Online Research collection summary

This report complements the online research collection /literature guide that can be accessed through the Empower2learn toolkit:
https://empower2learn.online/resources/

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1. Introduction

Personalised learning is not new (Dockterman 2018). Making learning personal to the needs and interests of a learner is, arguably, at the heart of all excellent teaching and learning. However, what is novel is the rise of technology that makes it possible to tailor the content, pace and intensity of study to an individual student's needs, abilities and goals at scale and at levels not previously seen.

Adaptive tools, including artificial intelligence (AI)-based software, are predicted to have a huge potential to empower learners through this new generation of personalised learning and, at the same time, a profound impact on educational practices by enabling new ways of teaching. This rapidly growing area of education has been identified by researchers and experts, as well as several European frameworks and reports, as the key of future learning. Yet it is an area where practitioners and policymakers alike lack information and understanding.

As commercial edtech interests rush into this space, never has that need for information and understanding been greater, if the pedagogy is not to be lost in the technology. In this short introductory report, produced as part of an Online Research collection for the Erasmus+ project Empower2Learn (2019-2022), we'll be looking closer into what is meant by personalised learning and how adaptive and AI-based tools are being used to support it. We'll also examine some of the issues around such use, from privacy and ethics to the nature of the teaching and learning involved. We'll also nod to the Best Practices Report, in which examples of promising practice will show the role of personalised learning in teacher professional development.

2. What is personalised learning?

'Personalised learning' is best seen as a fluid, evolving term conveying a notion that, essentially, invokes all of the philosophical, ethical and professional debate around the purpose and mechanisms of education. In some sense, all learning must be personalised if learners are to engage with it, and it is standard education practice to be 'adaptive': to use different teaching methods, materials and practices to teach different learners at different stages. Effective Special Educational Needs and Disability education (SEND)has had personalised learning at its core for many years.

However, as a general definition, the broad goals of personalised learning can be seen as "tailoring learning experiences to individual students' needs and interests".

For example, according to Fitzgerald et al (2018), personalisation means adjusting the learning experience, including showing the learner resources based on age, ability, prior knowledge or personal relevance or giving adaptive quizzes that get harder as more questions are answered correctly. It is intended as a riposte to a 'one-size-fits-all' approach that may disadvantage learners, as it offers tailored support based on engagement with online course materials and peer interaction.

Taking it a step further, beyond materials, is the personalised learning approach in which "the objectives, pathways and pace of learning experiences are optimised for each learner's needs, interests, and ongoing performance" (SRI International, 2018). Objectives refer to the particular learning goals a student is working toward; pathways to the learning activities, tools, presentation modalities and resources the student is using to attain these objectives; and pace relates to the amount of time the student needs to attain mastery of these objectives. Each of these elements can be assigned to or chosen by students on the basis of measures of their needs, interests or ongoing academic performance. The potential benefits of personalised learning may include increased interest and motivation for learners, greater pace of learning, more frequent and immediate feedback, more efficient use of time for both learner and teacher, and enhanced support for teachers.

Personalised learning does not need to involve technology – in the 1920s, individualised instruction meant workbooks and paper-and-pencil tests – and throughout the past century the notion of personalising or individualising learning has risen and fallen in popularity. It is currently enjoying a resurgence due to the rapid development of adaptive tools, including AI-based software (and the commercial interests that promote them), that enables personalised learning at scale.

Philanthropic bodies, such as the Bill and Melinda Gates Foundation and the Chan-Zuckerberg Initiative, and corporate edtech businesses have taken to technology-enabled personalised learning with enthusiasm – and funding. Between 2009 and 2016 the Gates Foundation committed $300 million to support research and development around personalised learning (Herold, 2016). This has led to some new takes on personalised learning, not all of them unproblematic. For example, in 2014 the Gates Foundation worked with a number of organisations to develop a 'working definition:

"Personalised learning seeks to accelerate student learning by tailoring the instructional environment—what, when, how and where students learn—to address the individual needs, skills and interests of each student. Students can take ownership of their own learning, while also developing deep, personal connections with each other, their teachers and other adults."

