United Nations Educational, Scientific and Cultural Organization

UNESCO Institute for Information Technologies in Education

Digital Transformation of Education

AI in Education: Change at the Speed of Learning

UNESCO IITE POLICY BRIEF

STEVEN DUGGAN

AI in Education:

Change at the Speed of Learning

UNESCO Institute for Information Technologies in Education
Author: Steven Duggan, Terawe Corporation
Editor: Svetlana Knyazeva, UNESCO IITE

Published by the UNESCO Institute for Information Technologies in Education
8, Bldg. 3, Kedrova Street, Moscow, 117292, Russian Federation

Tel.: +7 499 1292990

Fax: +7 499 1291225

E-mail: Liste.info.iite@unesco.org

www.iite.unesco.org

ISBN 978-5-6046449-2-8

Cite this content as: UNESCO IITE. (2020). AI in Education: Change at the Speed of Learning. UNESCO IITE Policy Brief. Author: Steven Duggan. Editor: Svetlana Knyazeva.

Contents

Foreword

In line with its mission to serve as facilitator and enabler for achieving Sustainable Development Goal 4 through ICT-enhanced solutions and best practices, the UNESCO Institute for Information Technologies in Education launches a new series of publications "Digital Transformation of Education". The series will include policy briefs, analytical reports and reflection papers developed to explore ongoing and emerging fundamental changes in education due to the use of technologies and their impact on education and other spheres of human life.

The first issue in the series is the policy brief on Artificial Intelligence (AI), which promises enormous benefit to students, teachers, school leaders, parents and education administrators. The appropriate and effective use of AI can provide considerable benefit in time to be spent for lesson preparation, devising creative and innovative ways to improve the learning experience for students, and developing individualized learning pathways. The Compendium "UN Activities on Artificial Intelligence" listing the actions of 35 UN agencies in this field to meet the most urgent world's challenges, from humanitarian crises to climate change, mentions that 'although it is still early days for AI' it should be 'a force for good, it must face complex questions about trust and address challenges.' This UNESCO IITE publication describes the promises of AI and also highlights the ethical aspects of its implementation and challenges that it might bring.

This policy brief was authored by Mr. Steven Duggan, who have worked in education for more than 30 years. Mr. Duggan is Member of UNESCO IITE Governing Board and Vice President of Terawe Corporation providing AI solutions for a wide range of public sector and commercial industries. Previously he served as the Director of Worldwide Education Strategy at Microsoft.

Mr. Tao Zhan
Director
UNESCO Institute for Information Technologies in Education

Executive Summary

AI will play a pivotal role in helping to realize the promise of personalized learning — the ability to tailor the delivery, the content and the pace of learning to the specific needs of each individual student. The ability to Ingest data from multiple data sources, Interrogate that data and to derive Insights — using tools such as predictive analytics and machine learning — is what makes AI such an exciting advancement in education technology and why its use will prove transformational for all stakeholders, from individual students to Ministries of Education.

For students, AI's ability to make connections between disparate data sources will help to identify areas where real-time interventions or additional assistance may be required. As a result, AI makes it possible to devise a tailored or individualized learning pathway for each student which is specific to them and designed to accommodate their strengths, weaknesses, talents and challenges. Advanced analytics and machine learning also hold significant potential for the development of social and emotional learning skills as they allow educators to personalize instruction and to analyse both qualitative and quantitative data to assist with a student's mastery of these skills. By enabling students to learn at any time, in any place, technology is also helping to democratize education and offers learners currently unable to attend a physical school the opportunity to achieve their full potential.

The effective use of AI, Data & Analytics and Machine Learning can enable educators to deliver engaging, immersive educational experiences. Far from becoming side-lined by the emergence of these exciting new technologies the primacy of the teacher's role has been reasserted, and the role of the educator will be enhanced rather than displaced by technology. The promise of AI for teachers lies in its ability to increase the effectiveness of their teaching and to assist them in providing the ideal conditions in which their students can learn and grow. By analysing all of the available data sources and generating insights to guide in the creation of personalized learning pathways, AI can save educators significant amounts of time that would otherwise have to be spent studying and collating such data — an almost insurmountable task when the data is continually changing and there are so many success factors and data sources to be considered. Data and Analytics can also support effective teamwork across a school. Subject teachers, department heads, counselling and welfare services and school leadership can coordinate efforts and collaborate in the building and delivery of individualized support programs based on a shared set of learnings and indicators.

Students whose parents take an active part in their education are more likely to attend school regularly, adapt well to school, take advanced classes, and to excel academically. Such students also tend to have better social skills and are more likely to graduate from high school and to attend post-secondary school. AI supports parental engagement by allowing them to become participants in, rather than reviewers of, their child's progress.

School leaders are responsible for decisions which can affect every student and faculty member. Whereas in the past it might have been deemed sufficient for school leaders to monitor academic progress, it is now accepted that preparing a student for the world beyond the school gates requires the development of a variety of skills and abilities, all of which need to be considered integral parts of a student's learning pathway. In addition to core factors such as Behaviour and Attendance, educators and school leaders must also evaluate Participation, Persistence, Optimism and Self-Belief, Critical Thinking and a range of other key determinants of future success. In the absence of AI, it is impossible for a school leader to analyse all of these disparate factors for each student within the school, or to derive the insights necessary to support timely interventions.

Management of the institution (of its human and capital resources, of the physical and digital environments, of compliance with and adherence to fiscal and legal requirements, etc.) is often accompanied by a myriad of other logistical and administrative tasks. For many school leaders the burden this imposes is exacerbated by the reactive nature of the tasks involved. Sudden, unexpected expenses for building maintenance and repair; provision of cover for absent teaching, facilities or administrative staff; peaks and troughs in student enrolment numbers — all of these can impose stresses and financial constraints upon the effective management of the school. The use of Data and Predictive Analytics can help school leaders to move from reactive to proactive management and to predict issues before they arise.

Ministries of Education, local authorities, municipalities and other organizations tasked with oversight and management of groups of schools or colleges are reliant upon accurate, up-to-date information. Traditionally these organisations have placed a premium upon data collection to guide decision-making, but in the main this data has been historic and is often out of date by the time it has been collated. Planning for the future armed only with information from the past is both imprudent and unnecessary. AI, Data & Analytics and Machine Learning technologies have the ability to generate insights in real time and to continuously update that guidance as the data is refreshed.

Ensuring that school and college curricula are up to date and can adequately prepare students for the world they will face upon graduation is a perennial challenge. In many subject areas, including but not limited to the sciences and technologies, the knowledge base is continuously changing and expanding, making it difficult to ensure that course content is relevant and up to date. The ability to interrogate large data sets, to analyse that data and generate insights, and to expose those insights via dashboards and visualizations tailored to the needs and roles of those tasked with curriculum design, can improve the currency and accuracy of the information available and the preparedness of those engaged in this essential work.

Despite the promise of AI, significant challenges remain, particularly in regard to equity of opportunity. 43% of the world's population still do not have access to the internet, and an estimated 40% of people have never once been online. Learners who have limited access to the information required to assist them in their studies and the ability to generate and share electronic data, may be disadvantaged when it

comes to the building of personalized learning pathways which adequately identify and address their needs.

If all learners are to reap the rewards of AI in education, regulation and ethical frameworks will be required. How can we ensure that gender, racial, socio-economic and ability biases are not introduced at the programming level? How can we ensure that social and cultural stereotypes are not promulgated? How can we ensure that all learners, regardless of where they live, have the same access to the benefits which will accrue? Given the power and influence such technologies will come to have in shaping the education — and by extension the opportunities and potentially the values of learners — transparency and oversight will be required to ensure that AI-enabled technologies conform to and strengthen fundamental human rights. AI technologies are continually evolving — emergent technologies such as Cognitive Services, Virtual, Mixed and Augmented Reality and the Internet of Things are reshaping our world and providing all stakeholders in education with opportunities to advance teaching and learning, and ethical challenges which will need to be addressed.

AI will play an important part in tackling the next great challenge being offered to education technologists: how to support personalized assessment. Current forms of assessment are seldom aligned to the skills that will be demanded of students when they enter the world of work. Multiple-choice, long- and short-form examinations can serve to evaluate some of the higher-order thinking skills that will be required in a 21st century environment — recall, comparison, analysis and inference — but soft skills, 'people skills', moral character, teamwork, collaboration and the ability to work effectively as part of a team are difficult to evaluate using these traditional forms — and they are at least as important to future employers and to a graduate's ability to survive and thrive in a 21st century workplace.

