical challenges. For example, there are concerns around privacy, as adaptive tutoring systems gather and store huge amounts of data from learners, and there is a risk of this data being misused or commercialised. Another concern focuses on the pedagogy adopted by many such systems. Although researchers have often grounded their tools in cognitivist or constructivist pedagogies, most commercial adaptive tutoring systems embody a behaviourist or instructionist approach which involves spoon feeding information while

avoiding failure. Spoon feeding also prioritises remembering over thinking and knowing facts over critical engagement, thus undermining student agency and robust learning.

A third concern is the potential impact of adaptive tutoring systems on the role of teachers. For example, the suggestion is that adaptive tutoring systems might lead to reduced student-teacher interaction and a loss of autonomy and control over the learning process, with 'black-box' AI algorithms making decisions about what content to teach, how to plan lessons, and how to assess student learning. The resultant lack of transparency and accountability makes it difficult for educators, students, and parents to understand how decisions are being made, which can lead to an erosion of trust in the educational process. In short, it is important to ensure that adaptive tutoring systems are used to complement, rather than replace, the role of teachers in education.

Potential benefits (i.e., the benefits that the developers claim)

improved student outcomes, personalised learning, real-time feedback, increased student engagement, reduced teacher workload.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited evidence for any of the benefits just listed, despite these tools being the most researched and the most funded. Almost all of the research has been conducted by academic researchers in small scale studies, or by commercial developers for marketing purposes. Some independent research at scale has been conducted in the USA but this usually compares a single tool with "business as usual" (i.e., no tool) making it difficult to draw robust or generalisable conclusions.

Risks and challenges

Data privacy, data and algorithmic biases, poor pedagogic practices, lack of accessibility, potential loss of teacher or teaching assistant jobs.

Example adaptive tutoring systems. NB Education International is not endorsing any of the tools featured in this list.	
Early years	*Lingumi* (https://lingumi.com). A set of learning activities designed to enable a child to learn and practise new words, sentences, and grammar structures, supported by a specialised child speech detection system.
Primary/ secondary education	*Carnegie Learning* (https://www.carnegielearning.com). A suite of AI-enabled adaptive applications in mathematics, literacy, coding, and language learning for students in K-12 education settings. *Koobits* (https://www.koobits.com), Learning platform designed to teach mathematics and critical problem-solving skills. *Pixatel* (http://www.pixatel.com), A learning platform that aims to provide children with adaptive content suitable to their individual learning level. There are very many other examples, including: *Alef*, *ALEKS*, *alta*, *AmritaCREATE*, *Assistments*, *Better Marks*, *Byjus*, *Civitas*, *CogBooks*, *Cognii*, *Domoscio*, *Dreambox*, *EnLearn*, *Gooru*, *Inq-ITS*, *iReady*, *Knewton*, *Liulishuo* (Laix), *Necole*, Qubena, *RealizeIt*, *Smart Learning Partner*, *Querium*, *Riiid*, *Savvi*, *Smart Sparrow*, *Snappet*, *Soffos*, *Squirrel AI*, *Summit Learning*, *Thinkster Math*, and *Toppr*.
Special educational needs	*MATHiaU* (https://www.carnegielearning.com). An AI-enabled adaptive applications for remedial mathematics.
Technical/ vocational education and training	*Universae* (https://universae.com/en/blog/big-data-education). Uses big-data and prediction to adapt their Technical/ vocational education and training offerings.
Tertiary education	Nothing specific to this sector found (apart from for remedial teaching, presumably because these tools are usually only capable of addressing lower-level teaching and learning).

Professional learning	*Area9 Lyceum* (https://area9lyceum.com). An AI-enabled platform that is designed to act as a personal tutor, automatically adjusting to the needs of individual learners. *Docebo* (https://www.docebo.com). An AI-enabled learning management system designed to enable enterprises to easily develop their own adaptive learning content. *Edthena* (https://www.edthena.com/your-ai-coach). An adaptive tutoring platform designed to support teacher professional development. *Stream Learning Suite* (https://discover.learningpool.com/learning-suite). An AI-enabled suite of tools designed to help managers upskill their workforces, using adaptive, data-driven content and self-directed learning experiences.

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AI-enabled Apps (e.g., maths, speech-to-text, language learning)

Over recent years, increasing numbers of AI-enabled educational applications ('apps') have become available on the popular app stores, due to the widespread availability of mobile devices and advances in AI. Examples include AI-enabled language translation tools, language learning apps, and mathematics apps. These apps are increasingly being used by schools, businesses, and individuals worldwide, sometimes to supplement traditional classroom teaching, providing students with additional opportunities for practice and feedback.

However, some worry that the introduction of these apps could further undermine learning in schools, just as it was once feared that calculators would mean learners would no longer need to learn manual calculation methods. The Chinese Ministry of Education, for example, has banned some AI-enabled homework apps that provide online answers to homework questions photographed and uploaded by students.

In fact, while these apps have been shown to be useful in some situations

(although there is no known robust independent evidence at scale), there is a risk that teachers may experience an increased workload due to having to manage and integrate them into their teaching. There is also a concern that an increased reliance on AI-enabled apps might perpetuate existing educational inequities, with some students having less access to them than others.

Potential benefits (i.e., the benefits that the developers claim)

Real-time feedback, increased student engagement, reduced teacher workload.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Data privacy, data and algorithmic biases, poor pedagogic practices, lack of accessibility, increased teacher workload. Some fear that these apps will undermine the learning of foreign languages and mathematics in schools.

Example AI-enabled apps.

NB Education International is not endorsing any of the tools featured in this list.

Early years	*Avokiddo* (https://www.avokiddo.com). A logic and problem-solving app involving logic puzzles, games and a platform where children can create, play and share their own puzzles.
Primary/ secondary education	*Duolingo* (https://www.duolingo.com). A language learning app that uses AI to provide feedback to users (USA). *Photomath* (https://photomath.com). A math app that uses AI to solve math problems and provide step-by-step explanations (Croatia). SayHi (https://www.sayhi.com). A spoken language translation tool.

Special educational needs	*ReadSpeaker* (https://www.readspeaker.com). A text-to-speech app developed in Sweden that uses AI to convert text into natural-sounding speech, making it accessible to people with reading difficulties or visual impairments. *Youper* (https://www.youper.ai). An app to support mental health care (included under Special educational needs but might be applicable in other categories.
Technical/ vocational education and training	Nothing specific to this sector found.
Tertiary education	Nothing specific to this sector found.
Professional learning	*ELSA* (https://elsaspeak.com). An English speaking coach.

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AI-enabled Simulations (e.g., games-based learning, VR, AR)

AI-enabled simulations, including games-based learning, virtual reality (VR), and augmented reality (AR), are technologies that use AI to create immersive and interactive experiences. In education, AI-enabled simulations involve virtual environments that students can explore, providing them with opportunities to develop, practise and apply their knowledge in an engaging way. They are often used to teach complex or abstract concepts in a more concrete and tangible way, making them easier for students to understand.

Digital games-based learning can provide a supportive space for students to develop problem-solving, critical thinking, and collaboration skills, by drawing on the affordances of commercial digital games (e.g., challenges and competition). It can also promote self-directed learning, active learning and student agency. However, there are concerns that digital games-based learning might have a negative impact on student socialisation, and that

it can perpetuate gender and cultural stereotypes and reinforce existing inequities.

Virtual reality (VR) can enhance learning by allowing students to explore scientific phenomena, historical events, or cultural practices that are difficult or impossible to recreate in the physical world. For example, language learners can use VR to practise real-life communication scenarios, such as ordering food at a restaurant; history students can visit historical settings that no longer exist; and medical students can simulate surgical procedures and gain practical experience – all in safe and controlled environments. VR in education also has the potential to address accessibility for students who have specific additional physical needs.

Augmented Reality (AR) overlays digital information and objects onto the real world, creating an apparently seamless integration of the virtual and the physical. This can enable students to visualise abstract concepts and theories in a more tangible and relatable way. For example, AR can be used to display 3D models of complex molecules in a chemistry lesson or to illustrate the workings of the human body in a biology class. However, AR applications may collect and store sensitive student data, such as location data or biometric information, which can raise concerns about data privacy and security.

Potential benefits (i.e., the benefits that the developers claim)

immersive experiences, interactivity, access to otherwise impossible environments, support for students who have specific additional physical needs.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Negative impacts on student socialisation, gender stereotyping, the cost of VR technologies (i.e., VR goggles), student disorientation.

Example AI-enabled simulations. NB Education International is not endorsing any of the tools featured in this list.	
Early years	There are many early years simulations available in the app stores (e.g., *Yoya World*, https://www.yoyaworld.com). However, it is unclear whether any of them use AI.
Primary/ secondary education	*Crystal Island: Lost Investigation* (https://projects.intellimedia.ncsu.edu/crystalisland). Students play the role of a medical field detective investigating a mysterious infectious disease outbreak affecting a team of scientists on a remote island, and engage with scientific knowledge. *Dinosaur 4D+* (https://octagon.studio/products). Enables students to explore realistic 3D dinosaurs that appear from flashcards. *Google Virtual Field Trips* (https://artsandculture.google.com/project/expeditions). Enables students to visit a wide variety of environments (from Mars to the palaeolithic era).
Special educational needs	*Brain Power* (https://www.affectiva.com/success-story/brain-power). Augmented Reality system to empower children and adults with autism to teach themselves social and cognitive skills. *iGym* (https://www.igym.solutions). Enables accessible ways for people with motor disabilities and their non-disabled peers to play and exercise together.
Technical/ vocational education and training	*Wrench* (http://www.wrenchgame.com). Supports trainee car mechanics learning to maintain engines, suspension, and braking systems.
Tertiary education	*Varjo* (https://varjo.com/solutions/medical-and-healthcare). Enables medical students to prepare for live medical interventions.
Professional learning	*Virtualspeech* (https://virtualspeech.com). Self-spaced training courses designed to help professionals improve their speaking skills.