This 'working definition' has been unpicked by Boninger et al (2019) who claim that it offers "a tech-friendly vision of an individualised, data-heavy, mastery-based educational system" that embeds a number of unstated assumptions about children, learning, assessment and technology. We'll be

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exploring how some of those issues play out in practice later in this report, from the ethics of data capture to the criticism that some technology-based individual learning programmes are less about tailoring learning than offloading learning from a single one-size-fits-all delivery system.

Finally, 'adaptive' learning is often used interchangeably with personalised learning. Here we're using it in the context of digital, particularly AI, tools, where the learning system is modified automatically and dynamically in response to the learner's strengths and weaknesses. In the next section we take a look at how that is happening in practice.

3. How is artificial intelligence supporting personalised learning?

The idea of personalized learning supported by technology is hardly new in the educational discourse and was argued as a more efficient way of learning already in the 1960'. The last decades resurgence of personalization, is however closely linked to the rapid development of adaptive AI-based software that is expected to offer personalized learning at scale. Thus AI in education thrives on academic, political, and commercial assertions of how machine learning and similar data-driven technologies in edtech will improve and personalize learning, augment, support and automate teaching while at the same time, transform all dimensions and levels of education (Luckin et al. 2016; Tuomi, 2018; Xie et al. 2019).

Russel & Norvig (2021) describe machine learning as the scientific study of how computer systems can "learn" from data without being programmed in specific ways However, these different technologies also need to be understood as intensive data processing that can impact and alter the behavior of individuals. Recent years advances in machine learning also inspire future imaginaries of how new kinds of mathematical precision, through the data analysis of educational activity, can provide more fine-grained understandings of how learning actually happens (Luckin et al., 2016).

There is always a danger in focusing too heavily on what the technology is rather than what the technology can achieve. As Rose Luckin (2016) writes, "the best technology for achieving personalised support for a learner might be achieved through the combination of augmented reality, voice-activated interface and AI-augmented tutoring technology." However, AI tools are currently taking centre stage, with much associated hype and scepticism, and that is where we will be focusing our attention in this section. As previously mentioned, AI can be seen as a catch-all term, ranging from rule based algorithms to neural networks and machine learning. The recent EU publication The Impact of Artificial Intelligence on Learning, Teaching, and Education (Tuomi, 2018) offers a good overview of AI and the different ways to understand it.

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AI education tools in schools can be seen to fall into three categories (Nesta, 2019): learner-facing (such as adaptive learning platforms that 'personalise' content based on a learner's strengths and weaknesses), teacher-facing (such as automated assessment tools or advanced teacher dashboards) and system-facing (eg analysing data from across schools to predict school inspection performance).

The new generation of AIed technologies can be found in e.g., different intelligent tutoring systems (ITS) that personalize learning trajectories of each student,[1] language learning apps[2], autocorrecting and grading systems[3], chatbots[4] and tutor robots[5]. Machine learning algorithms are also found in software that diagnose students' attention and emotion, recognize patterns that predict grades and student drop-out and in facial recognition applications used for exam proctoring or to monitor students' class attendance. Accelerated by the COVID-19 pandemic these heterogeneous and multifaceted technologies are beginning to enter K-12 classrooms in many parts of the world. With their entrance, thousands of data-points for each student are being captured on a daily basis, a data that is believed to reveal things about students and their learning that teachers are not able to observe with the same accuracy (c.f. Luckin 2016; Selwyn, 2019).

Personalised tutoring systems

Of these, the most common – and possibly the most problematic – applications of AI in education are the student-facing 'personalised', 'adaptive' or 'intelligent' tutoring systems. Working on individual computers, students are typically presented with information, a learning activity and a quiz. Their responses determine the next set of information, activity and quiz that the system provides, with each student following a pathway that is thereby personalised to their individual strengths and weaknesses. Machine learning algorithms try to pick up strengths, weaknesses and gaps in knowledge to build on and scaffold learning appropriately, with the aim of providing a greatly increased level of 'personalisation' (Nesta, 2019).