AI will form part of the foundation for the educational experiences and opportunities students will enjoy in the coming decade. For students, educators, school leaders, parents, administrators and system owners, AI in education is already delivering real benefits and will prove a powerful catalyst for change.

1. The Changing Role of Technology in Education

Students and teachers are facing a world of constant, ever-accelerating change. Those now exiting secondary school for the world of work or further study in the developed countries have never known a world without the ubiquity of the internet and the mobile phone. Although the first commercially-available mobile phone only appeared in 1985, by 1999 one phone was being sold in the United Kingdom every four seconds, and by 2004 — when these students were in grade 2 or 3 — there were more mobile phones than people in the UK[1]. The disparity between the developed and developing world in terms of access to the internet and smart devices was immediately recognised as a 'Digital Divide'; and as technology entered the classroom in schools where the socio-economic conditions allowed for such investments, fears were expressed that disadvantaged students of all nationalities would be left behind.

Conversely, many people held that access to technology and low-cost mobile devices could help close the educational gap caused by failures of the formal education system, and connect those who had left school or never had the opportunity to attend a classroom to rich educational experiences which could address foundational issues such as the global challenge of illiteracy.

In the event, the introduction of devices into the classroom did not bring about a commensurate improvement in exam grades — though it did help to enable new pedagogical modalities such as the flipped classroom — and illiteracy rates remained virtually unchanged[2]. The role of the teacher has been proven paramount, along with the need for adequate professional development supports which incorporate the building of digital skills[3]. Far from technology replacing teachers, the role of the teacher is now recognised as the most important factor in unlocking the potential of technology to advance teaching and learning.

In concert with the emergence of these new technologies was a focus upon what were termed '21st century skills'. Knowledge-acquisition was relegated in importance, and the ability to work in teams, to collaborate and communicate effectively and to develop analytical and digital skills to better prepare students for the world they would face upon leaving school assumed a primacy in curricular and pedagogical design. Learning how to learn and the importance of lifelong learning were regarded as intrinsically linked to the acquisition of digital skills and experience in the use of basic technologies.

---

1 The Guardian. (2009). *In just 25 years, the mobile phone has transformed the way we communicate*. Retrieved from https://www.theguardian.com/business/2010/jan/01/25-years-phones-transform-communication

2 World Population Review. (2020). *Literacy Rate by Country 2020.* Retrieved from https://worldpopulationreview.com/country-rankings/literacy-rate-by-country

3 OECD. (2018). *Teaching for the Future: Effective Classroom Practices To Transform Education.* OECD Publlishing, Paris. Retrieved from https://doi.org/10.1787/9789264293243-en

2. Advancements in Technology

2.1. Data, Analytics and Personalized Learning

The notion of personalized learning — the ability to tailor the delivery, content and the pace of learning to the specific needs of each individual student — emerged as a primary objective of educational reform. The promise of technology lays in its ability to support personalised learning pathways: but this could not be achieved through the use of hardware or software alone. To determine whether students were building 21st century skills it would be necessary to measure a variety of data, drawn from disparate sources.

The implementation of Student Information Systems (SIS) and Learning Management Systems (LMS) provided new digital data sets, but the majority of data pertinent to student progress and performance was still in paper form, and often resided solely in the heads of teachers. Before Artificial Intelligence (AI) or Predictive Analytics could be employed to assist in the creation of personalized learning pathways, progress was necessary in how data was gathered, stored, and made accessible.

The 'data journey' towards this state was comprised of the following key stages:

I. **Data collection**: the capturing of key student data relevant to some or all of the following core measures of student success: academic performance; attendance; participation; behaviour; consistency; resilience; persistence or 'grit'; confidence or self-belief; enjoyment or engagement; emotional development; social development; ethical development; physical development.

II. **Data presentation**: the display of data in a form which allows for review and interrogation, including visualizations.

III. **Historical analysis**: the analysis of past performance and student progress to date to derive insights and to identify areas requiring course-correction or review.

IV. **Predictive analysis**: the analysis of both current (real-time or near-real-time) data and historical data to enable projections with regard to such core concerns as student retention/dropout rates and to identify students in need of timely interventions, whether these relate to academic performance or issues of mental health or welfare, and to assist in future planning on a systemic, institutional, and individual student basis.

The majority of schools, colleges and education systems are currently at stage I of the data journey (data collection) but even at this stage Artificial Intelligence can deliver real benefits. Before we outline those benefits, we need to define what is meant by AI in an educational context.

2.2. Artificial Intelligence

Artificial Intelligence begins with data. The ability to Ingest data from multiple data sources, Interrogate that data and derive Insights — using tools such as predictive analytics and machine learning — is what makes AI such an exciting advancement in education technology, and why its use will prove transformational for all stakeholders, from individual students to ministries of education.

In an educational context, perhaps the best way to view Artificial Intelligence is to view it as Augmented Intelligence. The application of AI provides all stakeholders with additional information and with insights which can better inform decisions. Below are a number of the data points which need to be considered by key stakeholders:

Students: individual students need help to identify areas in their learning pathways where they need additional support or guidance, or where they require an increased focus in their studies

Educators: a typical primary-school teacher can have between 20-30 students in a class[4]. To measure progress against all of the core success metrics outlined in Stage 1 of the data journey above for each student in a class of 30 students would require them to track progress against 390 different data points. For a secondary school teacher, who might teach 6 or more groups of students in different grades or age groups, the challenge is exponentially greater. (It is a measure of the extraordinary dedication and skill that teachers as a profession display that they undertake to do this to the best of their abilities in service of their students and the students' families.) A professor or dean of faculty at a university may have an even larger cohort of students; and for all educators the student cohort will typically change on an annual or more frequent basis.

School Leaders: to manage an academic institution or to lead change, a school leader in K-12, Further Education or Higher Education needs to consider a vast range of factors and data points. In addition to student-centric data, he or she must consider staffing issues; financial and infrastructural management issues; matters relating to policy, governance and oversight; privacy, health and safety concerns, etc.

Curriculum Designers: those tasked with designing curriculum at an institutional, regional or national level need to consider information from a variety of sources, including the academic, the vocational and the societal, in order to ensure that evolving curricula can meet the current and future needs of students, and will adequately prepare them for the world they will face on leaving school. A curriculum based solely upon historic data, referencing a limited number of sources, cannot hope to meet future needs.

Having access to all of the relevant and available data is not sufficient. None of these challenges can be met with data alone. It is the ability of Artificial Intelligence to make connections across these different data points — to provide predictions

[4] OECD.Stat. (2020). *Average class size*. Retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=EDU_CLASS

of future outcomes in order to enable course-corrections in near-real-time and to derive insights which will allow all stakeholders to make more informed decisions — which constitutes its power and its promise.

2.3. Cloud Computing

Interrogating huge data sources is not possible without access to proportionate computing power. Advancements in computing power have been the primary driver of the rapid pace of innovation and technical advancement we have seen over the past few decades. In 1970, Gordon E. Moore, the co-founder of Intel Corporation, said that he believed the processing power of computers would double every two years. What became known as Moore's Law has proved prescient. The processing power of a computer processor (or CPU) can be measured in Floating Operations Per Second (FLOPS). Between 1956 and 2015 it is estimated that there has been a one-trillion-fold increase in FLOPS of computer processing power. This increase in computing power has been accompanied by a commensurate reduction in cost, which also provided a vital contribution to the pace of change[5].

Perhaps the single most important development in the evolution of Artificial Intelligence has been the shift from what is termed 'on-premises' computing — where users access a computer or network of computers housed locally — to Cloud Computing, where users access computing resources through the internet, with a virtually unlimited source of computing power that can increase in line with their needs. These resources include tools and applications like data storage, servers, databases, networking, and software. As long as an electronic device has access to the internet, it has access to the data and the software programs to run it.

Cloud Computing is not a single piece of technology but instead comprises three different types of services: Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS).

Software-as-a-service (SaaS) enables users to license a particular piece of software (for example, a productivity suite such as Microsoft 365[6]) on a pay-as-you-go or on-demand basis.

Infrastructure-as-a-service (IaaS) provides users with access to everything from operating systems to servers and storage as part of an on-demand service, meaning that organisations no longer need to purchase software or physical servers.

Platform-as-a-service (PaaS) provides users with a development platform for creating software, allowing them to develop, deploy and manage computer applications without having to build or maintain the infrastructure required to support this.

