October 2020
APPG AI Evidence Meeting

BIG INNOVATION CENTRE

AI in Education

Embedding AI tools into teaching curricula

PARLIAMENTARY BRIEF

AI in Education: embedding AI tools into teaching curricula *is a* Parliamentary Brief based upon the All-Party Parliamentary Group on Artificial Intelligence (APPG AI) Evidence Meeting held online on the 23rd March 2020.

This Evidence Meeting was chaired by **Stephen Metcalfe MP** and **Lord Clement-Jones CBE**.

We would like to express our appreciation to the following people for their oral evidence:

- **Professor Teemu Roos,** Professor of Computer Science and Lead Instructor *of Elements of AI,* University of Helsinki
- **Andy Lester**, Senior Strategy Manager, The Office of Qualifications and Examinations Regulation
- **Professor Kaska Porayska-Pomsta**, Professor of Artificial Intelligence in Education, University College London
- **Murray Morrison,** CEO, Tassomai
- **Professor Michael Thomas,** Director of the Centre for Educational Neuroscience, Birkbeck
- **Germán Bencci**, Founder and CEO, Code your Future
- **Shirin Bahai**, Primary Science and Teacher Education Lead Practitioner – LP, Harris Federation

Big Innovation Centre is the appointed Secretariat for APPG AI

- CEO, **Professor Birgitte Andersen**
- Rapporteur: **Dr Désirée Remmert**

The video recording of the Evidence Meeting can be found on our websites.

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Introduction

The APPG AI meeting of March 2020 debated on the benefits and challenges that emerge with the introduction of AI technologies into UK classrooms. The meeting discussed how AI tools can assist students with individual needs and abilities as well as help teachers cope with the growing complexity of their responsibilities. The goal of the meeting was to explore what policymakers can do to facilitate the safe integration of AI technologies into the current curriculum.

The APPG AI Evidence Meeting convened a group of experts in education research, technologists, teachers, and education policy.

- **Professor Teemu Roos,** Professor of Computer Science and Lead Instructor *of Elements of AI,* University of Helsinki
- **Andy Lester**, Senior Strategy Manager, The Office of Qualifications and Examinations Regulation
- **Professor Kaska Porayska-Pomsta**, Professor of Artificial Intelligence in Education, University College London
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Parliament has appointed Big Innovation Centre as the **Secretariat of the APPG AI**, led by **Professor Birgitte Andersen (CEO)**. The Project Manager and Rapporteur for the APPG AI is **Dr Désirée Remmert**.

The speakers at the APPG AI evidence meeting agree that a **clear definition of Artificial Intelligence in Education ("AI in Education") that differentiates it from other digital tools is necessary to devise auditing and regulatory practices**. Definitional clarity of the type of software deployed and the skills they foster, they stress, would eventually **increase stakeholder involvement, and facilitate the safeguarding against potential risks.**

Further, policymakers and regulators should work together to make sure that the alleged benefits of "AI in Education" systems are not overstated for commercial interests. False statements of the current capabilities and reliability of "AI in Education" systems would risk a loss of public trust and could cause an overreliance on decisions generated by potentially flawed technologies.

When deploying "AI in Education" technologies in classrooms this must happen with a **nuanced consideration of these tools' suitability for serving the intended educational purpose.** The technology must apply **teaching methods that are adequate for the specific age group and abilities of the students**.

In the following, the brief will discuss the potential of AI tools for creating a more supportive and personalised teaching experience for students of different age groups and abilities. In this context, we will address how the role of the teacher might change along with more fundamental AI-supported transformations in the classroom. We will then look at online courses that teach AI fundamentals to the public and explore how they can contribute to a greater AI literacy and a more inclusive and fair access to careers that require AI skills. The brief will conclude with suggestions for progressive policies that incentivise R&D and guarantee the safe application of "AI in Education" systems in classrooms.

1. How should AI be introduced to classrooms to respond to students' different needs and abilities?

AI supported learning and teaching applications have been present in the classroom for several years already. However, the sudden dependence on digital education during the temporary closure of UK schools due to the Covid-19 pandemic threw the changes they might bring to formal education into stark relief. Before the pandemic, the discussion of both the benefits and risks of AI-assisted learning and teaching methods had been rather confined to expert circles of educators and researchers. However, the recent events surrounding the move to temporary online education have propelled this topic into the centre of a public debate.

Only a few days before the APPG AI meeting, the UK government had announced the temporary closure of schools to prevent the Covid-19 virus from spreading further among the population. It soon became clear that **the subsequent move to online lessons and the cancellation of exams would complicate the fair assessment of students' performance**. The evidence presented at the APPG AI session appears to **have foreshadowed the controversy over the digital teaching methods and the flawed statistical models** that were applied for the standardisation of the A-levels results.