AI to Support Learners with Disabilities

AI-enabled tools have been designed to support people who have a disability, providing accommodations to address visual, auditory, physical, or cognitive impairments, and adapting to each person's unique needs and abilities. However, while many such tools may be used in educational contexts, few have been designed specifically for that purpose.

Nonetheless, the use of AI-enabled tools in education for people with disabilities has shown potential benefits. Examples include speech-to-text software and text-to-speech software. These tools have the potential to increase accessibility and enhance the learning experience for students with hearing impairments, reading difficulties, or visual impairments.

However, there are also ethical challenges. One major concern is the potential for algorithmic bias, particularly if the algorithms do not address diversity and inclusion by design. Poorly specified or biased AI algorithms can have serious consequences for the accuracy and fairness of educational outcomes. There is also a risk that sensitive data, such as students' medical or disability-related information, may be accessed or used inappropriately.

Potential benefits (i.e., the benefits that the developers claim)

Support for students who have specific visual, auditory, physical, or cognitive impairments, adapting to each person's unique needs and abilities.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Some AI-enabled tools adopt the deficit model of disability, rather than focusing on what needs to change in society.

Example AI-enabled Tools to Support Learners with Disabilities.

NB Education International is not endorsing any of the tools featured in this list.

All sectors	There are a number of mainstream AI tools, such as text-to-speech apps and automatic image captioning, that have been 'repurposed' for students who have learning difficulties. *CaptiVoice* (https://www.captivoice.com). A text-to-speech software that reads digital content aloud for students with reading difficulties or visual impairments. *Envision AI* (https://www.letsenvision.com). Provides audio descriptions of the world and reads text aloud for people with visual impairments. *OrCam MyEye* (https://www.orcam.com/en-gb/orcam-myeye). A wearable device uses AI to read text and recognise faces for people with visual impairments. *Seeing AI* (https://www.microsoft.com/en-us/ai/seeing-ai). An app provides audio descriptions of the world for people with visual impairments. *Smartpen* (https://www.livescribe.com/en-us/solutions/learningdisabilities). Enables students to capture words, scribbles and diagrams, and to convert handwritten notes into digital text. Especially designed for students with dyslexia. *Voiceitt* (https://voiceitt.com). A speech recognition app designed to recognise and transcribe speech from people with speech impairments.

Virtual Writing Assistants

Virtual Writing Assistants are designed to help improve writing and editing skills by suggesting better word choices, correcting grammar and spelling errors, and providing feedback on the clarity and coherence of writing.

Potential benefits (i.e., the benefits that the developers claim)

Real-time grammar, spell-checking, vocabulary choice, and structure suggestions, ensuring that students produce error-free writing, improve their writing confidence and self-efficacy.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

While virtual writing assistants may help students produce error-free writing, there is no robust evidence for the long-term benefits just mentioned (improving writing confidence and self-efficacy) or for virtual writing assistants' contribution to improvements in student learning.

Risks and challenges

Students may come to over-rely on virtual assistants, which might undermine their writing abilities; the suggestions that virtual writing assistants offer may narrow student writing choices and undermine students' critical writing skills.

Example Virtual Writing Assistants.

NB Education International is not endorsing any of the tools featured in this list.

All sectors (except early years)	*Grammarly* (https://www.grammarly.com). A tool designed to help users improve the quality of their writing (especially spelling and grammar). *Hemingway* (https://hemingwayapp.com). A tool designed to help users improve the quality of their writing (especially the complexity of words and sentences). *ProWritingAid* (https://prowritingaid.com). A tool designed to help users improve the quality of their writing (especially grammar and style).

Generative AI

The immediate reaction by many educators to the automatic text generation tool ChatGPT and other text GenAI was mostly negative, worrying how this and similar tools may be used by students to cheat, undermining academic integrity. Now, the Internet is awash with ideas about how generative AI may be adopted in education.

Suggestions range from using it to inspire new content, to generating examples and questions, developing presentations, and summarising existing materials. Every day, new ideas appear. Meanwhile, ChatGPT is being implemented in Microsoft Bing and Office, products are being built on top of the main GenAI technologies, and many GenAI extensions are available for Google Chrome, making it increasingly difficult to avoid.

Educators are still working out exactly what GenAI means for teaching, learning and assessment. Because of the multiple ethical and other concerns mentioned earlier (see Section 2.1), students need to be encouraged to take a critical view of everything that these tools generate, remembering that they can be superficial, inaccurate and full of biases, and mostly only generate standardised opinions while further marginalising already marginalised voices.

The Russell Group (an association of UK leading universities) has published a set of principles to guide the use of GenAI tools in universities, all of which might also be applicable to schools and other educational institutions:

1. Universities will support students and staff to become AI-literate.
2. Staff should be equipped to support students to use generative AI tools effectively and appropriately in their learning experience.
3. Universities will adapt teaching and assessment to incorporate the ethical use of generative AI and support equal access.
4. Universities will ensure academic rigour and integrity is upheld.
5. Universities will work collaboratively to share best practice as the technology and its application in education evolves.

Attitudes to GenAI remains a work in progress. This is not to suggest that teachers and learners should not use GenAI. The genie is out of the bottle and these technologies are only likely to become more powerful and more common in the coming years. However, it is extremely important that, when using GenAI, teachers and learners take a robust critical perspective, are aware of the many challenges, carefully check the outputs against reliable sources, and avoid becoming over reliant on commercial products.

Potential benefits (i.e., the benefits that the developers claim)

Generative AI is still relatively new in education, nonetheless it has been suggested that it can generate customised content tailored to individual student needs, automate administrative tasks, inspire creativity, facilitate interactive dialogue for language learning, and so on.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

To date, there is no robust evidence for any of the benefits just listed or for generative AI's contribution to improvements in student learning.

Risks and challenges

biased outputs, diminished role for human teachers, data privacy, loss of authenticity, narrowed voices (further marginalising those who are already marginalised), loss of authenticity in student work, reliance on automation may hinder critical thinking and problem solving.

Example Generative AI.

NB Education International is not endorsing any of the tools featured in this list.

All sectors (except early years)	Examples of text generative AI: *Bard* (https://bard.google.com) *ChatGPT* (https://chat.openai.com) *Hugging Face* (https://huggingface.co/chat) *Wenxin Yiyan* (https://yiyan.baidu.com/welcome)

All sectors (except early years)	Examples of image generative AI: *DALL-E 2* (https://openai.com/product/dall-e-2) *Stable Diffusion* (https://beta.dreamstudio.ai/generate) *Midjourney* (https://www.midjourney.com)
	Examples of video generative AI: *Runway* (https://runwayml.com) *Elai* (https://elai.io)
	Examples of music generative AI: *Aviva* (https://www.aiva.ai) *Soundraw* (https://soundraw.io)
	Examples of generative AI applications designed for education: *CourseAI* (https://courseai.com). Designed to automatically create online courses, including the course title, outline, description, and module content. *Clever Owl* (https://cleverowl.com). Among other tools, provides an AI-enabled tool to help teachers create educational curricula and materials. *ChatPDF* (https://www.chatpdf.com). Built on ChatGPT, it is designed to enable 'conversations' with PDF files (e.g., to answer questions about the content). *Education Copilot* (https://educationcopilot.com). Designed to help teachers automatically generate lesson plans, educational handouts, and project outlines. *QuillBot* (https://quillbot.com). An AI-enabled writing assistant designed to help users rephrase and paraphrase text by generating alternative sentence structures while maintaining the original meaning. *Teachable* (https://teachable.com/ai-curriculum-generator). An AI-enabled curriculum generator designed to empower teachers to create and deliver their own adaptive online courses.

Chatbots

AI-enabled chatbots have been available long before Generative AI (GAI) and are common in many settings, such as call centres and universities. Before GAI (many developers are embedding GAI into their chatbots), they already used natural language processing (NLP) algorithms to simulate a conversation with human users, using text and/or voice commands. Most current versions use a large but still limited database of possible user queries and their answers. The task of such chatbots is to identify which answer applies to the specific question being posed by the user – which means users have to phrase their questions carefully and there will always be some questions for which the chatbot does not have an appropriate answer. More recent (but still pre-GAI) AI-enabled chatbots can adapt to new information by applying machine learning techniques.

In education, chatbots can provide a quick and interactive way for students to get information and assistance (e.g., about the timing and venue of classes, or submission deadlines, or about educational materials). Some can also provide answers to specific subject questions and feedback on work (see Automated Formative Feedback). Their main benefits are that they are available 24/7 and can require minimal input (although not no input) from the education professionals (and therefore can sometimes save institutions money). However, chatbots raise various ethical challenges, such as privacy concerns and the potential for chatbots to perpetuate biases, which are likely only to increase once GAI is more widely used.