The key benefits of Cloud Computing — and the reasons why so many businesses and public enterprises have made the move to the Cloud — are the following:

---

5 Max Roser and Hannah Ritchie. (2013). *Technological Progress*. Published online at OurWorldInData.org. Retrieved from https://ourworldindata.org/technological-progress

6 https://www.microsoft.com/en-ie/microsoft-365

1. **Reduced Costs**: computer server hardware and traditional desktop software can be very expensive and are often under-utilized, meaning that servers can sit idle for much of the time and that organisations end up paying a high price to license software that not all of their staff members use or require. A low-cost cloud service based on a pay-as-you-go model, whereby the organization only pays a license fee based on actual usage, can provide significant savings.

2. **Unlimited Storage**: Cloud Storage is virtually unlimited and is charged on a usage basis. The organisation no longer needs to worry about meeting changing storage needs via the purchase of expensive hardware which it will need to maintain, and storage provision can be scaled up — or scaled down — as needed.

3. **Backup and Recovery**: all data stored in the Cloud is typically backed-up by the cloud service provider, with multiple fail-safes and automatic data replication across different locations, greatly reducing the danger of data loss and allowing for rapid data recovery in the event of a 'crash'.

4. **Ubiquitous Access**: key information can be accessed from virtually any place with an internet connection, at any time, and using any device. This in turn can improve communication and collaboration between team members and boost productivity.

5. **Security**: although many fears persist about placing sensitive or confidential information in the Cloud, cloud service providers often have enhanced levels of security and data protection along with services such as data encryption and remote wipe of lost or stolen devices which provide commensurate or improved levels of security compared to on-premises solutions.

6. **Flexibility**: organizations can scale services to meet their needs and increase or decrease capacity in line with demand to support fluctuating workloads.

2.4. Machine Learning

Machine Learning is an application of Artificial Intelligence which enables computers to act without being explicitly programmed, and to learn and improve from experience without human intervention or assistance. It is used to answer questions that cannot be answered by manual research, and is based on the idea that systems can learn to identify patterns and make decisions and can become more proficient over time, learning from previous computations to produce reliable, repeatable decisions and results.

Machine Learning uses algorithms — pieces of code comprising of a finite set of unambiguous step-by-step instructions that a machine can follow to achieve a certain goal. Algorithms use parameters based on training data — a subset of data that represents the larger set. As the training data expands through usage and the analysis of larger and larger data sets, the algorithm calculates more accurate results.

Different algorithms analyse data in different ways. They are often grouped by the machine learning techniques that they are used for: supervised learning, unsupervised learning, and reinforcement learning.

Supervised Learning: In supervised learning, algorithms make predictions based on a set of labelled examples that you provide. This approach is useful when you know what the outcome should look like. For example, you provide a dataset that includes city populations by year for the past 100 years, and you want to know what the population of a specific city will be four years from now. The outcome uses labels that already exist in the data set: population, city, and year.

Unsupervised Learning: In unsupervised learning, the key data points are not labelled — the algorithm labels them itself by organizing the data, or by describing its structure. This technique is typically used when you do not know what the outcome should look like. For example, you provide customer data, and you want to create segments of customers who like similar products. The data that you are providing is not labelled, and the labels in the outcome are generated based on the similarities that were discovered between data points.

Reinforcement Learning: Reinforcement learning uses algorithms that learn from outcomes, and decide which action to take next. After each action, the algorithm receives feedback that helps it determine whether the choice it made was correct, neutral, or incorrect. It's a good technique to use for automated systems that have to make a lot of small decisions without human guidance. For example, you are designing an autonomous car, and you want to ensure that it is obeying the law and keeping people safe. As the car gains experience and a history of reinforcement, it learns how to stay in its lane, go the speed limit, and brake for pedestrians.

Machine Learning is already widely used across many industries. On online retail websites it is used to help identify products you might be interested in buying based on your previous purchasing history, or upon searches you have made on the website for particular goods or services. Banks and other financial organizations routinely use machine learning to identify, predict and prevent fraudulent transactions. In healthcare, machine learning can help to identify patterns or anomalies, which can improve diagnoses and accelerate the provision of vital treatments.

3. The Promise of AI

3.1. Students

The application of Artificial Intelligence offers students of all ages, achievement levels and differing socio-economic backgrounds a number of significant benefits, each of which can result in enhanced learning experiences and improved learning outcomes.

Much of the data required may already be being collected, such as grade scores, results from school and state exams, attendance and punctuality records, school reports, comparative scores with regard to peers or classmates, Individualized Education Programs (IEPs) and other sources of qualitative and quantitative data.

Typical forms of qualitative data can include notes from classroom observations; minutes of staff meetings; feedback from a teacher, teaching assistant or department head; samples of the student's work with comments from their teacher; disciplinary or student welfare reports, etc. These can be augmented through the use of surveys, interviews and observations.

Typical forms of quantitative data can include assessment scores (individual and comparative), aggregates of survey results, and numerical results or measures of any sort pertinent to the student's progress. Essentially quantitative data in this context means any data which can be expressed as a set of numbers.

As schools and colleges proceed along the 'data journey', more of this information will be available in digital form, which assists in data analysis. It is worth pointing out that data does not need to be in digital form to be included in a data set. With the use of emergent technologies such as Cognitive Services, it is also possible to extract data from handwritten notes and audio or video recordings. Cognitive Services add the ability to see, hear, speak, search, understand, and accelerate decision-making to the processes of data collection and interrogation.

3.1.1. Personalization

AI, Data & Analytics and Machine Learning allow all those tasked with a student's education to access information and gain vital insights into key aspects of the student's progression, and into other factors which may underly a change in their attitude, engagement or performance.

AI's ability not only to ingest and interrogate vast amounts of data, but to make connections between disparate data sources, can help to identify areas where real-time interventions or additional assistance may be required. Extrapolating from this AI makes it possible to devise a tailored or individualized learning pathway for each student, which is specific to them and designed to accommodate their strengths, weaknesses, talents, and challenges.

The implications of this are enormous. Truly personalized learning provides students with the optimal environment in which they can achieve their full potential. In addition to the positive effect this will have upon their academic performance, a student's attitude to school, level of engagement, sense of being cared for and valued and their general happiness and well-being are also likely to be improved.

3.1.2. Social and Emotional Growth

Social and emotional well-being has become an increasing area of focus in education. There has been a recognition that automation and AI are radically changing the world of work, and that interpersonal skills, empathy and creativity will become essential attributes for the jobs of tomorrow. Social and emotional skills, such as problem solving and collaboration, are increasingly necessary for the labour market. The link between a student's outlook and mood, their ability to interact and collaborate with others and their capacity to learn has also been recognised, and had led to a demand for educational reform which places these skills at the centre[7].

Students' exposure to the internet and social media has also contributed to an increased focus upon the development of these skills. The prevalence of 'fake news', disturbing images and stories, issues of privacy and data protection, and the pressures upon children and young people to project and protect an idealized image of themselves against a backdrop of cyber-bullying and health and welfare disorders, including body dysmorphia, eating disorders, depression and anxiety, have underlined the importance of students acquiring the knowledge and skills to navigate the world in which many of them now live.

Research[8] has shown that artificial intelligence and multimodal social computing can help to improve cognitive, social and emotional skills. Advanced analytics and machine learning have long been employed in the private sector to deliver business insights, and increasingly these applications are entering education. Advanced analytics and machine learning hold significant potential for the development of social and emotional learning skills because they allow educators to personalize instruction, and to analyse both qualitative and quantitative data to assess and assist with a student's mastery of these skills.

3.1.3. 21st Century Skills

A consensus has been established in relation to the skills which can be regarded as essential for students to be successful both during their studies, and in the world of work. What have become known as '21st century skills' are a set of competencies and capabilities which students will require upon graduation to enable them to achieve their full potential.

---

7 The Economist Intelligence Unit. (2019). *Emotion and Cognition in the Age of AI: white paper*. Commissioned by Microsoft. Retrieved from https://clouddamcdnprodep.azureedge.net/gdc/gdcWRrXfv/original

8 Cassell, J., Bai, Z., Paranjape, B., Sinha, T., Slebodnick, D., Luo Yi Tan. (2016). *Sensing Curiosity in Play and Responding*. The ArticuLab, Carnegie Mellon University. Retrieved from http://articulab.hcii.cs.cmu.edu/projects/scipr/

Although lists of designated 21st century skills can vary, all authorities agree that certain skills lie at the core, including: Creativity, Collaboration, Critical Thinking, Perseverance, Problem-Solving, Self-Direction, Global Awareness and Digital Literacy Skills.