The speakers at the APPG AI evidence meeting agreed that "**AI in Education" technologies lack a coherent definition that clearly demarcates AI driven applications from other digital tools** in the education sector. This lack of definitional clarity would obscure the benefits as well as the dangers surrounding "AI in Education" systems. It would also make it difficult to determine their educational purpose. Kaska Porayska-Pomsta, Professor of AI in Education at UCL, argues that **the conflation of AI with other technologies would risk that the unique potential of "AI in Education" tools is underestimated**. She emphasises:

> *"It is conceived of as technology that has agency through autonomy of inference and action. So, in principle, AI applications differ from other technologies in that they explicitly aim to act as agents in the human environments by either mimicking or adaptively tapping into human ways of thinking and behaviours."*

The question of how AI tools affect human decision-making and competencies is not yet sufficiently researched, Porayska-Pomsta argues. However**, greater insights into how "AI in Education" systems affect child development would be critical** before introducing them to classrooms. For this reason, it would be important to **clearly demarcate discussions around "AI in Education" systems from those pertaining to other digital tools** that come with different challenges.

Further, several speakers observed a trend among vendors of EdTech tools to **use AI terminology to spur the commercial success of products that were not AI-driven**. They would advertise EdTech tools with **scientifically unproven statements** about their alleged educational benefits. Overstating the capacities and positive impact of teaching technologies and attributing these to AI elements, says Murray Morrison, CEO of Tassomai, would not only further **diffuse the definitional clarity of "AI in Education" systems** but might also imply the **danger of raising fears among users about the integration of new technologies in the classroom**. He argues:

> *"[…] to reap the benefits of this technology, the industry - and those bodies that surround it - must quickly embrace the context of education and educators in its development. We must treat these terms preciously - not to allow them to be exploited for marketing gain."*

Likewise, Porayska-Pomsta **criticises the current rhetoric of "AI in Education" systems being "inevitable" in UK schools**. This would suggest to the public that decisions on the deployment of these tools are more **driven by commercial and political objectives** than a deep understanding of the potential benefits that they can offer to the learning and teaching experience. This would be especially problematic as many "AI in Education" tools **must still overcome certain deficiencies** they share with AI-driven technologies in other fields – that is, **a lack of "knowability" of how they derive at results, limits to their accuracy, and the uncertain consequences of flawed results to users.**[1]

Considering this, the speakers at the APPG AI session agree that

- the **purposeful and safe deployment** of "AI in Education" tools in schools along with the **goals for integrating them** must be outlined.
- the **impact of "AI in Education" tools on child development and their cognitive capacities must be sufficiently researched**, and
- **educators and parents must be involved in the decision-making process** on the deployment of "AI in Education" systems in the classrooms as early as possible.

Morrison emphasises that by **putting the need for scientific evidence for the educational impact of these systems at the heart of the debate**, more companies could be incentivised to **seek collaboration with educators and other experts early in the development process**. Such collaboration would make it possible to **"develop efficacy first, build trust, and truly earn the label of 'education AI'".**

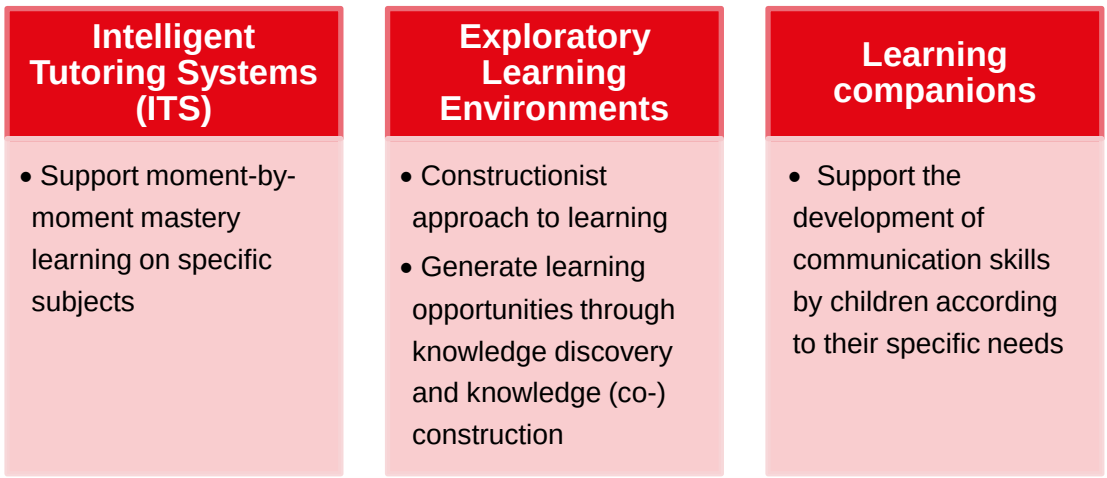
[1] Rauf, David Saleh (May 19, 2020): "Will COVID-19 Spur Greater Use of Artificial Intelligence in K-12 Education?" Education Week. Accessed September 7, 2020. https://www.edweek.org/ew/articles/2020/05/20/will-covid-19-spur-greater-use-of-artificial.html