Potential benefits (i.e., the benefits that the developers claim)

Individual 24/7 feedback and support, engagement and interactivity, workload reduction for teachers.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for chatbots' contribution to improvements in student learning.

Risks and challenges

Chatbots might struggle with cultural diversity, may provide misleading information, overreliance might hinder students developing critical thinking and problem-solving skills, privacy and data security.

Example Chatbots.

NB Education International is not endorsing any of the tools featured in this list.

Early years	Nothing specific to this sector found.
Primary/ secondary education	*Edubot* (https://innodatatics.ai/business_solutions/edubot). Designed to provide 'help desk' type support. *Roo* (https://roo.plannedparenthood.org/chat). Chatbot designed to provide sexual health information for teenagers. *U-Report* (https://ureport.in). Aims to engage young people in conversations around UNICEF programme priorities, emergency response, and advocacy action.
Special educational needs	*ADMINS* (https://iet.open.ac.uk/projects/admins). Enables students to disclose details of a disability more easily. *Tichron* (https://apps.apple.com/us/app/tichron-bot/id1490076201). Aims to support children who have a chronic disease.
Technical/ vocational education and training	*Ada* (https://www.boltoncollege.ac.uk/latest-news/praise-for-ada-bolton-colleges-chatbot). A chatbot designed by Bolton College (UK) to answer student questions about the college and campus services (e.g., 'what is my timetable?', or 'when is my next exam?').
Tertiary education	*Comm100* (https://www.comm100.com/engage/chatbots-and-automation). Designed for universities to implement, in order to support student services such as admissions, IT support, and student counselling. *Genie* (https://www.deakin.edu.au/about-deakin/news-and-media-releases/articles/deakins-genie-a-virtual-digital-assistant-out-of-the-bottle). A digital assistant designed to help students at Deakin University (Australia) navigate and organise their university experience.

Professional learning	*Power Virtual Agents* (https://www.microsoft.com/en-gb/industry/blog/education/2021/01/04/how-to-develop-a-chatbot-to-support-your-educators-and-students). A development platform with Microsoft Teams for the development of chatbots.

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Automatic Formative Assessment

Automatic formative assessment aims to provide feedback to students in real-time about their learning progress. It works by collecting data from student responses to questions, quizzes, and assignments. It then uses AI to analyse the students' answers and behaviours, to assess their knowledge level, identify knowledge gaps and their strengths and weaknesses, and provide customised targeted feedback and suggestions for improvement that the student can build on. It can also provide teachers with insights into their students' learning.

Benefits include individualised feedback, increased student engagement, and improved learning outcomes. However, there are also ethical challenges, such as concerns around data privacy and the potential for bias in AI algorithms, along with other challenges such as that the algorithms may not be accurate and students may not trust the feedback.

Automatic formative assessment can be integrated into some learning management systems, digital textbooks, or other educational software. In addition, some automatic formative assessment tools are now integrating Generative AI.

Potential benefits (i.e., the benefits that the developers claim)

Real-time feedback and data-driven insights to enable students to identify their own areas of strength and areas that need improvement, thus supporting self-regulated learning.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

While the benefits of formative assessment are well-known and understood, there is very limited robust evidence for any benefits of automated formative assessment.

Risks and challenges

Reliance on the accuracy of the data and algorithms that might not be justified, lack of contextual understanding, reduction in human interaction, privacy and data security concerns.

Example Automatic Formative Assessment tools.

NB Education International is not endorsing any of the tools featured in this list.

All sectors (except early years)	*Classkick* (https://classkick.com). A real-time assessment platform that includes an automatic formative assessment feature which provides students with immediate feedback on their responses. *Edulastic* (https://edulastic.com). A learning management platform that includes an automatic formative assessment feature that provide students with immediate feedback on their responses. *Floop* (https://floopedu.com). A platform to enable educators to easily provide automatic formative feedback to students based on rubrics. *MyKnowledgeMap* (https://www.myknowledgemap.com). A learning management platform that includes an automatic formative assessment feature that provides immediate feedback to students. *Smart Sparrow* (https://www.smartsparrow.com). An adaptive learning platform that includes an automatic formative assessment feature that provides students with immediate feedback on their responses.

Learning Network Orchestrators

Learning Network Orchestrators are AI systems that help create or facilitate networks of learners and/or teachers, providing support for learning, teaching, and collaboration. They use a range of AI techniques, such as natural language processing, machine learning, and social network analysis, to provide individualised recommendations, connect learners and teachers with peers and relevant resources, and facilitate self-directed learning, peer-to-peer learning, and collaboration.

Learning Network Orchestrators also face challenges, such as the need to protect learners' privacy and ensure the accuracy and fairness of AI-generated recommendations.

Potential benefits (i.e., the benefits that the developers claim)

Enhanced collaboration and networking opportunities, access to diverse learning experiences, support for lifelong learning.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Reliance on digital technologies and Internet access, privacy and data security concerns, digital literacy gaps.

Example Learning Network Orchestrators.

NB Education International is not endorsing any of the tools featured in this list.

Early years	Nothing specific to this sector found.
Primary/ secondary education	*Third Space Learning* (https://thirdspacelearning.com). An online tutoring service that uses AI algorithms to match students with qualified tutors (usually from other countries) for one-to-one instruction in mathematics. The platform also offers analytics tools to track student progress.

Primary/ secondary education	*SCOOT* (Student-centred one-to-one online tutoring). A tool designed to connect students to human tutors. The student enters the topic on which they would like help into the app, which presents them with a list of human tutors all rated by previous students. The student chooses which tutor to connect with and then receives 20 minutes of 1:1 tuition, sharing screen and audio only. This tool is worth noting as it is unusual in using AI to enable students to be in control of their learning. The student decides what they want to learn, not the AI, which only helps connect the student with a human tutor. The tool, however, is not generally available; an academic paper describing it is (Zhang et al., 2021).
Special educational needs	Nothing specific to this sector found.
Technical/ vocational education and training	Nothing specific to this sector found.
Tertiary education	*SNAPP* (Social Networks Adapting Pedagogical Practice) (see https://edutechwiki.unige.ch/en/SNAPP). A learning analytics tool designed to visualise the network of interactions among students and between students and resources in a course.
Professional learning	Nothing specific to this sector found.

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Dialogue-based Tutoring Systems

Dialogue-based Tutoring Systems (DBTS) are designed to provide one-on-one tutoring sessions to learners through Socratic-style conversational interactions. DBTS work by engaging learners in a dialogue, mimicking the conversational nature of a human tutor, asking questions, and

providing feedback, explanations, and guidance tailored to the needs and preferences of the learner. They use natural language processing and machine learning algorithms to tailor their responses to the learner's input. Some DBTS also incorporate facial and emotion recognition technology to assess the learner's engagement and adjust their approach accordingly.

Potential benefits (i.e., the benefits that the developers claim)

Personalised learning (adaptive content and pacing), real-time feedback and support, scaffolding support.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

The benefits of Socratic approaches to teaching and learning are well-known. However, there is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Reduced human interaction, limitations in contextual understanding, lack of adaptivity to different conversational styles, privacy and data security concerns.

Example Dialogue-based Tutoring Systems.

NB Education International is not endorsing any of the tools featured in this list.

Early years	Nothing specific to this sector found.
Primary/ secondary education	*AutoTutor* (https://www.memphis.edu/iis/projects/autotutor.php). A dialogue-based tutoring system developed by the University of Memphis that uses natural language processing and machine learning techniques to converse with students in natural language. It uses a conversational agent to simulate a conversation with the student, asking questions and providing feedback based on the student's responses. *iTalk2Learn* (https://www.italk2learn.com). Uses natural language processing to provide personalised feedback and recommendations to students learning math.

Special educational needs	Nothing specific to this sector found.
Technical/ vocational education and training	Nothing specific to this sector found.
Tertiary education	*Virtual Tutor* (https://www.ibm.com/watson/education/pearson, but no longer appears to be supported). Designed to assist students in improving their reading comprehension skills by engaging them in interactive conversations through a natural language interface.
Professional learning	Nothing specific to this sector found.

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Exploratory Learning Environments

Exploratory Learning Environments are educational tools that provide students with opportunities to explore and experiment with concepts and ideas through hands-on virtual activities. These tools provide interactive virtual environments that facilitate the exploration of concepts by means of interactive labs, graphs, charts, and diagrams. AI-enabled exploratory learning environments can also provide guided exploratory learning, adaptivity, feedback, and guidance.

Potential benefits (i.e., the benefits that the developers claim)

Fosters active engagement by encouraging learners to explore, experiment with and take ownership of their learning, and can simulate real-world scenarios.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Digital literacy and skill gaps, pedagogical alignment, privacy and data security concerns.

Example Exploratory Learning Environments.

NB Education International is not endorsing any of the tools featured in this list.

Early years	Nothing specific to this sector found.
Primary/ secondary education	*Fractions Lab* (https://www.italk2learn.com). An exploratory learning environment for the learning of fractions. *GeoGebra* (https://www.geogebra.org). Digital environment incorporating some AI, to support the learning of graphing and geometry. *Scratch* (https://scratch.mit.edu). A free coding environment for children, enabling them to create their own stories, games, and animations, sometimes using AI. *Smartick* (https://uk.smartickmethod.com). Mathematics and coding learning environment, including some tools supported by AI.
Special educational needs	Nothing specific to this sector found.
Technical/ vocational education and training	Nothing specific to this sector found.
Tertiary education	Nothing specific to this sector found.
Professional learning	Nothing specific to this sector found.