Technology can play a role in helping students to develop skills in all of these areas, and the application of AI can help educators to orchestrate and personalise the delivery of learning to meet their needs. It is the ability of AI to assess progress against a large and disparate set of measures, to ingest data from all of these often distinct and unrelated learning pathways, and to generate insights which provide a holistic view of the progress of each individual student that most clearly illustrates the value that AI can have in improving learning outputs.

Assisting a cohort of students in the development of the broad range of 21st century skills requires the collection and analyses of vast amounts of data — what is sometimes termed Big Data — and AI is required if useful insights are to be exposed, which assist them in that journey. As the organizational theorist Geoffrey Moore put it, "Without big data, you are blind and deaf and in the middle of a freeway."

3.1.4. Accessibility

Technology has long played a role in supporting students with disabilities. The first beneficiaries of education technology within schools and colleges were typically those for whom a laptop or similar device served to help 'level the playing field' for them as learners, facilitating improved access to learning objects and opportunities, freeing them from the constraints of set times and physical locations, and providing access to new tools and services specifically tailored to their needs.

Features such as text-to-speech and screen narration provide help to people with visual impairments; voice commands, descriptive audio and speech-to-text features provide assistance to students with hearing difficulties; simple features such as keyboard shortcuts and support for varied input devices and sensors have enabled those with physical disabilities to operate a computer device even if their disability is profound, as exemplified by the achievements of the late Stephen Hawking.

AI is opening doors for students with disabilities, which will profoundly alter their educational opportunities and levels of engagement. Among recent advancements driven by the use of AI have been Apps which can observe, analyse and describe the world around a visually impaired person through their mobile phone, with the ability to recognize the student's friends and acquaintances, and even to describe their emotions based on such factors as facial expression and posture[9].

3.1.5. Well-being

In recognition of well-being's impact on learning — and the education system's role in shaping the emotional and mental health of young people — the OECD

[9] https://www.microsoft.com/en-us/ai/seeing-ai

has measured student well-being as part of its Program for International Student Assessment (PISA)[10] ranking since 2015.

PISA defines well-being as "the psychological, cognitive, social and physical functioning and capabilities that students need to live a happy and fulfilling life," which includes the following elements:

Psychological Well-being: comprising students' sense of purpose, self-awareness, affective states and emotional strength.

Social Well-being: students' quality of social lives, including relationships with family, peers and teachers, as well as a sense of social belonging within a school community.

Cognitive Well-being: referring to students' proficiency in using academic knowledge and soft skills to become lifelong learners, effective workers and engaged citizens.

Physical Well-being: the ability to follow a healthy lifestyle based on self-reported measures of physical activity and nutrition.

AI can assist all interested stakeholders within an educational institution or system to identify, predict and prevent crises in student well-being or welfare. The ability to ingest data from data sources across the institution, including performance measures, attendance and punctuality records, notes and reports from faculty, administrative and counselling staff members, can be used to create dashboards and alerts which help the institution plan and allocate resources to support early interventions for students in need of assistance, in danger of dropping out, or undergoing a mental health, academic or personal life crisis. In this context, AI's ability to identify students in need of urgent assistance in real-time, and to predict when others may be in danger of experiencing a well-being crisis in the future using indicators and insights derived from machine learning, can literally prove a life-saver.

3.2. Educators

The effective use of AI, Data & Analytics and Machine Learning can enable educators to deliver engaging, immersive educational experiences and to build personalized learning pathways for each student utilising the augmented intelligence and insights derived from their use.

It is worth reiterating that AI will not replace teachers. Dr Thornburg's oft-quoted maxim that "Any teacher that can be replaced by a computer, deserves to be" is a contentious one, but it also serves to highlight the fact that no technology currently exists which can replicate let alone supplant the myriad skills and qualities of a great educator. Far from becoming side-lined by the emergence of these exciting new technologies, the primacy of the teacher's role has been reasserted. The promise of AI for teachers lies in its ability to increase the effectiveness of their teaching and to assist them in providing the ideal conditions in which their students can learn and grow.

[10] http://www.oecd.org/pisa/

3.2.1. Effectiveness and Timesaving

By analysing all of the available data sources and generating insights which they can use to create personalized learning pathways, AI can save educators significant amounts of time that would otherwise have to be spent studying and collating such data: an almost insurmountable task when the data is continually changing, and there are so many success factors and data sources to be considered.

By providing educators with a detailed view of each student's progress, they can quickly identify gaps and challenges and address these, resulting in better student outcomes and happier, more engaged class members.

AI can also save time for educators at the 'other end' of the process, by producing rich student reports which can be made available to the institution, to parents or guardians, and to the students themselves. Rather than historical reports which reflect past performance at set points in time during an academic year, such reports can be made available to all stakeholders as and when required and will be both more accurate and up-to-date than traditional reports or reviews.

Freeing up time from laborious administrative tasks can also have an impact upon educator recruitment and retention. Teachers spend an estimated 3-5 hours[11] each day grading papers and tests, preparing lesson plans and completing administrative work outside of the classroom. Not only is this a leading cause of teacher attrition, it also serves as a powerful disincentive when trying to attract top talent to our schools and classrooms.

3.2.2. Engagement and Enjoyment

Students, who are engaged and interested, learn more and retain that learning for longer. Successive studies[12] in the late 20th and 21st century in both England and the US suggest that an absence of enjoyment is one of the foundational reasons for young people failing to achieve their potential. Though perseverance and an ability to deal with frustration and failure are also key to a successful learning journey, these studies have amply demonstrated that children in particular learn better when they are excited and engaged.

Student enjoyment is not only a beneficial condition for learning: it is a desired outcome, and in some national curricula is assigned the same importance as being healthy and safe[13]. When educators can devote more of their time to class preparation and learning delivery, and less on assessments and the writing of reports, the benefits are felt by students in their classrooms and lecture halls. When students feel that their individual needs are 'seen' and considered by the educator, they feel supported and valued and are more likely to engage with their course of study.

---

[11] Murray, C. (2013). *How Many Hours Do Educators Actually Work?* Retrieved from https://edtechmagazine.com/k12/article/2013/08/how-many-hours-do-educators-actually-work

[12] Goetz, T., Nathan C., Hall, B., Anne, C., Frenzel, A., Pekrun, R. (2006). *A hierarchical conceptualization of enjoyment in students*. Learning and Instruction, 16, 323-338.; Shernoff, D.J., Csikszentmihalyi, M., Schneider, B., Shernoff, E.S. (2003). *Student engagement in high school classrooms from the perspective of flow theory*. School Psychology Quarterly, 18(2), 158-176.

[13] Department for Education and Skills. (2003a). *Every child matters*. London: DfES.

3.2.3. Collaboration

Data and Analytics can reveal insights which support effective teamwork across a school, and can inform a personalized learning plan (PLP) or similar whole-school support program. Subject teachers, department heads, counselling and welfare services, and school leadership can coordinate efforts and collaborate in the building and delivery of individualized support programs, based on a shared set of learnings and indicators. Team-teaching modalities are also enhanced when it is possible to effectively map student needs to educator strengths and talents.

AI can help department and faculty heads to identify the range of strengths and weaknesses across their educator cohort, and to structure collaborative approaches which maximise the collective skills of the team. Best practices which improve learning outcomes can be identified and shared, and mentorships and peer coaching relationships enhanced by ready and ongoing access to quantitative and qualitative data.

3.2.4. Professional Development and Self-Reflection

Effective, ongoing professional learning is essential, if schools and colleges are to support the development of the increasingly complex skills students will need to learn for further education, and for work in the 21st century. Sophisticated forms of teaching are needed to develop student competencies such as critical thinking, complex problem-solving, deep mastery of challenging content, effective communication and collaboration, and self-direction. To enable educators to support the development of 21st century skills they need access to professional development which helps them to learn and refine the pedagogies required to teach these skills.

Studies would suggest that these needs are poorly served in many institutions and education systems. Constraints of time, money and resources, and a tendency for many forms of professional development to take place outside of the classroom, often limit the number of hours or days educators can devote to developing their skills in an academic year. Educators also need opportunities to collaborate in their learning, to practice the same types of learning they will bring back to their classrooms, and to share ideas and best practices. We cannot build 21st century skills and support deep learning within educational institutions by subjecting educators to outmoded forms of instruction during their professional development.