AI in Education Applications

Despite the definitional ambiguity and commercialisation issues that were discussed above, recent research shows promising results regarding the efficacy of certain tools in serving students personal educational needs. Porayska-Pomsta outlines the currently most promising "AI in Education" applications as follows:

1) **Intelligent Tutoring Systems (ITS)**: AI is used to support moment-by-moment mastery learning on specific subjects (e.g. a specific area of maths or physics).
2) **Exploratory Learning Environments:** This technology adopts a constructionist approach to learning. AI is used to generate learning opportunities through knowledge discovery and knowledge (co-)construction.
3) **Learning companions**: AI agents that support the development of communication skills by children according to their specific needs.[2]

Illustration 1: "AI in Education" systems and their functions.



Shirin Bahai, Primary Science and Teacher Education Lead Practitioner, Harris Federation, also points to the **unique promises which these technologies hold for personalised learning**. She stresses that it has been scientifically proven that children's capacity to learn is improved when guided by non-authoritative sources. Thus, "AI in Education" tools **that adjust to students' individual knowledge level, learning patterns, and types of motivation** tap

[2] See Professor Porayska-Pomsta's evidence in the appendix for a more detailed description of these tools.

into this need and can convey knowledge more effectively. Shirin Bahai accentuates:

> *"Lower attaining pupils can benefit from extra support both visually and auditorily by working on a structured and tailored programme. Pupils with difficulties such as English as a second language and SEN benefit from the guided support using AI independently. Higher attaining children will benefit from extending their knowledge and moving on with learning without being held back by the slow pace of the class."*

Nevertheless, Teemu Roos, Professor of Computer Science, University of Helsinki and lead instructor of the online course *Elements of AI,* cautions against the assumption that "AI in Education" technologies could substitute human teachers in the classroom. He advocates for **a sensible approach to AI with a clear view of their limitations and an understanding of what "AI can and cannot do".**

AI technologies have shown promising results when it comes to intelligent tutoring systems, exploratory learning environments, and learning companions. However, in the realm of education they **have proven more controversial when applied to the assessment of student work or even the standardisation of exam results**. Recently, the controversy around the AI-supported standardisation of the A-levels results demonstrates how flawed modelling, if applied in such sensitive decisions, can result in severe consequences for individuals.[3]

AI technologies also still **struggle with the nuanced evaluation of student work that requires highly qualitative data analyses**. The assessment of essays, for instance, involves more complex cognitive skills than the binary decisions required for the evaluation of multiple choice tests.[4] Often being trained with the objective of resembling a human rater, these technologies have the **dangerous potential of amplifying existing human biases in their results instead of eliminating them**.[5] However, once AI-software is advanced enough to detect and remove bias in the marking of examinations, it might be able to offer a significant contribution to a fairer grading system.

Andy Lester, Senior Strategy Manager at Ofqual, notes that **marking is a cognitively highly demanding task** for teachers. Research is underway, he notes, for software that flags mistakes in exam marking. Yet, its development **involves extensive long-term research on global assessment practices** as well as a **large amount of reliable testing data**. For this reason, it might not be entering UK classrooms in the very near future.

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[3] Wakefield, Jane (August 20, 2020): "A-Levels: Ofqual's 'cheating algorithm' under review." *BBC*. Accessed September 7, 2020. https://www.bbc.com/news/technology-53836453
[4] Feathers, Todd (August 20, 2019): "Flawed Algorithms are Grading Millions of Students' Essays." *Vice*. Accessed September 7, 2020. https://www.vice.com/en_us/article/pa7dj9/flawed-algorithms-are-grading-millions-of-students-essays
[5] Amorim, Evelyn, Marcia Cançado, and Adriano Veloso (2018): "Automated Essay Scoring in the Presence of Biased Ratings." *Proceedings of NAACL-HLT 2018*: 229–237.