These systems are already being used in schools. The British platform Century Tech signed a deal in March 2020 to roll out its system in 700 schools across Belgium, in addition to its schools in the UK (Anderson, 2020). In the US, Summit Learning (funded to the tune of $99.1 million by Facebook's Mark Zuckerberg's Chan-Zuckerberg Initiative) is in place in more than 400 schools (Barnum, 2019). In Brazil, adaptive learning platform Geekie is used by more than 5,000 schools across the country to provide customised learning experiences for students. Through machine learning, the software

1 e.g., British Century Tech www.century.tech, Chinese Squirrel AI www.squirrelai.com, Swedish Sana Labs www.sanalabs.com
2 e.g., U.S Duolingo www.schools.duolingo.com
3 e.g., U.S. Gradescope www.gradescope.com
4 e.g., U.S. Korbit www.korbit.ai or Norwegian Differ www.differ.chat
5 e.g., the robots NAO and Pepper www.softbankrobotics.com

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provides more personalised content as the student uses it more often, and flags up any difficulties they encounter (Unesco, 2019).

However, the global giant is Chinese edtech company Squirrel AI. The company has already enrolled two million student users, opened 2,600 learning centres in 700 cities across China and raised $150m from investors (Beard, 2020). Squirrel AI combines physical and digital schooling, where students can learn remotely online or go to one of the company's bricks-and-mortar learning centres. Through a combination of a human coach and virtual, AI-driven tutor, they receive a personalised lesson plan tailored to learning needs and gaps in their knowledge. "Each course is subdivided into the smallest possible conceptual pieces, such that the algorithm can diagnose student gaps in understanding as precisely as possible, adjusting learning pathways in real time. Middle school mathematics, for example, is broken into 10,000 'knowledge points' such as rational numbers, the properties of a triangle and the Pythagorean theorem." (Liu, forthcoming). The goal is that personalised pathways such as these are convenient and efficient for learners and free up teachers from rote jobs such as grading, enabling them to spend more time on more complex and valuable tasks. We'll consider the limitations in the next section.

Assessment and feedback

Traditional assessment systems have long been a focus of digital tools, given some of the clear advantages of computer-based testing over traditional formats. These include paperless test distribution and data collection, efficiency gains, rapid feedback, machine-scorable responses and positive effects on students' motivation, concentration and performance (Redecker, 2013). AI systems offer the potential for automatic test generation and assessment. They holds promise for more frequent low-stakes formative assessment, without increasing teacher workload, and reducing the need for high-stress, high-stakes summative testing: "Current AI systems are very good in combining evidence from complex and varied sources of data and using them for real-time pattern recognition. For example, student homework can relatively easily be checked and diagnosed by an AI system that has data on both individual student history and peer responses" (EU 2018).

Of even greater importance, it opens up the possibility of changing the focus of what is assessed, broadening out the narrow range of knowledge and abilities currently tested, reducing 'teaching to the test' and allowing teachers to be more innovative.

Learning analytics

The 'digital exhaust' of data produced through edtech systems has been harnessed to learning analytics dashboards, which use AI to provide insights to students and teachers. Learning Analytics has been described as the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in

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which it occurs (Siemens, 2013). Learning Analytic (LA) is an emerging area within AI in education research concerned with how to use, and apply big, real-time data to understand and support students learning through pedagogical interventions (Cerratto Pargman, & McGrath, 2021).

Educational data is often perceived as an objective source of knowledge and efficiency and some of the most common data points include login information, tracking not only when students log in but also how long they interact with teaching material, student performance and activity data on downloads, quizzes as well as video views online via the learning management systems (Cerratto Pargman, & McGrath, 2021). However, this monitoring through automatic data capturing, processing, storage, and analysis are, as noted before, far from being neutral acts and coupled with ethical concerns in particular around privacy, protection of harm and misinformation vis-à-vis students (c.f. Luckin et al., 2016; Williamson, 2017). Moreover, many social implications of this kind of use of the data are still poorly understood (Eynon, 2013).).