The effective use of technologies such as AI can provide educators with the same access to anytime, any place learning, and enable them to build the same skills that their students will require, via the same pedagogies and modalities they will be asked to model in their schools and colleges. AI can also assist with on-the-job and informal or independent professional development. Educators are assisted in the processes of self-reflection and skills development when supported by objective data rather than, or in addition to, subjective appraisals to which some educators may be resistant, or in which they may be unwilling to participate.

3.3. Parents

3.3.1. Involvement and Engagement

Parents[14] are key stakeholders in the education of children and young people yet to reach the age of majority, and are typically deeply involved and interested in the education of their children above this age during the course of further and higher education. Their active participation can be a key factor in determining the successful completion of the student's learning journey. Students whose parents take an active part in their education are more likely to attend school regularly, adapt well to school, take advanced classes, and to excel academically. Such students also tend to have better social skills and are more likely to graduate from high school and to attend post-secondary school.[15] In fact, some studies suggest that parental engagement can prove the single most important determinant of student success[16].

Schools and colleges themselves also benefit from the active engagement of parents. In addition to providing essential support to the institution, when parent — teacher relationships are prioritized the learning environment is improved, which in turn affects learning outcomes for all students. Teachers who focus on parental engagement find that the more parents are involved in their children's education, the better their entire class's motivation, behaviour, and grades become. School leaders are also more likely to make effective and impactful decisions when parents are included as participants in the governance and strategic planning.

Parental engagement can be viewed as a progression from parental involvement. Many schools and colleges involve parents in activities, fund-raising initiatives, and school events. The school in turn provides parents with information relating to the student's academic progress and social development. The data shared with parents in these cases tends to be historical and shared at particular points-in-time: usually at the end of a school term or following a school or state exam. Parental engagement is when parents are active participants in their children's education, sharing responsibility with the school or college for the student attaining his or her educational goals. This requires a willingness on both parts to listen and to share — bringing different perspectives to the table to collaborate on the development and delivery of a learning pathway tailored to the needs, abilities, and aspirations of the student.

AI supports parental engagement by allowing them to become participants in rather than reviewers of their child's progress, by ensuring that all parties have access to data and insights to inform that collaboration. When parents can monitor their child's progress and intervene at an appropriate juncture, and can communicate

[14] For the sake of concision, the terms 'parents' and 'parental' are intended as representative of all parents, guardians and care-givers.

[15] Henderson, Anne T., Mapp, Karen L. (2002). *A New Wave of Evidence. The Impact of School, Family, and Community. Connections on Student Achievement. Annual Synthesis 2002*. National Center for Family and Community Connections with Schools, SEDL. Retrieved from https://sedl.org/connections/resources/evidence.pdf

[16] National PTA. (2000). *Building Successful Partnerships: A Guide for Developing Parent and Family Involvement Programs*. National Education Service, Indiana, USA.

with the child's teachers in an informed manner, then all parties benefit — the school, the teacher, the parent, and the child.

3.3.2. Reinforcing Values

When parents are active participants in a student's education they reaffirm the belief that education is important. The child in turn will be more likely to recognize the value and importance of education. The impact of parental engagement can be multi-generational: children tend to model adult behaviours and when parents are actively involved in their education they will internalise that lesson and will be more likely to emulate those behaviours when they too become parents. By providing parents with greater visibility of their child's progress, AI enables them to become more actively involved, and to reinforce the message that they regard education as of importance. However, to achieve this, schools and colleges must be willing to grant access to key data and the information systems which house it, in support of a culture of trust and shared responsibility.

3.4. School Leaders

3.4.1. Oversight and Insight

School leaders, deans, presidents and senior administrators are responsible for decisions which can affect every student and faculty member. Data and insights which can assist them in the decision-making process can have obvious benefits, a fact which is recognised by the majority of school leaders who regard digital technologies as an important supplemental resource which can be employed to personalize the learning experience based on each student's strengths, weaknesses, and preferences[17].

The challenge for school leaders[18] is an exponential one. Whereas an individual teacher at primary or elementary school level may have to monitor the progress of 25-35 students, a secondary or high school teacher may teach multiple classes with a total student cohort of up to 180 students, a university professor may teach a large class of more than a hundred students but tutor a much smaller number, a school leader is typically responsible for a student population running into the hundreds or even thousands of students.

The focus upon 21st century skills has also had an exponential impact upon the process of student assessment. Whereas in the past it might have been deemed sufficient to monitor academic progress, it is now accepted that preparing a student for the world beyond the school gates requires the development of a variety of skills and abilities, all of which need to be assessed as integral parts of a student's learning pathway. In addition to core factors such as Behaviour and Attendance,

[17] Education Week Research Center. (2018). *School Leaders and Technology. Results from a National Survey*. Retrieved from https://www.edweek.org/media/school-leaders-and-technology-education-week-research.pdf

[18] For the sake of concision, the term 'school leader' is intended as representative of all school leaders at primary, secondary and tertiary level.

educators and school leaders must also evaluate Participation, Persistence, Optimism and Self-Belief, Critical Thinking and a range of other key determinants of future success. Simply put, in the absence of AI it is impossible for a school leader to analyse all of these disparate factors for each student within the school, or to derive the insights necessary to support timely interventions.

3.4.2. Efficiencies and Resource Management

School leaders have many responsibilities apart from those directly connected to teaching and learning. Management of the institution (of its human and capital resources, of the physical and digital environments, of compliance with and adherence to fiscal and legal requirements, etc.) is often accompanied by a myriad of other logistical and administrative tasks. School leaders often say that their first duty in fact is to 'keep the lights on' — to ensure that the school can continue to operate and provide the structures and the services essential to the delivery of learning.

For many school leaders the burden this imposes is exacerbated by the reactive nature of the tasks involved. Sudden, unexpected expenses for building maintenance and repair; provision of cover for absent teaching, facilities or administrative staff; peaks and troughs in student enrolment numbers — all of these can impose stresses and financial constraints upon the effective management of the school. The use of Data and Predictive Analytics can help school leaders to move from reactive to proactive management, and to predict issues before they arise. AI solutions can be used to lower energy costs by ensuring that heat and light are provided in line with actual demand, with accurate forecasts generated using machine learning based on historical patterns. Management of staff rosters can be improved, and contingency plans drawn up in advance of any last-minute crisis. Resource planning can be optimized, reporting can be automated, and rich dashboard views presenting real-time data can be made available to all key staff, specifically tailored to their roles. Higher Education institutions in particular are embracing the promise of AI and the Internet of Things (IoT) to increase efficiencies and reduce the number of unforeseen events (and the bureaucratic overhead which often accompanies them).

3.4.3. Teacher Retention

One of the biggest challenges any school leader faces is in attracting and retaining talent. Great educators are a finite resource, and their impact can be immeasurable. Not just upon individual student success — but on the culture and health of the organization as a whole.

However, globally a teaching crisis is driving what has now been recognised by the World Bank as a Learning Crisis[19]. School enrolments in developing countries, at both primary and secondary level, have shot up in recent years — but attracting and

[19] International Bank for Reconstruction and Development / The World Bank. (2018). *The World Development Report 2018 (WDR 2018). LEARNING to Realize Education's Promise*. Retrieved from https://www.worldbank.org/en/publication/wdr2018

keeping qualified, motivated and effective teachers in those classrooms remains an enormous challenge, and graduation rates in a large proportion of those schools are often tragically low. This challenge is not restricted to the developing world. Even when educators are relatively well paid and have access to appropriate resources, the retention rate can be disturbingly low. The United States currently faces an annual estimated shortage of more than 100,000 teachers, and an additional 12% of teachers have indicated that the COVID-19 pandemic may lead them to leave the profession, even though they were not planning to do so before the crisis. Teachers with health challenges across the globe have been forced to consider early retirement, at a time when teacher absences are also expected to grow, and when an estimated 50% of new teachers were already choosing to leave the profession within the first 5 years[20]. The UNESCO Institute of Statistics (UIS) has estimated that countries need to recruit an additional 68.8 million teachers to provide every child with primary and secondary education over the next decade, and retention of existing teachers poses a significant additional challenge.