AI in Education can reduce teachers' workload

AI technologies that relieve educators of some of the administrative burdens promise to make a largely positive impact on classroom teaching. **Alleviating the workload of teachers by assuming time consuming administrative tasks**, these technologies can be helpful assistants that can enable teachers to **spend more time engaging with their students in class**. A recent study by McKinsey on AI in K-12 education has found that "20 to 40 percent of current teacher hours are spent on activities that could be automated using existing technology". [6] This time could be redirected to time spent with students in class and other tasks that cannot easily be automated. Substantiating the arguments brought forward by the speakers at the APPG AI evidence session, the study asserts that human teachers will remain irreplaceable in the classroom when it comes to creating a learning environment that fosters motivation, connection, and a strong class community:

> *"Many of the attributes that make good teachers great are the very things that AI or other technology fails to emulate: inspiring students, building positive school and class climates, resolving conflicts, creating connection and belonging, seeing the world from the perspective of individual students, and mentoring and coaching students. These things represent the heart of a teacher's work and cannot— and should not—be automated."*[7]

Thus, "**AI in Education" systems are unlikely to substitute human teachers in areas of teaching that require complex social skills and perceptiveness** anytime soon. Nevertheless, "AI in Education" technologies open fascinating opportunities for building skills, making the teaching and learning experience more gratifying for both students and teachers. Technologies based on Open Learner Models, for example, can **assist teachers by offering important insights into students' learning patterns and abilities** that are difficult to assess in a conventional classroom setting.[8]

However, there might be a risk that the technological limitations of some tools determine teaching methods as well as the skills that are conveyed to students. It has been found, for instance, that **certain types of software are prone to replicating outdated teaching methods** which UK schools reformed decades ago. Professor Michael Thomas, Director of

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[6] Bryant, Jake, Christine Heitz, Saurabh Sanghvi, and Dilip Wagle (January 14, 2020): "How artificial intelligence will impact K-12 teachers." *McKinsey and Company*, p.2. Accessed September 7, 2020. https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20and%20Social%20Sector/Our%20Insights/How%20artificial%20intelligence%20will%20impact%20K%2012%20teachers/How-artificial-intelligence-will-impact-K-12-teachers.pdf

[7] Ibid. p. 2.

[8] Porayska-Pomsta, Kaska and Gnanathusharan Rajendran (2019): Accountability in Human and Artificial Intelligence Decision-Making as the Basis for Diversity and Educational Inclusion." In Jeremy Knox, Yuchen Wang, and Michael Gallagher (eds.), *Artificial Intelligence and Inclusive Education: Speculative Futures and Emerging Practices,* pp. 39-59. Singapore: Springer Nature.
Cf. Michael S. C. Thomas and Kaska Porayska-Pomsta (forthcoming): "Computational methods in education: Neurocomputational models of cognition versus technology as a tool for supporting learning and teaching." Houdé, O. & Borst, G. (Eds.), *The Cambridge Handbook of Cognitive Development, Volume 3: Education and school-learning domains*. Cambridge, UK: Cambridge University Press.

the Centre for Educational Neuroscience at Birkbeck, brings forward these concerns in his evidence presented to Parliament:

> *"Many thousands of children have undertaken education at home. However, this has often felt like the Victorian classroom model, with teachers setting worksheets to be completed at home, and perhaps a little use of cognitive tutors, for instance on-line games for spelling or mathematics. Particularly for younger children, progress has depended in large part on monitoring and support from parents, leaving outcomes vulnerable to social inequalities and the risk of increasing the attainment gap."*

We will explore this issue further and discuss how to align AI technologies with the curriculum to realise an AI-supported learning environment in the next chapter. It is crucial that "AI in Education" applications meet the personal needs of students and teachers and create an atmosphere that fosters creativity and connection in the classroom. At the same time, the curriculum must respond to novel needs for skills that are required in a world with AI technologies.

2. How should schools teach the new skills that are needed in a world that relies increasingly on AI technologies?

To create a basis for thorough AI competencies with an open yet critical mindset, it is important to **adjust the teaching of relevant skills that is appropriate for the specific age group to the respective abilities of students**. Further, to increase the acceptance of AI-driven educational tools, **teachers, students, and parents must understand the purpose of these technologies and be reassured of their safety**. The integration of AI technologies into the curriculum, Bahai stresses, can open new opportunities to students for finding their passion early in life: **"AI in Education" tools which support personalised learning tap into students' individual educational needs and motivational factors**. At the same time, AI technologies can also **assist teachers in fostering students' individual needs and interests**.