Health apps

AI-enabled tools can play a role in detecting and supporting student health issues. For example, by analysing data sources such as student behaviour patterns, language use, and academic performance, AI-enabled tools might identify early signs of mental health concerns or well-being issues. By detecting potential stressors and triggers early on, educators and mental health professionals can intervene promptly to provide appropriate support. AI-enabled tools are also being used to monitor students' well-being by analysing physiological indicators, such as heart rate, sleep patterns, or stress levels.

AI-enabled chatbots and virtual assistants have also been designed to provide accessible and confidential platforms for students to receive mental health support. These tools can offer 24/7 non-judgmental listening, provide information about available resources, offer coping strategies, and guide students to appropriate professional help where needed.

Potential benefits (i.e., the benefits that the developers claim)

Early detection and intervention of mental health concerns, individualised coping strategies, data-driven insights for research and policy development, and contributing to a proactive and holistic approach to student health and mental well-being.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed.

Risks and challenges

Reliance on technology over human interaction, the need for ongoing human oversight and intervention, data privacy and security concerns, potential for misinterpretation of data or misdiagnosis, and lack of training and support for educators.

Example Health Apps.

NB Education International is not endorsing any of the tools featured in this list.

Early years	Nothing specific to this sector found.
Primary/ secondary education	*Speakout!* (https://speakout.thecybertrust.org). Provides stories to offer the user advice or information aimed at resolving a problem or difficulty they, or someone else, may be facing.
Special educational needs **Technical/ vocational education and training** **Tertiary education** **Professional learning**	NB None of the following examples have been validated for use with/by students. They are included here only to illustrate the range of AI health apps that are currently being used outside educational contexts, and might in the future be used in educational contexts. *MindDoc* (https://minddoc.com/us/en). Specialises in understanding mental health conditions such as depression, anxiety, eating disorders, and insomnia. *Replika* (https://replika.com). An AI chatbot that builds a digital persona of the user based on personality features, aiming to help them cope with stress while improving their mental health. *Woebot* (https://woebothealth.com). Designed to help address the mental health needs of teenagers who have been diagnosed with mild-moderate depression. *Wysa* (https://www.wysa.com). An AI-enabled mental health app that aims to provide immediate support for those in need. It provides emotional help by tracking mood, highlighting optimism, and reframing thinking (CBT). *Youpa* (https://www.youper.ai). Engages in conversations with users to gauge their mental state and provides tailored approaches based on the insights gathered.

2. Teacher-focused AIED

Plagiarism detection

AI-enabled plagiarism detection systems have been designed to identify instances of academic misconduct (plagiarism) by students. They use machine learning algorithms to compare student work against a large database of texts, including published materials and previously submitted student work, and to identify similarities that suggest plagiarism. They usually provide a report to the instructor highlighting any potential instances of plagiarism. AI-enabled plagiarism detection systems have become increasingly common in recent years as online learning has become more widespread, and are now widely used by universities and schools around the world. They are typically integrated into learning management systems and can be used to check student work automatically when it is submitted online.

Potential benefits (i.e., the benefits that the developers claim)

Helps maintain academic integrity by deterring and detecting instances of plagiarism; educates students about proper citation and the importance of originality in academic work.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

May generate false positives, flagging legitimate content as plagiarised, leading to unfair accusations; may lead to a diminished role for human evaluation; requires students to upload their work which the software company then uses to further enhance its product.

Example Plagiarism Detection Tools.

NB Education International is not endorsing any of the tools featured in this list.

All sectors (except early years)	*Copyleaks* (https://copyleaks.com). An AI-enabled tool designed to use text matching algorithms to detect potential plagiarism in student submissions.

All sectors (except early years)	*Plagiarism Checker X* (https://plagiarismcheckerx.com). A plagiarism checker mainly designed for students to check their work before they submit it for assessment. *Scribbr* (https://www.scribbr.co.uk/plagiarism-checker). A free academic plagiarism detection service designed to use AI algorithms to check student submissions. *Turnitin* (https://www.turnitin.com). A widely used plagiarism detection tool designed to compare student submissions with an extensive database of academic papers, articles, and web pages. The company Turnitin also owns many smaller plagiarism detection companies. *Unicheck* (https://unicheck.com). Designed to use AI algorithms to check student submissions against an extensive database of academic and online sources.

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Curation of Learning Materials

AI-enabled curation of learning materials involves the use of Artificial Intelligence and machine learning algorithms to identify and curate learning content (e.g., books, academic papers, websites) as specified by a teacher (or student). When a teacher is looking for materials to support their teaching, they might use one of these systems to quickly find suitable educational resources, more easily and more accurately than using a simple web search. This can be especially helpful when looking for Open Educational Resources (OER). There can be so many OER, that teachers often get lost in the possibilities; so these tools aim to enable the teacher to find exactly what they are looking for. Some systems can also curate videos and can point to a section in the video that is relevant to the teacher's request. Others can also automatically translate educational resources into the local language.

Potential benefits (i.e., the benefits that the developers claim)

Can efficiently search and curate a vast array of learning materials, making it easier for teachers to find relevant resources.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for the benefit just given or for improvements in student learning.

Risks and challenges

May include unreliable or biased content; may lack the nuanced judgment and contextual understanding of human curators and educators; may unintentionally introduce biases in content selection, resulting in limited representation or exclusion of diverse perspectives; may overlook niche or lesser-known resources.

Example Tools for the Curation of Learning Materials.

NB Education International is not endorsing any of the tools featured in this list.

Early years	Nothing specific to this sector found.
Primary/ secondary education	*Teacher Advisor* (https://www.ibm.com/ibm/responsibility/ initiatives/activitykits/teacheradvisor). An AI-enabled platform designed to help teachers and students find educational resources.
Special educational needs	Nothing specific to this sector found.
Technical/ vocational education and training	Nothing specific to this sector found.
Tertiary education	*x5gon* (https://www.x5gon.org). Designed to use AI algorithms to curate learning content from various open educational resources (OER). It uses natural language processing to help provide relevant results.
Professional learning	Nothing specific to this sector found.

Classroom Monitoring

AI assisted Classroom and Student Monitoring systems are a new way of monitoring students' activities and behaviours during class sessions. These systems analyse students' facial expressions, body movements, and other parameters to detect signs of disengagement or distractions. They are designed to help teachers identify students who may need additional support, and to enable early intervention before students fall behind.

They typically involve the use of cameras, microphones, and other sensors to gather data, which is then analysed by AI algorithms to detect patterns of behaviour and engagement. Some systems also use natural language processing to analyse students' verbal interactions and identify signs of confusion or disinterest.

Potential benefits (i.e., the benefits that the developers claim)

Enables teachers to (i) identify individual learning patterns, (ii) adapt instructional strategies, and (iii) provide targeted interventions, leading to better academic performance; provides continuous assessment of student attentiveness, ensuring that students stay on task and leading to enhanced student participation and engagement; provides continuous professional development for teachers, enhancing teaching expertise.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Surveillance; data security and student privacy; may diminish the importance of human connection and empathy in the learning process.

Example Classroom Monitoring Tools. NB Education International is not endorsing any of the tools featured in this list.	
Primary/ secondary education	*BrainCo* (https://brainco.tech). Portable EEG (electroencephalography) headsets designed to record students' brain activity in order to 'monitor' their attention and help teachers identify pupils who need extra help. *Impero* (https://www.imperosoftware.com/impero-classroom-management-software). Designed to enable teachers to identify students who are off task when using online tools, to remove online distraction and to restrict browsing functionality. *Real-Time Attention Monitoring System for Classrooms* (https://www.mdpi.com/2504-2289/7/1/48). A research tool designed to monitor student attention in classrooms. TeachFX (https://teachfx.com). Designed to empower teachers with an easy way to reflect on classroom instruction. Aims to enhance teaching practice to increase student engagement.
Other sectors	Nothing specific to other sectors found.

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Automatic Summative Assessment

AI-enabled automatic summative assessment and essay marking aim to help reduce the workload of teachers in grading assignments, essays and other forms of academic assessments. These systems use natural language processing (NLP) algorithms and machine learning techniques (analysing many examples of assessments graded by human graders) to evaluate student responses and assign grades automatically. They are beginning to be used by schools and universities around the world to grade assignments and online natural language assessments, to evaluate essays and provide feedback to students, and in standardised testing and university admissions. Some of these applications focus on grammar and spelling, while others use more sophisticated techniques to evaluate the structure

and content of written essays.

Potential benefits (i.e., the benefits that the developers claim)

The ability to grade more assignments quickly and efficiently, to provide consistent grading across different teachers, and to provide automatic feedback.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is limited robust independent evidence at scale for any of the benefits just listed or for improvements in student learning.

Risks and challenges

May struggle to capture subjective elements of assessment, such as creativity, originality, or complex problem-solving skills; may introduce biases based on factors such as race, gender, or socio-economic background, leading to unfair outcomes; may have difficulty understanding context, background, or cultural influences; may narrow the curriculum and encourage teaching strategies that prioritise test preparation rather than holistic learning; and raises concerns about privacy and data security.