Artificial Intelligence cannot create new teachers — nor replace the great teachers we already have. However, it can help school leaders to manage and reduce attrition rates by addressing some of the root causes why teachers opt to leave. Surveys have repeatedly shown that higher pay is not the central issue for teachers, nor will it of itself address retention rates. What teachers want, it appears, is more autonomy, more time to spend teaching and preparing classes, less bureaucracy, and less time spent conducting tests and writing reports[21]. What drives great teachers, moreover, is their desire to make a difference in a student's life. By allowing them to create personalized learning paths for each of their students — to identify and address each student's specific needs — and to generate automated, real-time reports with the click of a button, AI can help to remove many of the frustrations teachers currently face while enabling them to do what they love best in a more effective and rewarding way.

3.4.4. Student Retention and Welfare

There is a myriad of reasons why students at all levels of education fail to graduate. Academic under-performance is but one of these — and in many causes is an effect rather than the cause of a student dropping out. The ability to identify and/or predict which students are in danger of dropping out — and to do so in time to make an intervention to prevent this — allows schools and colleges to marshal their limited resources in a more targeted and effective manner. AI's ability to ingest data from a disparate set of unconnected data repositories — including learning management systems (LMS's), student information systems (SIS's) and records of attendance or behavioural reports — and to derive insights which can be presented as real-time alerts, is transformational.

For schools and colleges, student retention is an important issue for a variety of reasons. A student who drops out can represent a financial loss due to lost tuition

[20] Education Week Research Center. (2020). *The Substitute Teacher Gap: Recruitment and Retention Challenges in the Age of COVID-19*. Kelly Education.

[21] Riggs, L. (2013). *Why Do Teachers Quit? And why do they stay?* The Atlantic. Retrieved from https://www.theatlantic.com/education/archive/2013/10/why-do-teachers-quit/280699/

fees or per-capita government grants; a drop in graduation rates can negatively impact the college's ability to attract future students; a reduction in student numbers can also affect the student/teacher ratio, meaning that a school can lose teachers. For the students themselves, the consequences can include reduced career opportunities, lower earning potential; and in some cases a significant student debt without the qualifications to help to service this.

Financial difficulties, family or health crises, and difficulties settling into a new environment with new people and increased academic demands — often while having to do so when living away from home for the first time — are all recognised as major causes of a student leaving a college or university. Increasingly, schools and colleges are looking beyond these factors towards a deeper and more insidious threat — student mental health.

A recent survey of New Zealand students reported that 56% of all respondents had considered dropping out of tertiary study, the main reasons mentioned were feeling of being overwhelmed, living with mental illness, and fears of failure[22]. Student well-being and student welfare are increasingly important areas of focus for schools and colleges, with historic levels of anxiety, stress and depression being reported by students. Whether this represents an increase in mental health issues, or a welcome reduction in the stigma attaching to mental health (or both) what is inarguable is the benefit which accrues when a mental health crisis is averted.

Student suicides are on the rise in countries around the world. In the UK, a major survey in 2018 saw a significant increase in the rates of young people aged between 10 and 24 killing themselves, with the overall rate for that age group reaching a 19-year high and the rate for young females reaching an all-time high[23]. That same year saw a 33% increase in the number of Japanese elementary, junior high, and high school students who died by suicide[24]. The most recent survey by the National Crime Records Bureau in India found that of the total number of suicides in the country, 6.7% were by current students, the most common factors identified were stress and depression[25]. The use of Artificial Intelligence to interrogate vast amounts of data and to identify a specific individual in need of help is increasingly viewed by counselling services as a valuable, if not an essential tool in their efforts to prevent these tragic losses.

One practical way in which AI is being used is through the use of machine learning to add context to internet searches. Not only can AI help to avert cybersecurity breaches and protect sensitive student data, it can also generate an alert, if, for example, it noticed a student searching about self-harm.

---

22 New Zealand Union of Students' Associations. (2018). *Kei Te Pai? Report on Student Mental Health in Aotearoa*. Retrieved from https://gallery.mailchimp.com/b109fde7924adea2d9afaa28d/files/ad0db517-d37f-4075-9984-6236b5838f0d/Kei_Te_Pai_Mental_Health_Report_Main_.pdf

23 Office for National Statistics. (2018). *Suicides in the UK: 2018 registrations*. Retrieved from https://www.ons.gov.uk/releases/suicidesintheuk2018registrations

24 The Nippon Communications Foundation. (2019). *Child Suicides at Highest Rate Ever in Japan*. Retrieved from https://www.nippon.com/en/japan-data/h00572/child-suicides-at-highest-rate-ever-in-japan.html

25 Saha, D. (2017). *Every hour, one student commits suicide in India*. Hindustan Times. Retrieved from https://www.hindustantimes.com/health-and-fitness/every-hour-one-student-commits-suicide-in-india/story-7UFFhSs6h1HNgrNO60FZ2O.html

3.4.5. Communications and Community

Just as parents benefit from the increased involvement and engagement AI enables, school leaders are also beneficiaries when closer collaboration between the school, the parents and the local community is facilitated. The foundation for closer relationships is effective communications, and AI can play a part in maintaining and improving these. Personalisation does not only apply to the students' learning pathways: it is also possible to personalize the ways in which communications are managed with each parent. Learning which methods or mediums work best for each parent, and their main areas of interest or concern, can help to ensure that the information parents receive is relevant, and that they are neither starved of information nor the victims of 'information overload'. When an active discourse between the school, the parents and the local community is supported, the school leader's voice is amplified, and he or she has access to immediate feedback, and to a range of differing perspectives, which can assist in policy-making and strategic planning for the institution.

3.5. Local, Regional and National Administration

Ministries of Education, local authorities, municipalities and other organizations tasked with oversight and management of groups of schools or colleges, are reliant upon accurate, up-to-date information. Traditionally these organisations have placed a premium upon data collection to guide decision-making, but in the main this data has been historic, and is often out of date by the time it has been collated. Planning for the future armed only with information from the past is both imprudent, and unnecessary.

Although administrative bodies may be at different stages in their data journey, AI, Data & Analytics and Machine Learning technologies have the ability to ingest the available data and to generate insights to assist in the planning process. Because AI is capable of generating those insights in real time, and can continuously update that guidance as the data is refreshed, it enables planners to predict as well as to measure vital components within the planning process. With access to augmented intelligence the finger in the air can become the finger on the pulse.

3.5.1. Resource Planning

In addition to the tracking of key demographical information, capital requirements, staffing and professional development needs, etc., AI can also assist with services such as the predictive maintenance of plant and industrial, IT and electronic assets, allowing planners to proactively address the provision of adequate resources in line with a changing environment. The COVID-19 pandemic has highlighted the importance of having up-to-date information at hand so that contingency plans can be devised and implemented at speed — and can be developed ahead of time using accurate models, in response to a variety of scenarios. Nobody knows what the lasting effects of the pandemic might be in relation to such matters as travel and traffic, work-from-home and childcare issues, a potential population shift away from city centres as the need to travel to a physical office declines, or an ongoing dependence upon remote learning facilities and services.

In the main, regional and national governments have done an excellent job in responding to the current crisis, but not all students have been equally served during this period, and best practices were often slow to identify and replicate. With AI it will be possible to analyse any number of possible scenarios, and to have the learnings and potential solutions for such eventualities available before the next crisis arrives.

3.5.2. Curriculum Design

Ensuring that school and college curricula are up to date and can adequately prepare students for the world they will face upon graduation is a perennial challenge. In many subject areas, including but not limited to the sciences and technologies, the knowledge base is continuously changing and expanding, making it difficult to ensure that course content is relevant and up to date. The curriculum must also change and evolve in response to changing pedagogies and emphases, as different skills gain or lose primacy. Shortages of essential skills and proficiencies can hold economies and societies back, stalling or even halting progress for their nations. A lack of qualified educators, or college places in key subject areas, can mean that demand outstrips supply for lengthy periods of time. Education's purpose is not merely to serve a nation's economy (education is an end as well as a means) but it is the bedrock upon which all economies are built.

AI cannot address this challenge on its own. Implementing large-scale changes to a national curriculum is the work of several years and involves a huge number of stakeholders and interested parties. The ability to interrogate large data sets, to analyse that data and generate insights, and to expose those insights via dashboards and visualizations tailored to the needs and roles of those tasked with curriculum design can improve the currency and accuracy of the information available to, and the preparedness of those engaged in this essential work.

4. Challenges

4.1. Equity, Equality and Access

The term 'digital divide' has been in use since the late 1990s but was never intended as a simple measure of students' and teachers' access to computers or the internet. It was coined as a way of identifying an emerging gap between the "information haves and have nots." Information — not hardware, not software, not broadband access — was the key factor then as now in evaluating inequalities and inequities in the provision of education technologies.