Teachers and students need to learn new skills

Teacher training, notes Bahai, would be critical to the effective implementation of "AI in Education" systems. To adapt to new teaching methods at school and to create an AI-supported learning environment, teachers must be educated about "AI in Education" systems and their benefits. Ideally, **schools should work with researchers to develop strategies to integrate new AI technologies into the curriculum**. Further, it must be made sure that the new technologies **assist students in learning the skills that are needed for a job market which increasingly requires knowledge relevant to working with or developing AI technologies**. To prepare students for a working world in which skills conveyed in STEM subjects are of growing importance, schools must guarantee that they are given enough space in the curriculum. Bahai stresses in her evidence that

> *"[t]eaching abstract concepts such as physical science can benefit from AI tools to support the children's conceptual understanding. For example, the concept of energy and forces, evolution and genetic and chemical interactions in STEM education can use this tool effectively in primary science education."*

She points out that relevant issues such as climate change will play an even more pivotal role in the future. While these topics are considered highly urgent among experts in STEM education, the current curriculum in the UK only addresses it marginally. A practical solution to make students familiar with this subject matter and to teach the scientific underpinnings of global warming, for instance, would be the **deployment of "AI in Education" systems in subject areas that cannot be addressed in depth by teachers.**

The challenges implied in AI-driven assessment tools

Overall, “AI in Education” technologies promise to **enable a move away from standardised education by enabling students to learn according to their own pace and interests**. However, not all “AI in Education” systems are suitable for realising these educational methods. Especially AI-driven software that supports adaptive learning as opposed to personal learning can undermine progressive teaching efforts. **Adaptive learning software** understands the specific skill sets of students and fills detected knowledge gaps, but it **does not understand students’ personal learning style or what motivates them**.[9] Applications that support personal learning, by contrast, would allow students to learn at their own pace, with different motivations that might lead them along an individual path to reach an understanding of the subject matter. In certain cases, also the destination is personalised, depending on the specific educational path the student plans to take (ibid.).

Despite the recent advances of “AI in Education” technologies, **human oversight and correction of the results** they generate are still indispensable**. Flexible AI designs**, Porayska-Pomsta notes, currently appear to be the most secure and effective technologies among “AI in Education” systems. These can be **adjusted by teachers and students according to their specific needs.** They also allow human actors to have authority over any final decisions and can offer alternative interpretations of results. These technologies “serve to enhance rather than replace human educators.”[10]

Another important aspect that must be considered is the **suitability of the specific technology for the cultural context** in which it will be applied. “The vast majority of applications and research”, Porayska-Pomsta stresses in her evidence, “is also bespoke to particular socio-cultural and geo-political settings.” For this reason, software that has been developed for a cultural setting with vastly different teaching methods and educational objectives compared to the ones in the UK might not be suitable to be deployed in local schools without having been adjusted to existing educational standards.

In conclusion, for “AI in Education” systems to be successfully integrated into the curriculum, **students, parents and teachers must gain a certain degree of AI literacy** to understand the benefits and potential problems that the deployment of these technologies might entail. Online courses such as ***Elements of AI*** have been **successful in several EU countries in conveying basic AI knowledge to the public** and might also be of great value in upskilling the British population on relevant AI skills. Roos, lead instructor of the programme that piloted in Finland, stresses, however, **that a comprehensive education programme must be supported by a government-led initiative** to reach all parts of the public and must be secured by ongoing funding. *Elements of AI* has had an impressive impact on AI literacy

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[9] Hao, Karen (August 2, 2019): “China has started a grand experiment in AI education. It could reshape how the world learns.” *MIT Technology Review*. Accessed September 8, 2020. https://www.technologyreview.com/2019/08/02/131198/china-squirrel-has-started-a-grand-experiment-in-ai-education-it-could-reshape-how-the/

[10] See evidence statement of Professor Kaska Porayska-Pomsta in the appendix of the brief.

across the EU. Since its launch in 2018, 0.5 million people have taken the course. One goal of the free online programme, Roos points out, is also to **teach the public to critically reflect on their online behaviour.** This could be especially helpful to parents to get a realistic picture of how AI technologies can positively contribute to the development of children, but also educate them about the potentially harmful aspects of certain data-driven technologies.

However, there should be an increased awareness of the **lack of access to basic technologies among certain parts of the public** says Germán Bencci, Founder and CEO of Code your Future. Not owning a laptop or desktop would naturally mean a **substantial barrier to participating in any online offers for upskilling one's digital skills**. He experienced in his work at a coding school for refugees and disadvantaged people that these **economic disadvantages would soon translate into reduced employability**. No access to relevant technologies excludes people from taking online courses and other educational opportunities. For this reason, it must be made sure that structural barriers to AI education in the society are removed. **Ensuring that all students have reliable access to computers to participate in early AI education** would thus be an **important step to reaching AI literacy** across the population and to create equal opportunities to jobs that build on AI skills.