Real-time tracking enables teachers to monitor learning pathways more easily and take action earlier. The dashboards offered by platforms such as Century Tech can present strengths and weaknesses of individual learners in a visual way so that teachers quickly see which students are struggling and what specific learning objectives they are struggling with, and provide focused, personalised support. Beyond the classroom, there are now dashboards that allow schools to track their students through their post-16 pathways, to university and beyond (Jisc, no date). There are, inevitably, data and privacy implications of these systems, illustrated and discussed below.

Classroom monitoring

The use of facial recognition and eye tracking AI systems in classrooms is one of the more controversial uses of AI technology in education. Already installed in some classrooms in China and being trialled in India and the US, cameras track the facial expressions of students to collect data on alertness. Again, there are clear privacy implications to these initiatives. (Liu, forthcoming)

Special Needs Education

Eye tracking is being used in a less controversial way in Special Needs education where AI-based approaches have shown potential. For example, the Swedish company Lexplore has developed a system that quickly scans for students at risk and detects dyslexia by tracking reader eye movements. The system uses data-based pattern recognition, and the company is now expanding to the US and UK, offering school and school-district-wide scanning. AI-based systems have also been successfully developed for the diagnosis of autism spectrum disorder and attention deficit hyperactivity disorder (ADHD) (Tuomi, 2020).

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4. What are its limitations?

Pedagogical concerns

While the personalised tutoring systems discussed above may be an 'efficient' method of learning, there are questions around their pedagogical effectiveness and appropriateness. Where learners are spoon fed chunked-up 'knowledge points' in a way that minimises engagement with teachers and peers, there is a clear risk that they are no longer active decision-makers in their own experience and their agency as learners has been removed. This style of personalised learning has been criticised for offering 'personalisation' in only a very limited sense:

"Modern personalised learning envisions a series of discrete skills and scraps of knowledge, acquired in a particular sequence. This ignores everything we know about integrating learning into prior knowledge and the world at large. It stifles creativity and critical thinking; rather than forge paths and develop a personal relationship with a body of knowledge, personalised learning calls on students to just move down a path that has already been laid out with pavement, guardrails, and penalties for daring to wander" (Greene 2019).

Assessment may be ripe for revolution and AI tools may automate it in a way that enables it to become more authentic and accessible but there is also a risk that personalised learning simply means conforming to the system's idea of success. "In short, computer programs scale up very well, and AI can easily scale up bad pedagogical ideas" (Tuomi, 2018).

Ethical issues

There are clear concerns around privacy, collection and use of data, accessibility and transparency with the introduction of personalised learning systems and tools in schools.

***Privacy and data**:* By necessity, personalised learning systems collect, store and analyse learner data. What information is it appropriate for a private company to hold about a child? There must be clarity about what data is being processed, where and how, along with suitable regulation.

"This is potentially problematic, because, whereas the human teacher assumes change, AI assumes continuation. Today, when a kindergarten student makes a mistake, the human teacher will try to

help the student overcome it and the mistake will eventually be forgotten. In contrast, an intelligent tutoring system could not only store that information and tailor a personalised pathway for the student in the first grade, it may extrapolate that information many years later, when the student is in high school. These are fundamentally different approaches to an individual's capacity for change and growth" (Liu, forthcoming).

Schools also need to ensure that they have suitable security systems in place, given the threat of hacking educational technology systems and the potential for theft of personal data.

***Accessibility**:* Globally, while AI has the potential to offer opportunities to extend education to children who are currently denied it through geographical location or shortage of teachers, there is also a real danger that depending on such advanced technology to fill these gaps only serves to increase inequality. The least developed countries are at risk of suffering new technological, economic and social divides with the development of AI (Unesco, 2019) and recent studies have mapped the obstacles for introducing AI in education in developing countries. The key ones include: ICT hardware availability; electrical availability; internet reliability; data costs; students' basic ICT skills; language; and lack of culturally appropriate content (Nye, 2015).

***Transparency**:* All actions or recommendations made by AI-systems need to be subject to review by a human. However, this may not be simple given the 'black box' nature of AI programs: who can determine how it reached the decision it did and so how can it be challenged?