The intervening years have seen significant advances, with hardware devices becoming cheaper, more powerful and more mobile, and increased battery life and alternate forms of connectivity enabling an additional number of learners to get online. However, the most recent global report on internet penetration[26] reported that 43% of the world's population still do not have access to the internet, and an estimated 40% of people have never once been online. The disparity between the most and least connected regions is stark. In North America and Northern Europe 95% of all citizens have access to information via the internet. In Middle Africa only 12% have the same opportunity.

The COVID-19 pandemic exposed this disparity, revealing what has been termed a 'homework gap'. Whilst internet access was widespread in most of affected countries (as of August 2020) it was not ubiquitous. A significant percentage of underserved students also report having access to only a single device — most often a smartphone — and insufficient internet access at home[27]. When considering the challenges of writing a paper, analyzing data, or even reading extensively, this differentiation of access puts these students at a serious disadvantage.

AI begins with data. Although the manual recording of data by educators and institutions can help to address this divide, as electronic data capture becomes the norm, learners who have limited access to the information required to assist them in their studies, and the ability to generate and share electronic data, may be disadvantaged when it comes to the building of personalized learning pathways which adequately identify and address their needs.

4.2. The Ethical Dimension

If all learners are to reap the rewards of AI in education, regulation and ethical frameworks will be required. At present it is private companies who are leading the way in bringing the power of AI to education, giving rise to concerns about the

[26] Pensworth, L. (2019). *2019 Internet Statistics, Trends & Data*. DailyWireless. Retrieved from https://dailywireless.org/internet/usage-statistics/

[27] ACT Center for Equity in Learning. (2018). *The Digital Divide and Educational Equity*. Retrieved from https://equityinlearning.act.org/wp-content/themes/voltron/img/tech-briefs/the-digital-divide.pdf

privacy, protection and use of student data. Although for-profit organizations can have a significant role to play in advancing the educational benefits of these new technologies, their priorities will understandably differ from those tasked with the provision of education to a general populace, and the cost of such services may also exclude communities of learners most in need of these advantages.

An ethical foundation for AI is required during the development of AI-enabled services and solutions: not just at the deployment stage. How can we ensure that gender, racial, socio-economic and ability biases are not introduced at the programming level? How can we ensure that social and cultural stereotypes are not promulgated? How can we ensure that all learners, regardless of where they live, have the same access to the benefits which will accrue?

Given the power and influence such technologies will come to have in shaping the education — and by extension the opportunities, and potentially the values of learners — transparency and oversight will be required to ensure that AI-enabled technologies conform to and strengthen fundamental human rights; and that the application of AI in education helps to advance the Sustainable Development Goals, in particular SDG 4 which enshrines the need to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all."

4.3. Technology Dependence

Artificial Intelligence or Augmented Intelligence can prove of enormous benefit to all the stakeholders named in this brief. The appropriate and effective use of AI will always require human input. Perhaps the greatest benefit AI can provide is time — time for educators, administrators and others to spend in class preparation, in devising creative and innovative ways to improve the learning experience for students, and to assess and apply the insights generated by AI to develop individualized learning pathways.

The role of the educator therefore is likely to be enhanced rather than displaced by technology. An increased reliance upon AI will not be entirely to our benefit. We can expect to see an increased number of jobs replaced by automation, in both the developed and developing world. There is also a danger that our ability to delegate tasks and cognitive functions to machines can increase our dependence upon technology whilst eroding our own ability to perform these, in what might be termed a 'use it or lose it' scenario. Do students who rely on a computer keyboard lose the ability to write legibly? Do those who perform calculations using a spreadsheet or calculator become less skilled at mental arithmetic? Has a reliance upon GPS affected our ability to navigate — quite literally to 'find our own way'? As these technologies become smarter and more capable, it will also become more important than ever to know where it is we want to go.

4.4. Continuous Professional Development

To derive the benefits of AI in education, it will be necessary to equip educators and administrators with the skills to assess and interpret the results. Thankfully,

this does not require deep technical knowledge. It is common to overestimate the level of technical expertise required with modern AI solutions. The reality is that most educators and administrators already have a sufficient level of digital literacy to assess and apply the learnings if they have experience of using a smart phone and/or a laptop. Effective AI solutions generate easy-to-interpret visualizations and dashboards which allow users to interrogate the data and absorb insights in real time. Custom views and reports, tailored for different roles and functions, can easily be produced. The core focus of CPD in this context involves training educators to leverage the insights generated so as to incorporate them into their teaching practice, and to assist them in creating personalised learning pathways for their students.

As all technologies, the software and cloud services will likely evolve and go through successive iterations, or may be replaced by services or solutions from different organisations or vendors. In this context, it is important that educators remain up to date with any new features and changes in the user interface (UI).

5. Change at Scale and Change at The Speed of Learning

If we accept the promise of AI, then perhaps the greatest challenge which will face governments and those responsible for education systems is how to extend these benefits to all learners. At both the institutional and the systemic level there is a clear progression in the development and implementation of AI in education:

i. Data Collection

ii. Data Analysis

iii. Data Visualization

iv. Derive Insights

v. Predict Outcomes

vi. Direct Outcomes

It is not possible to skip any one of these key stages and arrive at a point where AI is not simply providing useful information, but is helping policymakers to formulate policies to bring about real change. Different systems or institutions are likely to be at different stages in this process, so the most immediate step is to establish where on the continuum they currently sit. The process of data collection is continuous, so even if a majority of the available data is not currently digitised and/or available for analysis, it is still possible to proceed. As more data is added, the AI solution will become more effective and accurate.

In order to analyse the data to generate visualizations and to derive insights, it will be necessary to put an appropriate technology solution in place. The data will need to be stored — either in the cloud, in an on-premises data store, or using a hybrid cloud solution which combines both. Data privacy and security measures will need to be implemented, and all regulations such as the GDPR (General Data Protection Regulation) strictly observed. An AI solution which can ingest Big Data, apply Predictive Analytics, generate rich Dashboards and Visualizations, and utilize Machine Learning to continuously improve the accuracy and currency of the insights and predictions the AI solution produces will then need to be developed and/or deployed.

Unlike most technology deployments, which typically occur at a specific point in time (most typically, when the institution is closed to students for vacation or other reasons), AI in education solutions and services can be implemented at any time and will continually develop and evolve through use. AI implementations can be done iteratively, consecutively or concurrently. Some institutions begin with a single department or faculty and later expand the solutions and services across the campus to include data from other sources. At a systemic level AI is often

implemented system-wide with a focus upon a specific data source or sources (for example, ingesting data from records of attendance and academic grade scores to help identify students in danger of dropping out of school). An effective technology solution will support either approach and will be capable of generating reports and dashboards tailored to the needs of all stakeholders as the AI implementation moves forward.

The phrase 'data-mining' is often used when referring to technology solutions of this kind and is an apt term in this context. We can think of data sources like unexplored fields of information, with 'nuggets' buried and waiting to be unearthed. The vital insights you need are already there — you just need the right tools to locate them. Once they have been exposed, they can provide immediate benefits. As a result, any strategy to employ AI in education should align with the learning process. One of the ways in which AI proves transformational derives from its ability to identify necessary course corrections or intervention points during as opposed to after the delivery of learning. Most assessment systems are historical — they look at past performance as measured by assessments conducted after the fact. AI is more than simply another form of continuous assessment — used effectively, it allows educators and administrators to predict future performance, and inform action plans to proactively address needs — to affect change at the speed of learning.

6. What's Next?

6.1. New Ways of Seeing

6.1.1. Cognitive Services

Cognitive Services are a set of emergent technologies which help developers to create applications that can see, hear, speak, understand, and even begin to reason. They allow developers to add features such as emotion and sentiment detection, vision and speech recognition, and natural language understanding to their applications without having direct AI or data science skills or knowledge themselves. Because these services are made available to developers by large companies such as Microsoft — as sets of AI algorithms and application programming interfaces (APIs) — they can easily be added as enhancements to existing solutions.

Such technologies are already becoming ubiquitous in the commercial world. Computer vision and speech recognition services are now widely used as a means of unlocking a smartphone. National Language Processing (NLP) allows people to perform web searches simply by asking a question in their own voice, using everyday words and phrases. Text to speech and speech to text services can be used to both create and narrate documents and webpages.