3. How to make sure that society benefits from an early AI education in the long run: Suggestions for policymakers

Experiences which people make with AI applications in their everyday life shape their perception of the technology's usefulness and thus have a decisive impact on the public acceptance of AI-driven systems in the education system. Thus, for schools to successfully integrate AI technologies into the curriculum, it is important that **students, teachers, and parents have a foundational knowledge of AI and are educated about the benefits and risks of deploying these technologies in the classroom**.

Programmes like *Elements of AI* which convey basic AI literacy via user-friendly online courses, and which do not require prior digital skills can play a pivotal role in increasing AI literacy in the population. However, to reach all parts of the public, the programme must be supported **by a government-led initiative.** Finland has launched a successful national campaign that aims at educating 1% of its population about basic concepts of AI. Based on its population's increased AI knowledge, the country intends to expand the application of data-driven technologies in various sectors.[11]

Beyond this, the government should not only contribute to national initiatives for AI education, but must also **set incentives for developers to develop safe and effective "AI in Education" applications. Applications** that support learning and teaching according to the **goals set out by the national curriculum.**

Further, teachers and researchers should be encouraged to **collaborate with developers in the design of "AI in Education" systems** and their introduction to the classroom. Only **a strong collaboration between government, education experts, and developers** can ensure a safe and effective implementation of "AI in Education" technologies in UK schools.

Importantly, the government must facilitate **equal access to new technologies for schools across all regions.** It must make sure that not only schools which possess the financial means and structures to implement "AI in Education" tools can profit from new innovative technologies. Similarly, it must be guaranteed that **all students have access to the relevant technologies needed to benefit from "AI in Education" systems** deployed in the

[11] Delcker, Janosch (April 19, 2019): "Finland's grand AI experiment." *Politico*. Accessed September 9, 2020. https://www.politico.eu/article/finland-one-percent-ai-artificial-intelligence-courses-learning-training/
Baraniuk, Chris (February 15, 2019): "Inside Finland's plan to become an artificial intelligence powerhouse." *Wired*. Accessed September 9, 2020. https://www.wired.co.uk/article/finland-artificial-intelligence-online-course

classroom.

For “AI in Education” systems to fulfil their desired purpose and help students build the skills needed in a society in which AI technologies play an ever-increasing role, the **technologies must adhere to national teaching standards**. Instead of strengthening a trend towards standardised testing, they should **foster students’ creativity and inquisitiveness.** Moreover, as technical skills will be in even higher demand on the job market in the future[12], students should be offered the opportunity of a **thorough STEM education** in schools that does not only raise curiosity for scientific topics but which will also offer them a thorough foundation to pursue a career in this field.

The speakers at the APPG AI evidence meeting agree that a clear definition **of “AI in Education” that differentiates it from other digital tools is necessary to devise auditing and regulatory practices**. **Definitional clarity** of the type of software deployed and the skills they foster, they stress, would eventually **increase stakeholder involvement, and facilitate the safeguarding against potential risks.**

[12] Kisser, Lauren (September 3, 2020): “New skills and diversity can transform the future of work.” *New Statesman*. Accessed September 10, 2020. https://www.newstatesman.com/spotlight/skills/2020/09/new-skills-and-diversity-can-transform-future-work

4. Evidence

Professor Teemu Roos, Professor of Computer Science and Lead Instructor of Elements of AI, University of Helsinki

I will talk about the *Elements of AI* online course. It is an online course with the topic “Artificial Intelligence”, but it is not a typical AI course as it is not intended for technical experts. This one is for people to gain AI literacy. We would like people to understand what AI is and what it is not, what it can do and what it cannot do, and to be able to distinguish between fact and fiction. This especially important if we talk about something that affects our life as much as AI technologies. The result should mainly be that people critically reflect on and possibly change their online behaviours. They should be able to understand how AI is used on social media, for instance, how it leads to filter bubbles and political polarisation.

We want people to be critical of what they see online and to be able to look beyond hypes. Many businesses struggle with keeping up with what is going on and what is important. We also touch upon topics like statistics, discussing how people could match different source information and so on.

We have launched this course just a little bit under two years ago and we have had already 375,000 people signed up for the course. This means we had a lot of success in spreading the news and getting people to take the course. I would like to stress that if you want to start an action like this online course, this is not an action that should be restricted to one company, one university, or one organisation pushing their programme to others. We have been able to make it into a national initiative.