Example Automatic Summative Assessment Tools.

NB Education International is not endorsing any of the tools featured in this list.

All sectors (except early years)	*e-Rater* (https://www.ets.org/erater.html). Designed to automatically assess key writing skills, score essays, provide feedback on writing, and assess both analytical and independent writing skills. *ExamSoft* (https://examsoft.com). A suite of tools designed to help teachers manage assessments, including automated grading and analytics. *Gradescope* (https://www.gradescope.com). An AI-enabled grading and assessment platform that is designed to automatically grade multiple choice, numeric, and short answer questions. *GRAIDE* (https://www.graide.co.uk). An AI-enabled tool designed to help teachers grade essays. Also provide some automatic grading tools.

All sectors (except early years)	*Progressay* (https://www.progressay.com). AI-enabled tool designed to automatically assess essays. *RobotDon* (https://robotdon.com). An AI-enabled tool designed to grade essays and help students improve their writing. *WriQ* (https://www.texthelp.com/en-gb/products/wriq). An AI-enabled writing assessment tool designed to analyse student writing skills and to provide feedback on areas for improvement.

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AI-enabled Teaching Assistant (including assessment assistant)

AI-enabled teaching assistants are a speculated possible use of AIED. The idea is that they would be designed to directly support teachers in their work with students, to help reduce workload and help teachers enhance the quality of their teaching.

Unlike much student-focused AIED, AI-enabled Teaching Assistants would be designed to support teachers in their day-to-day work, rather than replace them. They might incorporate other AI-enabled tools (such as classroom orchestration). Currently, there is little research into either the specification or development of AI-enabled teaching assistants.

Potential benefits (i.e., the benefits that the developers claim)

As this is a speculated possible use of AIED, any potential benefits are yet to be confirmed. Nonetheless, as noted, benefits might include directly supporting teachers in their work, helping reduce teachers' workload, and helping teachers enhance the quality of their teaching. The key is that such tools should be designed to support not replace teachers.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

As this is a speculated possible use of AIED, there are currently no evidenced benefits.

Risks and challenges

Over-reliance on AI-enabled teaching assistants might undermine teacher/student relationships (i.e., human interaction); data privacy and security.

Example AI-enabled Teaching Assistants.

NB Education International is not endorsing any of the tools featured in this list.

All sectors	At the time of writing, there is little evidence of research into AI-enabled tools to genuinely support teachers (rather than to take on teacher functions), and only one commercially-available application. *Merlyn Mind* (https://www.merlyn.org). Uses generative AI to support teachers in their day-to-day work.

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Classroom Orchestration

AI-enabled classroom orchestration are a speculated possible use of AIED. The idea is to use Artificial Intelligence for managing and optimising classroom activities. They would work by leveraging data collected from various sources such as student interactions, learning management systems, and other classroom technologies. The data would be analysed to provide insights on student performance, engagement levels, and overall class dynamics. This would allow teachers to make informed decisions in real-time and adjust their teaching accordingly.

Potential benefits (i.e., the benefits that the developers claim)

As this is a speculated possible use of AIED, any potential benefits are yet to be confirmed. Nonetheless, as noted, benefits might include helping manage and optimise classroom activities, provide insights on student performance and class dynamics, and enable teachers to make informed decisions in real time.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

As this is a speculated possible use of AIED, there are currently no evidenced benefits.

Risks and challenges

Over-reliance on AI-enabled classroom orchestration might undermine teacher skills; data privacy and security.

Example Classroom Orchestration tools.

NB Education International is not endorsing any of the tools featured in this list.

Primary/ secondary education	*Classcraft* (https://www.classcraft.com). An AI-enabled assisted classroom management platform using gamification elements and designed to track student behaviour and encourage student engagement. *NetSupport School* (https://www.netsupportschool.com). AI-enabled classroom management software designed to help teachers monitor and control student devices, as well to communicate with students in real-time.
Other sectors	Nothing specific to other sectors found.

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Professional development

AI-enabled teacher professional development is a speculated possible use of AIED. The idea is that they would involve a range of approaches (and other AIED tools) to support and enhance the development of teachers. For example, appropriate tools may assess the strengths and weaknesses of individual teachers and develop personalised learning paths based on their specific needs. The tools may identify areas where the teachers require improvement and provide targeted resources, training modules, and recommendations to enhance their professional skills. They may also provide real-time feedback and coaching, by analysing classroom observations, student assessments, and teacher-student interactions. The

tools may also be used to analyse data collected from various sources, including student assessments, learning management systems, and classroom observations, to identify patterns, trends, and insights, and to inform instructional decision-making. Finally, the tools may also facilitate communities of practice, through which teachers can collaborate, share resources, and engage in professional discussions.

Potential benefits (i.e., the benefits that the developers claim)

As this is a speculated possible use of AIED, any potential benefits are yet to be confirmed. Nonetheless, as noted, benefits might include supporting and enhancing the development of teachers, perhaps identifying areas where a teacher requires improvement and providing targeted resources, real-time feedback and coaching, and facilitating teacher communities of practice.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

As this is a speculated possible use of AIED, there are currently no evidenced benefits.

Risks and challenges (in addition to the risks and challenges identified for other AIED)

Data privacy, data and algorithmic biases, poor pedagogic practices, lack of accessibility.

Example Professional Development tools.

NB Education International is not endorsing any of the tools featured in this list.

Technical/ vocational education and training	*Artificial Intelligence in Vocational Education and Training MOOC* (https://digital-skills-jobs.europa.eu/en/opportunities/training/artificial-intelligence-vocational-education-and-training-mooc). Aims to help ensure the future workforce is prepared for a world increasingly touched by AI and automation.
Professional learning	*Area9 Lyceum* (https://area9lyceum.com). An AI-enabled platform that is designed to act as a personal tutor, automatically adjusting to the needs of individual learners. (see 'Adaptive Tutoring Systems' above).

3. Institution-focused AIED

Admissions (e.g., student selection)

AI-enabled admissions systems, also known as student selection systems, are designed to assist institutions in selecting the 'best' or most appropriate candidates for admission. These systems have become increasingly popular in recent years, as institutions of higher learning face an ever-growing pool of applicants. The claimed benefits are increased efficiency, improved accuracy and consistency, and reduced bias in the selection process.

AI-enabled admissions systems use a combination of algorithms, machine learning, and data analytics to analyse large amounts of data about each applicant, including grades, test scores, essays, letters of recommendation, and other factors, and to create a candidate profile. This profile is then automatically evaluated against a wide range of predetermined criteria, to determine whether or not the students should be interviewed and/or admitted.

There are concerns about the ethical implications of using AI-enabled admissions systems, particularly with regard to issues of bias and discrimination, as they may reinforce existing inequities and may be more likely to overlook the potential of candidates from underrepresented groups.

Potential benefits (i.e., the benefits that the developers claim)

Increased efficiency, improved accuracy and consistency, and reduced bias in the selection process.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Bias, discrimination, lack of transparency, data privacy and security, fairness (e.g., not adequately accounting for socioeconomic disadvantage), overreliance may lead to homogenisation of student groups, diminished role of human judgement. One AI-enabled admissions systems (GRADE, which was developed at the University of Texas Austin) was dropped when it was found to be replicating the problems that it aimed to address.

Example Admissions Tools. NB Education International is not endorsing any of the tools featured in this list.	
Early years	Nothing specific to this sector found.
Primary/ secondary education	Nothing specific to this sector found.
Special educational needs	Nothing specific to this sector found.
Technical/ vocational education and training	Nothing specific to this sector found.
Tertiary education	*Admityogi* (https://admityogi.com). An AI tool designed to help prospective students choose the most appropriate university for their needs and aims. *Element451* (https://element451.com/product/applications). Designed to save admissions teams hours of repetitive work and to personalised admissions experiences for students. *iSchool 360* (https://ischool360.net). Designed to support universities through every step of the admissions process. *Kira Talent* (https://www.kiratalent.com). An AI-enabled video interviewing and assessment tool designed for use in the admissions process. *Mainstay* (https://mainstay.com/solutions/admissions). An AI chatbot designed to help guide students through admissions tasks, such as applying for scholarships and completing paperwork. *Salesforce* (https://www.salesforce.org/education/solutions/recruiting-admissions). Designed to personalise interactions with prospective students and automate admissions processes.

Tertiary education	*Student Select* (https://www.studentselect.ai). Designed to identify traits and skills (including non-cognitive traits, personality measures, and skills) that are believed to be useful predictors for university admissions.
Professional learning	Nothing specific to this sector found.

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Course-planning, Scheduling, Timetabling

AI-enabled course planning, scheduling, and timetabling systems are designed to help educational institutions better manage their academic resources (including staff and rooms). These systems use machine learning algorithms to analyse data on student preferences, course requirements, faculty availability, and other factors to optimise the scheduling process, minimise conflicts, and maximise resource utilisation.

They have the potential to save institutions significant amounts of time and resources, increase student satisfaction, and improve faculty work-life balance.

However, there are also ethical concerns around algorithmic bias and the potential for unintended consequences such as reinforcing existing inequities. In addition, there are concerns about the over-reliance on technology and the potential loss of human expertise in the scheduling process.