Wider societal concerns

The rapid rise of AI-enabled personalised learning systems raises the question of who is driving this move. Is it the teachers, the students, the school leaders, the parents or commercial interests? There are wider, societal questions to be asked around how these systems affect the very nature of education. As Neil Selwyn puts it, "if we are all immersed in our personalised learning journeys, what implications might this have for education as a supportive, social and shared endeavour?" (2016, p77). It is now widely accepted that, far from being neutral, technology reflects the assumptions and biases of those who build it. If education software is largely created by the white, wealthy men of Silicon Valley, what does that mean for the content and the pathways?

Teacher professional development and support

A two-year research project exploring two Gates Foundation personalised learning initiatives, involving 39 US schools in 17 cities and towns and 4508 teachers, found that while personalised learning had strong support, innovative practices rarely got beyond a handful of pilot classrooms (Gross, 2018). The blocker was that teachers were tasked with innovating but didn't have the strategies or supports they needed to successfully innovate. They struggled to translate abstract

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goals into meaningful student outcomes to guide classroom practice, lacked useful systems and structures to learn through prototyping and iteration, and school heads often failed to provide the coordination and guidance necessary to formalise and codify individual teacher experiments and convert them into school-level practices and principles.Teacher professional development is critical to the success of personalised learning programmes and this is a topic we will return to in depth in our next report, which will also highlight examples of promising practice.

5. Conclusion

In 1922 Thomas Edison wrote that “motion pictures are destined to revolutionise our schools”. The promise of technology to transform education has been held out for centuries. The potential of teaching and learning personalised to each learner is equally long-standing. However, the likely scale and the far-reaching implications of the use of AI technology to achieve these goals is, as Antony Seldon describes it, “a once in a five-hundred year revolution” (Seldon, 2018).

In an interview in 2018, Rose Luckin set out her vision of “a system where learners are in charge. They have their own personal AI but it is there to help them and their tutors understand their progress, to help them collate the data that demonstrates and gives evidence for what they’re good at, what they’ve achieved, why they can accomplish a particular job satisfactorily, or why they should be given a place at a university…the AI is there to work with the educators to support students to be the best learner they can be. Human educators are a much sought-after resource in this vision, because everybody will need to learn throughout their lives.” We argue that this kind of ‘augmented intelligence’ – the best of human educators and the best AI tools – offers the most promising way forward.

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References

Anderson, J. (2019). *A British start-up will put AI into 700 schools in Belgium*. Quartz, 21 March 2019. Available from https://qz.com/1577451/century-tech-signs-deal-to-put-ai-in-700-classrooms-in-belgium/

Barnum, M. (2019). *Summit Learning declined to be studied, then cited collaboration with Harvard researchers anyway*. Chalkbeat, 17 January 2019. Available from https://chalkbeat.org/posts/us/2019/01/17/summit-learning-research-harvard/

Beard, A. (2020.) *Can computers ever replace the classroom?* Guardian, 19 March 2020. Available from https://www.theguardian.com/technology/2020/mar/19/can-computers-ever-replace-the-classroom

Boninger, F., Molnar, A. & Saldaña, C.M. (2019). *Personalized Learning and the Digital Privatization of Curriculum and Teaching*. Boulder, CO: National Education Policy Center. Available from http://nepc.colorado.edu/publication/personalized-learning

Cerratto Pargman, T. & McGrath, C. (2021). Be Careful What You Wish For! Learning Analytics and the Emergence of Data-Driven Practices in Higher Education. p. 203–226 in Petersson, S. ed. *Digital Human Sciences: New Objects—New Approaches*, Stockholm: Stockholm University Press, DOI: https://doi.org/10.16993/bbk.i.

Dockterman, D. (2018). Insights from 200+ years of personalized learning. *npj Science Learn* 3, 15. https://doi.org/10.1038/s41539-018-0033-x

Herold, B. (2016). Personalized learning: what does the research say. *Educ. Week* 36: 14–15.