We started with the goal of reaching 1% of the Finnish population. We reached this initial goal very quickly. We then started reaching out to other countries. We started the programme in Sweden and then started a similar campaign in Estonia and Germany. The next countries are going to be Italy, France and probably Denmark. We just received funding from the Finnish government to translate the course into all EU languages.

The lesson that we have learnt is that it is important to have a campaign that goes with the content. If you just put stuff online, it is not going to reach the general public. The course is not advanced in terms of using AI and analytics to understand the students' behaviour and to personalise it. It is very old school. One message I would like to share in to conclude is that there are good use cases of AI, but we should not overdo it. We should not think that we could replace the teacher's understanding of students.

In sum, the *Elements of AI* started as an online course and a national campaign with an ambitious, concrete goal: train 1% of the Finnish population on the basics of AI. Since its launch in 2018, the campaign has expanded to a European and global level, with over 0,5 million users to date.

The lessons we have learned through the Elements of AI campaign are as follows.

Key ingredients for a successful public campaign include:

- inclusivity and diversity of viewpoints (not only industrial)
- enabling organizations willing to join in the campaign
- a concrete goal
- government involvement is essential to facilitate adoption across the board and internationally
- long-term planning with project funding is a challenge

Andy Lester, Senior Strategy Manager, The Office of Qualifications and Examinations Regulation

More than 100m questions are marked in school leaving exams in England, with many millions more in other qualifications taken in industry and within apprenticeships. Outside of the simplest of questions, marking is a complex process, with fine and balanced judgements required to judge a complex set of information, evaluate against a mark scheme, and determine the right mark for each student. Humans, almost always experienced teachers, mark almost every one of these responses.

Given the volumes and demand, mistakes are inevitable. Exam boards deploy sophisticated quality assurance mechanisms to identify and remove markers who aren't up to the job, but even the best can make mistakes and almost all questions are only reviewed by one marker. We require exam boards to operate a review and appeals process to put things right when mistakes happen.

Can technology help? Could machine learning or artificial intelligence perform a role, by second marking responses, to identify where humans might have made an error, so that another human can check? Would this catch some errors before a review or appeal? Can it do this in the areas where humans find the judgements most complex, like judging essay writing?

Technologies like this are in use today in different ways around the world – marking short essays in graduate entry tests in the USA, and in scoring speech and writing in language testing for immigration for example. Whilst these mostly work on simpler responses and simpler marking scales than are common in GCSE, AS or A levels, might they be able to add

value to our system?

Ofqual, the qualifications regulator for England, is running a proof of concept study to test whether the kind of technologies used globally could work in the types of questions and mark schemes we use in England, and particularly whether it would add value to the quality assurance of the marking humans do. Our work involves looking at how these technologies are used globally, for what, and how they work. We plan a data science challenge to ask the global data science community to compete to determine how well technology can mark real English language GCSE essays, whether it can identify errors in the marks of others, and whether it can do this in a bias-free way. And we are researching the views of students, parents and teachers on how the technology might be used in future, and what impact there might be on public confidence in qualifications and grades if it were ever used.

Our aim is to expose evidence and stimulate the sector to respond if the evidence is positive. Our aim is for research to strengthen the knowledge of all those involved of the risks and potential benefits of the technology, strengthen our position as an expert regulator so we can encourage the system to adopt good practices safely, and stimulate the debate of how we continue to raise the bar so that our qualifications system is as good as it possibly can be at reflecting each student's performance.

Professor Kaska Porayska-Pomsta, Professor of Artificial Intelligence in Education, University College London

I specialise in three inter-related areas. First, I use AI techniques to computationally model the nature and impact of emotions and motivation on learning. Second, I build AI applications for supporting learning and teaching in a variety of knowledge domains and competencies. This includes applications which utilise AI agents as social communication partners, for example for children with Autism. Third, I bring together my understanding of the AI engineering and the educational practice to inform debates about and solutions to the ethics of AI. In all of the strands I draw from multi-disciplinary perspectives of the Learning Sciences, Neuroscience in Education, Computer Science and Engineering.

Focus of the evidence and motivation

This evidence focuses on AI as a mechanism for supporting teaching practices and curricula.

In this context, there is a wealth of research, conducted mainly within the field of AI in education, which demonstrates the potential of specific “AI in Education” applications and growing research focusing on how best to deploy these applications at the front-line.