Potential benefits (i.e., the benefits that the developers claim)

Optimisation of resource use, can assist in accommodation of diverse needs (e.g., accessibility requirements), can be updated in real time, can scale across courses and physical estates.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

May lead to unfair treatment of diverse students, neglect important contextual factors, be difficult to interpret, may be inflexible to human requirements.

Example Course-planning, Scheduling and Timetabling Tools.

NB Education International is not endorsing any of the tools featured in this list.

All sectors	*Asc Timetables* (https://www.asctimetables.com). An AI-enabled platform designed to provide course scheduling and timetabling for educational institutions. *Edval* (https://www.edval.education/what-we-do/timetabling). Offers a range of tools including an AI-enabled timetabling system. *FET* (https://lalescu.ro/liviu/fet). A free open-source application that is designed to automatically schedule the timetable of a school, high-school or university. *QuickSchools* (https://www.quickschools.com). Offers a range of tools including an AI-enabled timetabling system. *UniTime* (https://www.unitime.org). An open-source university course scheduling and timetabling application that supports developing course and exam timetables, managing changes, sharing rooms, and scheduling students to individual classes.

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School Security

AI-enabled school security systems aim to improve the safety and security of educational institutions. They can use a variety of techniques such as facial recognition, biometric profiling, and predictive analytics to monitor schools and prevent potential threats. For example, they might be designed to identify individuals who are not authorised to be on school grounds or who have a history of violent behaviour. Some universities insist that their students install an app on their mobile phone, so that their whereabouts on the campus can be automatically monitored in real time. They can also help schools respond more quickly to emergencies. However, there are also several ethical challenges. For example, the use of facial recognition technology has privacy concerns, and may disproportionately target certain groups.

Potential benefits (i.e., the benefits that the developers claim)

Threat prediction and detection, faster emergency response, automated access control, real-time behavioural analysis.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed or for improvements in student learning.

Risks and challenges

Infringing student and staff privacy rights, surveillance, algorithmic biases leading to discriminatory outcomes, susceptible to cyberattack, may create an atmosphere of constant monitoring and surveillance, negatively impacting the school environment and student well-being.

Example School Security Tools.

NB Education International is not endorsing any of the tools featured in this list.

All sectors	*Actuate* (https://actuate.ai/ai-security/use-cases/schools). Designed to turn existing security camera systems into intruder and gun-detecting systems, enabling instant, real-time responses to trespassing and weapons.

All sectors	*Athena Security* (https://www.athena-security.com). An AI-enabled security systems for schools. Designed to use facial recognition and other technologies to identify potential threats (e.g. weapons) and to alert authorities. *Gaggle* (https://www.gaggle.net). Designed to ensure the safety and well-being of students and schools, and that all students get the mental and emotional help they need. *GoGuardian* (https://www.goguardian.com/safety-security). A suite of tools including AI-enabled tools to support student safety by identifying online activity that indicates a risk of suicide, self-harm or possible harm to others. *Psstworld* (https://www.psstworld.com). Designed to enable students to report anonymously something that they have heard or seen and are concerned about. *SafeZone* (https://safezoneapp.com). A mobile safety app designed to enable students and staff to request assistance quickly and easily in the event of an emergency. *SpotterEdu* (https://spotteredu.com). Designed to automatically record attendance during a student's class or event. In addition, at many universities, AI-enabled systems are being used to monitor a student's movements through the campus (sometimes by means of a mobile phone app), what they download from the online learning management system, what they buy from the cafeterias, and much more besides (Moriarty-Mclaughlin, 2020).

Identifying Dropouts and Students at Risk

Some AI-enabled systems have been designed to predict which students are most likely to drop out of school or face academic failure. These systems analyse data on student attendance, grades, test scores, behaviour, and demographic information to identify patterns that indicate a student may be struggling. Usually, the goal is to identify at-risk students early so that schools can intervene and provide support before it's too late.

These systems can help schools target interventions to the students who need them the most. They can also provide early warning signs to teachers, counsellors, and administrators, allowing them to intervene before a student falls too far behind. However, there are also ethical challenges. These systems rely on sensitive student data, and there is a risk that this data could be used to unfairly label students or discriminate against certain groups. There are also concerns about how these systems could impact student privacy and data security. Finally, there is the question of who should see the data and the system's predictions – teaching staff, administration staff, and/or the students themselves – raising issues around privacy?

Potential benefits (i.e., the benefits that the developers claim)

Can identify students who are at risk before they drop out or fail their course, triggering staff to give appropriate support.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for the benefits just listed or for improvements in student learning.

Risks and challenges

Could miscategorise students, leading to unintended labelling and discrimination, data privacy and security concerns, overreliance may diminish professional skills in identifying students at risk, may limit student agency and self-determination. While for reasons of transparency, the data and predictions should be shared with the student concerned, we do not know the possible impact. For example, if a student is informed that they are likely to fail, does that undermine them, are they more likely to give up, or does it lead to them redoubling their effort? There is no robust evidence either way.

Example Tools for Identifying Dropouts and Students at Risk.

NB Education International is not endorsing any of the tools featured in this list.

All sectors (except early years)	NB Many of the tools mentioned above under 'adaptive tutoring systems' include functions designed to identify dropouts and students at risk. *BrightBytes* (https://www.brightbytes.net). An education analytics company that offers a variety of tools designed to help schools measure student progress and identify at-risk students. *OU Analyse* (https://analyse.kmi.open.ac.uk/). A system enabled by machine learning methods designed for the early identification of students at risk of failing at the UK's Open University.

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e-Proctoring

AI-enabled e-proctoring and other tools to facilitate examinations became increasingly popular in educational institutions worldwide due to the rise of online learning during the Covid pandemic. These tools aim to prevent cheating and ensure the integrity of exams by using AI to monitor and analyse student behaviour during the test-taking. They use AI-enabled technologies such as facial recognition and eye tracking to monitor student activity during online exams, and are designed to flag suspicious behaviour, such as looking away from the screen or using multiple devices, and alert instructors or administrators to investigate further.

One of the claimed benefits of AI-enabled e-proctoring is that it can help to level the playing field for students, by providing a secure and reliable way to take exams from anywhere, regardless of their physical location. However, these tools also present ethical challenges, such as potential biases in facial recognition software and concerns around privacy and data security. A key issue is that e-proctoring systems have been shown to be easy to get around (using technologies such as a phone link to someone in another room, or simply sticking notes on the wall behind the camera). In other words, the use of e-proctoring systems can impact negatively on students who have no intention of cheating, while the minority who do intend to cheat can easily outwit the restrictions.

Potential benefits (i.e., the benefits that the developers claim)

Allows students to take exams remotely, which can be useful for those with physical disabilities or geographical constraints, deters academic dishonesty, can provide immediate feedback.

Evidenced benefits (i.e., the benefits for which there is robust, independent evidence at scale)

There is very limited robust evidence for any of the benefits just listed.

Risks and challenges

Involves the collection and analysis of personal data, raising privacy concerns and potential misuse of student information; can infringe student privacy, cause stress and impact negatively on student performance; can discriminate against people from certain cultural backgrounds; requires specific technology that may be inaccessible to many students; possible to circumvent by determined cheaters; and can create a culture of suspicion and erode trust between students

and institutions, undermining the integrity of the educational process. e-Proctoring is probably one of the clearest examples of using AI to automate poor pedagogic practices, rather than using it to develop innovative approaches.

Example e-Proctoring Tools.

NB Education International is not endorsing any of the tools featured in this list.

	Honorlock (https://honorlock.com). Designed to offer a variety of AI-enabled monitoring options, including facial recognition and keystroke analysis.
	Inspera Assessment (https://www.inspera.com). Designed to deliver AI-enabled secure examinations, assessment grading, and online proctoring.
All sectors (except early years)	*Proctorio* (https://proctorio.com). An AI-enabled tool designed to monitor student behaviour during online exams, and provide instructors with reports on suspicious activity.
	Proctortrack (https://proctortrack.com). Designed to monitor student behaviour during online exams.
	Talview (https://www.talview.com). AI-enabled tools designed to monitor online examinations, including facial recognition.

Issues raised by AI&ED's Unintended Consequences

In this section, we explore five issues raised by Artificial Intelligence and Education. It is likely that, on careful reflection by teachers, there are others.

1. Intelligence

> *"I think Artificial Intelligence will be much more intelligent than us in the future. How do we survive that?".* (Hinton, the "godfather of AI" 2023)[11]

The claim that AI is intelligent has been a topic of debate for many years and has reappeared thanks to the arrival of Generative AI. However, while AI has the ability to process and analyse vast amounts of data at a speed that is far beyond human capabilities, it is not capable of replicating the nuanced and complex thinking that is inherent in human intelligence. In particular, while the outputs of AI, especially Generative AI, may look like the product of intelligence, they are instead a mechanical sequencing of words (or code, or music, or pixels) in ways that are common in its source data. It is true that the outputs often look intelligent, but the AI systems do not understand either their source data or their outputs, and thus are not intelligent in any meaningful sense.

The suggestion that AI is intelligent has negative implications for society in general and for education in particular. It can lead to a devaluation of human intelligence (especially the intelligence of teachers) and an over-reliance on AI systems (especially by policymakers), which may be harmful or even dangerous in certain situations. In education, the claim that AI is intelligent can also be detrimental to the development of critical thinking skills and creativity. By relying too heavily on AI systems, students may become less skilled at problem-solving and may have a limited understanding of the complexity and nuance of certain issues; meanwhile teacher functions and competences (i.e., teachers) may be replaced. In addition, the emphasis on AI's intelligence in education can lead to a neglect of the social and emotional aspects of learning, which are crucial for developing well-rounded individuals.