The implications for education are immense. For learners with a disability in particular they can help to remove barriers of access and opportunity, and serve to democratize education. For learners with foundational learning challenges, such as literacy and numeracy deficiencies, they can enable active participation in higher-order learning at the same time as the students develop those skills, rather than excluding them until those capabilities are mastered. When added to existing AI solutions and services they can accelerate the generation of vital insights — an educator can simply ask the AI a question, rather than having to input a detailed query using their keyboard or mouse.

6.1.2. Virtual, Mixed and Augmented Reality

Virtual Reality (VR) immerses a user in an entirely virtual environment generated by a computer. Although VR experiences are typically provided via a headset, either connected to an external computer or gaming console, or functioning as a stand-alone device, the most advanced VR experiences can allow for freedom of movement — users can move in a digital environment, hear sounds and use special hand controllers to navigate, and to replicate tactile experiences.

In Augmented Reality (AR), users can still see and interact with the real world, while viewing digital content made accessible to them via special glasses or headsets, which overlay the digital content onto the real-world environment.

Mixed Reality (MR) combines virtual objects with the real world and allows the user to interact with both. The user can not only view digital content but can interact with the virtual objects, which can be anchored within the real-world environment.

VR, AR and MR learning content can revolutionize education, making learning immersive and more engaging. With VR, students can travel anywhere in the world from their classroom and experience a recreation of that world, at any time in history, within a virtual environment. With AR, students can view holographic instructions or information overlaid upon a physical object, providing them with additional information about the object they are viewing. MR can be used, for example, in medical training or engineering, allowing students to 'dissect' limbs or 'repair' machinery which they view as holograms within the real-world environment, enabling learners to focus on practice rather than theory[28]. Although these new technologies are still evolving, the speed of change is exponential and some education technologists are already predicting that, in the future, low-cost versions of such technologies will supplant the textbook and free learners from the confines of their classroom.

AI will make it possible not just to deploy these exciting new technologies — but to analyze their effectiveness and to optimize the benefits they can provide to students and educators alike.

6.1.3. IoT and Edge Computing

The Internet of Things (IoT) describes the network of physical objects (things) that are embedded with sensors, software and other technologies, which allow them to connect and exchange data with other devices and systems over the internet, without involving a human being. An IoT device can be as simple as a lightbulb which can be turned on and off remotely, or as complex as a driverless car. There are already more connected 'things' than there are people, and researchers have predicted that there will be more than 40 billion such devices by 2025[29].

The IoT is already being used by many education institutions to help manage their infrastructure more efficiently and cheaper — from using sensors to control heating and lighting based on the actual occupancy of classrooms or buildings, leading to increased energy efficiency and reduced operating costs; to the use of remote cameras and biometrics to help make campuses more secure.

Edge computing is an information technology (IT) architecture in which data is processed at the periphery (edge) of the network, as close to the user or the source of the data as possible. This means that the data does not need to be sent to a centralized (cloud) location to be processed or stored, reducing time and bandwidth requirements. The key benefit of edge computing is the potential reduction in latency — simply put, things can happen faster.

---

[28] Microsoft HoloLens. (2017). *Windows Mixed Reality: An Evolution for Education*. Retrieved from https://www.youtube.com/watch?v=7Xv8A9vqeBw

[29] International Data Corporation. (2019). *The Growth in Connected IoT Devices Is Expected to Generate 79.4ZB of Data in 2025, According to a New IDC Forecast*. Retrieved from https://www.idc.com/getdoc.jsp?containerId=prUS45213219

6.2. New Ways of Doing

6.2.1. Metacognitive Scaffolding

Scaffolding is defined as providing assistance to a student on an as-needed basis, reducing or 'dialing down' the assistance as the competence of the student increases. The use of AI in education makes it possible not just to identify when and where a student requires assistance — but to monitor when to increase or decrease the levels of assistance the students require, as their learning progresses. As both resources and an educator's time are finite this can have profound implications for an institution's ability to effectively and efficiently serve the needs of all of its students; enabling them to optimize learning delivery, and to maximize the number of students who successfully graduate at the conclusion of their learning journey.

Innovative learning environments — though they have many benefits — can also pose new challenges for students. The need to learn effectively in group or collaborative situations, to benefit from the new modalities and pedagogies which may accompany remote learning or flipped classroom environments, to communicate effectively in different mediums — all these place increased demands upon a student's ability to regulate his or her own problem-solving and learning activities. Students will need assistance in planning and preparing to learn, in monitoring their understanding during learning, and in evaluating their learning at the conclusion of a learning experience.

AI can play a role in metacognitive scaffolding by allowing the students themselves to benefit from the insights generated during the course of their learning pathways. Increasingly, students will become the primary users of AI solutions and services, rather than simply the subjects of the data analyzed by educators, administrators and system owners. A learner who is provided with greater insight into how they learn, and how they think, has greater agency and control over their education, and is equipped with vital knowledge of self to act as a bedrock for lifelong learning.

6.2.2. Personalized Assessment and Credentialing

By enabling students to learn at any time, in any place, technology is helping to democratize education and offer learners currently excluded from a physical school or college the opportunity to achieve their full potential. Building upon advances in the use of education technologies over the past decades, AI has the potential to deliver on the promise of personalized learning by making it possible to ingest vast amounts of data and generate insights which can be used to develop a learning pathway tailored to a student's individual needs and talents.

AI will also play an important part in addressing the next great challenge being offered to education technologists: how to support personalized assessment. We know that current forms of assessment in our schools and colleges are seldom aligned to the skills that will be demanded of students when they enter the world of work. Multiple-choice, long- and short-form examinations can serve to evaluate some of the higher-order thinking skills that will be required in a 21st century environment — recall, comparison, analysis and inference — but soft skills, 'people

skills', moral character, teamwork, collaboration and the ability to work effectively as part of a team are difficult to evaluate using these traditional forms, and they are at least as important to future employers and to a graduate's ability to survive and thrive in a 21st century workplace.

To supplement standardized tests many institutions and education systems are including performance-based assessments, student portfolios and standards-based projects and assignments that require students to apply their knowledge and skills. These formative and summative types of assessment offer educators the opportunity to provide their students with immediate feedback, rather than a historic evaluation of past performance such as that employed in most state examinations. On a practical level, providing multiple evaluation and assessment points will necessarily result in a significant increase in the amount of data generated and will need to be tracked and analyzed by educators and administrators alike. AI will be required if this data is to support accurate and useful feedback that informs a student's progress.

There is also an increasing demand for new forms of credential which can provide a fuller picture of student capability and accurately represent the breadth of what students know and can do — and who they have become — as a result of their learning. Many institutions and an increasing number of school systems are investigating the use of micro-credentials that measure complex and general learning capabilities, including such 21st century skills as critical thinking, creativity, communication skills and entrepreneurship[30]. To establish the relevancy of these micro-credentials and to help to build a closer connection with the local business community these are often designed in conjunction with employers and/or endorsed by them.

The development of new credentials is a significant task. At a systemic level it will typically be the work of months or years, involve multiple stakeholders, require a lengthy consultation process, and affect curriculum design. If these new credentials are to remain relevant after their introduction it will also be essential to conduct a continuous analysis of their efficacy and effectiveness, and to present these findings and insights using real-time dashboards tailored to each stakeholder's area of interest or expertise.

Looking at new developments in teaching and learning — and in technology — it is clear that AI and the use of data, analytics and machine learning will form part of the foundation for the educational experiences and opportunities students will enjoy in the coming decade. For students, educators, school leaders, parents, administrators and system owners, AI in education is already delivering real benefits, and will prove a fundamental catalyst for change.

[30] Milligan, S., Luo, R., Hassim, E., Johnston, J. (2020). *Future-proofing students: What they need to know and how educators can assess and credential them*. Melbourne Graduate School of Education, The University of Melbourne. 17-29. Retrieved from https://education.unimelb.edu.au/__data/assets/pdf_file/0005/3397469/MGSE_Future-Proofing-Students_Web_Updated-9-7-20.pdf

Acknowledgements

The author is indebted to the following experts for their assistance in the drafting of this brief: Dr Kevin Marshall, Gavin Dykes, Mark Sparvell, Ian Campbell, Alan Kilduff, Dominic Register, and Dr Ram Peruvemba.

He would also like to thank the Director, staff and the Governing Board members of the UNESCO Institute for Information Technologies in Education for their guidance and wise counsel.