FitzGerald, E., Jones, A., Kucirkova, N., & Scanlon, E. (2018). A literature synthesis of personalised technology-enhanced learning: what works and why. *Research in Learning Technology*, *26*. https://doi.org/10.25304/rlt.v26.2095

Greene (2019) *Can personalized learning actually deliver?* Forbes, 2 May 2019. Available from https://www.forbes.com/sites/petergreene/2019/05/02/report-can-personalized-learning-actually-deliver/#74df47db2020

Gross, B. & DeArmond, M. (2018). *Personalized learning at a crossroads*. CRPE. Available from

https://www.crpe.org/sites/default/files/crpe-personalized-learning-at-crossroads.pdf

Xie, H., Chu, H. C., Hwang, G. J., & Wang, C. C. (2019). Trends and development in technology-enhanced adaptive/personalized learning: A systematic review of journal publications from 2007 to 2017. *Computers & Education*, *103599*. https://doi.org/10.1016/j.compedu.2019.103599

Jisc (2018) *Rose Luckin: The AI revolution is here*. Available from https://www.jisc.ac.uk/news/the-ai-revolution-is-here-17-aug-2018

Jisc (No date) Progression through HE report. Webpage available at https://www.jisc.ac.uk/progression-through-he

Liu, Yi-Ling (Forthcoming Nesta essay collection on AI in public services in China)

Luckin, R (no date) *Keeping up with the edtech*. Education Technology. Available from

https://edtechnology.co.uk/latest-news/roundtable-professor-rose-luckin/

Nesta (2019) Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges. Available from https://www.nesta.org.uk/report/education-rebooted/

Nye, BD (2015). Intelligent Tutoring Systems by and for the Developing World: a review of trends and approaches for Educational Technology in a Global Context. *International Journal of Artificial Intelligence in Education*, 25 (2): 177-203

Redecker, C, Johannessen, O (2013) Changing Assessment - Towards a New Assessment Paradigm Using ICT. *European Journal of Education* 48 (1): 79-96

Russell, S.J. & Norvig, P. (2021). *Artificial intelligence: a modern approach*. (Fourth edition.) Hoboken: Pearson.

Seldon, A (2018) *The Fourth Education Revolution*. Buckingham, UK: University of Buckingham Press

Selwyn, N (2019) *Should robots replace teachers? AI and the Future of Education*. Cambridge, UK: Polity Press

Selwyn, N (2016) *Is Technology Good for Education?* Cambridge, UK: Polity Press.

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Selwyn, N. (2019). *Should robots replace teachers? AI and the Future of Education*. (1st ed.) Polity Press.

Siemens, G. (2013). Learning Analytics: The Emergence of a Discipline. *American Behavioral Scientist*, *57*(10), 1380–1400. https://doi.org/10.1177/0002764213498851

Singler, B (2020) Are we ready for AI? Jisc. Available from https://www.jisc.ac.uk/blog/are-we-ready-for-ai-27-jan-2020

SRI International (2018) Using Technology to Personalize Learning in K–12 Schools. SRI International, Menlo Park, CA. Available from https://www.sri.com/work/publications/using-technology-personalize-learning-k-12-schools

Tuomi, I. (2018). *The Impact of Artificial Intelligence on Learning, Teaching, and Education.* Policies for the future Publications Office of the European Union, Luxembourg, JRC113226. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113226/jrc113226_jrcb4_the_impact_of_artificial_intelligence_on_learning_final_2.pdf

Tuomi, I. (2020). Research for CULT Committee - The use of Artificial Intelligence (AI) in education, Policy Department for Structural and Cohesion Policies

Unesco (2019) *Artificial intelligence in education: challenges and opportunities for sustainable development*. Available from https://unesdoc.unesco.org/ark:/48223/pf0000366994

van der Vorst, T, Jelicic, N (2019) *Artificial Intelligence in Education: Can AI bring the full potential of personalized learning to education?*, 30th European Conference of the International Telecommunications Society (ITS): "Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June 2019, International Telecommunications Society (ITS), Helsinki

https://www.econstor.eu/bitstream/10419/205222/1/van-der-Vorst-Jelicic.pdf

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