11 https://fortune.com/2023/05/04/geoffrey-hinton-godfather-ai-tech-will-get-smarter-than-humans-chatgpt

Nonetheless, some might wonder, if AI is intelligent, why do we need to spend years studying? Just as we can use the Internet to find information, we can use AI to analyse situations and take decisions on our behalf. It may be the case that the arrival of AI in classrooms may change what we think our students should learn, and perhaps we should stop teaching some things that AI is good at and instead focus teaching and learning on what makes us essentially human (e.g., the abilities to make critical judgements and to align ideas with human values). However, it is a misunderstanding of education, teaching and learning, to suggest that today's AI will replace most of what happens in classrooms. The researcher Biesta notes (2011, pp. 19–20) that education has three key functions: 'qualification' (providing students with "the knowledge, skills, and understandings… that allow them to 'do something'"), 'socialisation' (which involves "the many ways in which, through education, we become part of particular social, cultural and political 'orders'"), and 'individuation' (the process "that allow[s] those educated to become more autonomous and independent in their thinking and acting"). To date, the application of AI in education has focused on qualification to the virtual exclusion of socialisation and individuation.

In fact, the claim that AI is intelligent is often made by those who stand to gain from the development and deployment of AI systems, such as technology companies and governments. They use the claim of AI's intelligence to justify the use of AI systems in various sectors of society, including in education. However, the claim overlooks or distracts us from existing negative impacts that AI systems are already having on society.

> *"I'm not worried about machines taking over the world. I'm worried about groupthink, insularity and arrogance in the AI community."*
> (Gebru, 2021) [12]

2. Personalised learning

Personalised learning has been proposed as a solution to many of education's problems, including student disengagement, lack of motivation, and the achievement gap. However, as Watters has argued (2021), personalised learning is not a new concept, and the current incarnation of personalised learning is heavily influenced by the Silicon Valley worldview, which sees technology as a solution to all problems and emphasises individualism over community.

12 https://www.nytimes.com/2021/03/15/technology/artificial-intelligence-google-bias.html

A fundamental issue with personalised learning is that it undermines the social interaction aspects of teaching and learning, between teachers and students, and between students and students. In other words, it can lead to a loss of the human element in education, which is essential for building trust, motivation, and engagement, and it can undermine teachers' crucial role in supporting students' social and emotional development. As teachers are well-aware, education is not just about acquiring knowledge but is also about community-building and the development of social skills. By emphasising individual learning pathways and personalised experiences, personalised learning can lead to a loss of the social dimension of education, which is crucial for the development of students' social skills and their ability to function in society.

Another fundamental issue with personalised learning is that it is based on a reductionist view of education. By reducing education to a series of skills, competencies, and outcomes, personalised learning can neglect the holistic development of students and their engagement with the wider world. This reductionist view of education can lead to a narrow focus on test scores and academic achievement, rather than a broader understanding of the value and purpose of education. It can also lead to a focus on a narrow range of subjects, prioritising those that can more easily be datafied (such as the natural sciences) over those that require critical thinking and the application of human values (such as the humanities and arts), thus not only negatively impacting the quality of education but also the breadth of the curriculum. In addition, personalised learning can perpetuate existing power imbalances and inequities. It can reinforce existing socio-economic and cultural differences, leading to a further marginalisation of underprivileged students who may not have access to the latest technologies or who may not be able to afford personalised learning services.

Finally, all known examples of personalised learning AIED systems (especially the adaptive tutoring systems) focus on individualised pathways through the material to be learned, in order to facilitate the 'efficient' learning of what has been prespecified – in other words, to get every student quickly to the same learning outcomes. Real personalisation, however, involves every student learning and achieving what they individually want to achieve, to what is called self-actualisation. No current AIED system comes anywhere near helping students to achieve that (Holmes et al., 2018).

Personalised learning is not the panacea for education's problems that is often suggested. While it might individualise learning pathways and might improve limited student outcomes, it can also undermine the social interaction aspects of teaching and learning, perpetuate existing power imbalances and inequities, and neglect the holistic development of students.

3. Disempowering teachers

> *"Recent advances in AI are likely to spell the end of the traditional school classroom.... Human involvement would still be essential... but could be drastically different from the traditional role of a teacher, potentially incorporating 'playground monitor' responsibilities."*
> (Stuart Russell, author of the leading AI textbook) [13]

Unfortunately, the narrative outlined by Stuart Russell is not new. It, and the claim that technology will save teachers time, were first made by the behaviourist B. F. Skinner almost a hundred years ago, and it has been endlessly repeated about educational technologies ever since, although it has never actually happened (although technology often does displace teacher activities). Now, with AI and AIED, we are told, things are different. AIED applications are better at teaching than teachers – albeit in very narrow domains, a subtlety lost on many policymakers – and will save teachers time... However, nothing is further from the truth.

Instead, despite no AIED system being as intelligent, skilled, nuanced or empathetic as a teacher, the arrival of AIED applications in classrooms is effectively disempowering teachers, reducing their role in the learning process. All too often, the teacher's role is relegated to switching on the technology, maintaining behaviour and troubleshooting, while the AI-enabled system – or rather the commercial organisation behind the AI-enabled system – decides what the students should be learning, in what order and how. In short, AIED can mean teachers being expected to outsource some of their responsibilities (e.g., marking) and professional discretion (e.g., assessment) to the AI, which is likely to lead to the devaluation of teaching as a profession. This is because, when AIED is introduced, education is often treated as a commodity, with teachers viewed as service providers rather than professionals. However, this fundamentally misunderstands the role, expertise and professionalism of teachers. It reduces the role of educators in the learning process, and undermines teacher agency, autonomy, motivation, confidence, status and leadership. Where are the AIED applications designed explicitly to support teachers, helping them do what they wish to do, rather than applications that replace teacher functions? And, while teachers might find some AI-enabled applications helpful for their practice, it is unlikely they will save them much time. Instead, it is likely only to displace their time, as they coax the system into doing what is needed for that particular classroom and group of students (getting a generative AI tool like ChatGPT to generate something useful can take many attempts at prompt writing and then require re-writing the outputs).

13 https://www.theguardian.com/technology/2023/jul/07/ai-likely-to-spell-end-of-traditional-school-classroom-leading-expert-says

Nonetheless, the automation of tasks, such as grading and assessment (when and if such a thing becomes genuinely possible) could be attractive to some policymakers looking to save money. However, implementing AIED tools in place of teachers is only likely to compromise classroom practices, reduce the quality of education and undermine the rights and success of students.

4. Commercialisation

The commercialisation of education has become an increasingly concerning issue in recent years. As education becomes increasingly digitised, companies are seeking to exploit new data-rich business models that integrate AI into education (there are at least 30 multi-million-dollar-funded AIED corporations worldwide). These commercial AI tools are marketed to schools and institutions as providing personalised learning and increased efficiency, which leads to a distortion of the goals of education and a lack of democratic control, which is essential for ensuring that education is accessible to all and serves the interests of society as a whole.

When commercial operators have control over education, their focus is primarily on profits rather than human rights or social justice. This can lead to the creation of education systems that are exclusive, inaccessible, and not accountable to the wider society. This is particularly concerning when AIED is introduced, as algorithms and machine learning systems can reinforce existing biases and inequities, exacerbating the divide between the privileged and underprivileged, which poses a serious risk to the integrity of education as a social and democratic institution.

In addition, the commercialisation of education can have detrimental effects on students and teachers. For example, the emphasis on standardised testing and measurable outcomes can lead to a neglect of the individual needs and interests of students. Teachers are often forced to teach to the test, rather than nurturing the intellectual curiosity and creativity of their students. This can result in a narrow and stunted education, which fails to prepare students for the challenges of the future.

There are multiple other concerns about the commercialisation of education through the increased implementation of AIED:

- Exploitation of student data. AI tools collect large amounts of data on students, including their learning progress, preferences, and behaviour. This data is used to inform the AI algorithms and adapt the learning experience for each student, but it can also be monetised in other ways. The use of student data in this way raises serious

issues around privacy, surveillance, and the exploitation of vulnerable groups, such as children. For example, a recent report in the UK, by the Digital Futures Commission, found that EdTech companies such as Google are collecting "unknown quantities and types of personal data from child users during their learning and use this for commercial purposes" (The Digital Futures Commission, 2022). Similarly, Human Rights Watch found that 89% of 164 EdTech products used in 46 countries appeared to engage in data practices that risked or infringed on children's rights. "These products monitored or had the capacity to monitor children, in most cases secretly and without the consent of children or their parents, in many cases harvesting personal data such as who they were, where they were, what they did in the classroom, who their family and friends were, and what kind of device their families could afford for them to use" (Human Rights Watch, 2022).

- Potential for AIED to exacerbate existing inequities in education. The use of AI in education may perpetuate bias and discrimination by relying on pre-existing data sets that reflect and reinforce social, economic, and cultural inequities. This can have significant implications for the distribution of educational resources and opportunities, as well as for the rights of individuals and groups to non-discrimination and equal access to education. It also risks creating a new digital divide between those who can afford access to the latest AI-driven tools and those who cannot, entrenching and exacerbating existing social inequities. This can further limit opportunities for disadvantaged students.
- Loss of human connection and empathy in education. While AI-driven education tools can automate many aspects of teaching and learning, they cannot fully replace the human interactions and emotional connections that are essential for effective learning. This can lead to a dehumanisation of education and a lack of personalised attention and support for students.
- Potential for AI to entrench a narrow and technocratic view of education that emphasises only measurable outcomes and neglects the holistic development of students. The focus on test scores and data-driven decision-making may lead to a reduction in the richness and diversity of educational experiences and may undermine the development of critical thinking and creativity.
- Potential for AIED companies to misuse or mishandle student and teacher data, which could lead to violations of students' and teachers' privacy rights. The use of AIED could result in an increase in surveillance, where student data is collected, analysed and used for commercial purposes without their consent. This could lead to the development of a culture of constant monitoring and evaluation, which could be detrimental to students' autonomy, self-determination, and sense of trust in the educational system.

5. Neo colonialism

Following on from the issues raised by the commercialisation of education by AIED corporations, a related issue is that of neo-colonialism. This is the practice of exerting economic, political, or cultural influence over a nation or region by a more powerful nation or group of nations, which in the context of AIED refers in particular to the ways in which AIED tools are used (albeit unintentionally) to reinforce existing power imbalances and perpetuate systemic inequities in developing nations.

Many LMIC countries are turning to AIED in the hopes of improving educational outcomes and promoting economic growth. However, the development and implementation of these technologies are often driven by Western or Chinese organisations, which can result in a perpetuation of cultural biases and a reinforcement of existing power dynamics. One example of this is the use of AI-enabled adaptive learning systems. As noted earlier, these systems use algorithms to adapt learning experiences for individual students, with the goal of improving student outcomes. However, the algorithms are often based on data sets that are biased towards high income countries' cultures and languages, which can result in a reinforcement of cultural hegemony and a suppression of local languages and cultures.

In addition, as we have seen, the use of AIED can result in the commodification of education, with private companies and organisations seeking to profit from the implementation of these technologies. This can result in a further marginalisation of underprivileged students, who do not have access to the latest technologies or who cannot afford to pay for these services, and can perpetuate existing power dynamics between developed and developing nations. For example, the deployment of AIED in Africa is often driven by Western or Chinese organisations seeking to promote their version of economic growth in the region. However, the tools are usually designed and implemented without considering local contexts and cultures, resulting in a disconnect between the technology and the students it is intended to serve.

One possibility to mitigate these issues is through the development of locally-led and community-driven AIED. By involving local communities in the design and implementation, the technology may be more responsive to local needs and contexts and may not so strongly reinforce existing power dynamics. However, it is also essential to ensure that the AIED is guided by principles of transparency, accountability, and ethical responsibility.

Recommendations

1. Ethics by design

Ethics by design is a crucial concept that serves as a foundation for innovation, including the application of Artificial Intelligence in education. It goes beyond mere compliance with regulations and standards; it entails actively considering ethical implications and embedding ethical principles into the design and development of educational technologies and AI systems from the beginning. By embracing ethics by design, educators and technologists can ensure that innovation in education aligns with ethical values and facilitates good practices.

In the context of AI in education, ethics by design involves several key principles. First and foremost, transparency and explainability are essential. AI systems used in education should be designed in a way that allows users to understand how decisions are made, what data is used, and the potential biases and limitations of the technology – although note that this, although essential, is not an easy technical challenge for the AI engineers. Implemented well, transparency and explainability can empower teachers, students, and other stakeholders to engage with the technology more effectively and can enable them to make informed decisions. It allows teachers to be confident that they understand the AI-enabled system's output, so that they can challenge and/or overturn its recommendations and retain control of decision making in classrooms.

Second, privacy and data protection are fundamental considerations. Educational institutions and technology developers must prioritise the responsible collection, storage, and use of student data. Implementing robust security measures and adhering to relevant privacy regulations helping to build trust among users.

Third, ethics by design involves addressing biases and promoting fairness. AI algorithms can unintentionally reflect and amplify societal biases, leading to potential discrimination and inequities in educational settings. By proactively identifying and mitigating biases during the development stage, AI technologies might contribute to equitable access to quality education for all learners.

Fourth, the ethical design of AIED must foster human agency and accountability. While AI might provide valuable support and insights, it cannot replace human educators or decision-making processes. Maintaining a human-centred approach ensures that education, as a social and democratic

institution, allows for critical reflection, context-specific judgment, and individualised support (to be distinguished from the personalised learning that so many AI-enabled applications claim to provide) that takes into account not only the unique needs but also the unique circumstances and diverse perspectives of each learner.

Finally, ethics by design involves the choice of pedagogy embedded in the AIED. It advocates for a shift away from traditional didactic approaches towards constructivist approaches. Didactic approaches typically assume a one-way transfer of knowledge from the teacher to the students, often relying on passive learning experiences. In contrast, constructivist approaches emphasise active engagement, critical thinking, and collaborative learning, where students construct their own knowledge through meaningful interactions and hands-on experiences. In other words, when designing AIED, it is essential to consider how they can support constructivist pedagogies, enabling students to explore and construct knowledge. By offering adaptive feedback, interactive simulations, and opportunities for inquiry-based learning, AIED that is ethical by design might facilitate student-centred approaches that promote deeper understanding and active participation.

In summary, ethics by design in the realm of AI and education aims to harness the potential of innovative technologies while safeguarding human values and promoting positive learning experiences. It emphasises proactive measures to anticipate and prevent harm, rather than merely reacting to ethical issues after they arise. By embracing ethics by design, education might leverage the power of AI to enhance teaching, learning, and educational outcomes in a responsible and ethical manner – something that we are yet to see.

2. The role of teachers and teacher trade unionists

Teachers and teacher trade unionists play a crucial role in ensuring that teaching with AI and teaching about AI supports human rights and social justice, strengthens education as a democratic and accountable public good, empowers teachers, and supports student agency. They can do this by advocating for greater democratic control over education, by defining the educational problems that the AIED tools aim to solve (rather than being passive recipients), by ensuring that AI tools are used in a responsible and ethical manner that takes into account the human dimension of AI literacy, and by being genuinely involved by the developers in the design of the AIED applications.

One way to ensure that teachers retain control of their classrooms is to provide them with the training and support they need to effectively evaluate AI tools and incorporate them into their teaching practice. This can involve

providing teachers with opportunities to learn about AI and its potential impact on education, as well as providing them with the resources and tools they need to evaluate the effectiveness of different AI tools in their classroom.

Another way to ensure that teachers retain control of their classrooms is to ensure that they are involved in the decision-making process regarding the use of AI tools in education. All teachers, not just teachers of computer science or related subjects, should be consulted and involved in the selection and evaluation of AI tools, as well as in the development of AI literacy curricula. This can help to ensure that the use of AI in education is aligned with the principles of social justice and human rights, and that the human dimension of AI literacy is effectively taught.

Moreover, teachers and teacher trade unionists can play a key role in advocating for greater transparency and accountability in the use of AI tools in education. This can involve advocating for greater regulation and oversight of AIED tools, as well as ensuring that the tools are used in a way that is consistent with human rights principles.

It is also essential to involve other stakeholders in the process. Alongside teachers, this includes students, parents, and other community members. By involving all stakeholders in the process, it is possible to ensure that the use of AI in education is aligned with the principles of social justice and human rights, and that the human dimension of AI literacy is effectively taught.

Teachers and teacher trade unionists play a crucial role in ensuring that teaching with AI and teaching about AI supports human rights and social justice, promotes democratic values, empowers teachers, and supports student agency. However, to ensure that teachers retain control of their classrooms, it is essential to provide them with the training and support they need to effectively evaluate AI tools and how to incorporate them (if appropriate) into their teaching practice.

As a final note, the arrival and wide take-up of Artificial Intelligence-enabled tools in educational contexts is often taken to be an application of technology that is to the benefit of everyone – students, teachers, and wider society. However, it is increasingly clear that the narrative promoted by the tech industry, that technology equates to progress, misdirects our attention. There remains little evidence that what is good for the technology industry is good for the world; similarly, there is little evidence that what is promoted by the AIED industry is good for students and teachers. In fact, while it is true that, on average over recent centuries, living standards have improved across the world, this is not necessarily due to technological advances. To the contrary, as a recent publication notes:

> *"Today's 'progress' is again enriching a small group of entrepreneurs and investors, whereas most people are disempowered and benefit*

> *little… The broad-based prosperity of the past was not the result of any automatic, guaranteed gains of technological progress… Most people around the globe today are better off than our ancestors because citizens and workers in earlier industrial societies organised, challenged elite-dominated choices about technology and work conditions, and forced ways of sharing the gains from technical improvements more equitably."* (Johnson & Acemoglu, 2023, p. v)

Accordingly, if the human right of students to receive a quality education is to be protected, and if teachers are not to be disempowered, teachers and teacher trade unionists must engage critically with the AIED narrative. Maybe there is positive potential. However, it is essential that the many usually unsubstantiated claims are challenged, that independent evidence at scale of both efficacy and safety is demanded, that the assumption that AIED is inevitable and will only benefit education is questioned, and that teachers working together make the key decisions about the teaching and application of AI in education.

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