Although there is a growing number of very promising AI applications in education as highlighted below, it is important to recognise their limitations both in terms of their specialised nature, and our understanding of their fit to the specific educational and classroom contexts. There is also little in the way of research investigating how exactly different forms of AI in and outside of formal learning situations impact on human cognition, despite growing evidence that different habitual uses of technology change the way people perceive, remember and interpret

their environment. Finally, AI technologies are notoriously conflated with other non-AI technologies, despite unique characteristics of AI which have potential and still ill-understood implications for the autonomy of human decision-making and action, i.e. competencies which are ultimately shaped through formal education. In this context, there is a pressing need for a precise definition of:

1. what we mean by AI technologies for education – to clearly characterise what is and what is not AI, and to identify the unique characteristics of AI that may benefit or hinder human learning and best pedagogical practices;

2. the educational goals that we aspire to achieve with those technologies – to inform ourselves about what are and what are not desirable outcomes of AI-enhanced learning and teaching.

Aided by such a definitional clarity, we can then devise auditing and regulatory practices that allow different stakeholders (teachers, learners, parents, policy makers, researchers and EdTech providers) to become informed about and to leverage the beneficial aspects of "AI in Education", and make decisions about the deployment of "AI in Education" in the mainstream of education, while safeguarding against any potential undesirable impacts thereof.

Main evidence

There are multiple prominent examples of different types of "AI in Education" applications that show promise in enhancing learning and teaching practices in different educational contexts. Such examples include:

- Intelligent Tutoring Systems (ITS), where AI is used to support moment-by-moment mastery learning on specific subjects (e.g. a specific area of maths or physics);
- Exploratory Learning Environments, which adopt a constructionist approach to learning, where AI is used to generate learning opportunities through knowledge discovery and knowledge (co-)construction;
- AI Agents which act as learning companions, for example by supporting the development of communication skills by children with autism.

Some individual components of intelligent learning environments are also used to support targeted learning and teaching competencies and practices:

- Learning Analytics (LAs): these are typically used to generate and interpret behavioural data about students to help teachers differentiate their assessments and to better tailor their pedagogies to individual and specific groups of students
- Open Learner Models (OLMs): originally developed in the late 1980s to improve the accuracy of student diagnoses by AI, these are a form of dynamic learning analytics about students' performance and domain mastery which are offered to the learners to

support them in self-reflection, self-explanation and in helping them improve their self-monitoring and control during learning (metacognitive competencies)

Research evidence suggests that many of those systems or the application of the specific components such as LAs or OLMs can offer powerful forms of learning [1], with growing cases studies demonstrating how they may be deployed and tailored for different educational settings and age groups [2]. There is also evidence suggesting that some intelligent tutoring systems approach in their effectiveness human tutors [3]. Emergent conclusions related to the best deployment of "AI in Education" technologies include calls for flexible AI designs which (i) can be altered by the users (schools, teachers, learners) on demand according to their specific needs; (ii) allow the users to remain in control of final decisions and even 'argue' with the AI for alternative interpretations; (iii) serve to enhance rather than replace human educators.

However, although these systems are very good at what they do, it is important to appreciate that they also specialise in particular and often narrow knowledge domains and that each system is designed for specific kind of learning, target group and also often to specific educational system. The vast majority of applications and research is also bespoke to particular socio-cultural and geo-political settings. Such systems are for most part experimental in nature, they are expensive to develop both in terms of time and financial investment (some of the most successful ITSs such as Cognitive Tutors have been the subject of fundamental research and development for over 30 years), and they still seldom make it to real classrooms.

At the other end of the spectrum, it is not uncommon for industry driven educational technologies to be disguised as AI in the name of innovation or to increase their allure to promote sales. In this context, the need to ground the designs of the products in the Learning Sciences research and to carefully consider both pedagogical best practices and user requirements can be often trumped by the need for commercial advantage and quick profit.

This means that broader, longitudinal evidence of the benefits and potential downsides of such applications is still limited and this has to be recognised explicitly in any discussion of "AI in Education". Policy makers and researchers must work together to ensure "AI in Education" is not overhyped and that the cognitive and developmental safety of learners is safeguarded against over-inflated claims and commercial predators. At the same time, the specialised nature of "AI in Education" applications suggests that the questions we ask about whether and how to use AI to support learning and teaching need to be asked precisely in relation to the specific skills or competencies or experiences that we as a society want to foster. These are not easy questions to formulate and neither the processes required to generate the answers or the answers themselves will be easy to identify.

In this context definitional clarity is critical to our being able to formulate questions about whether, why and in what way AI should be used in Education. These questions are fundamental to our being able to critically appraise the need for "AI in Education" from the perspectives of:

a) the educational benefits to pupils,

b) professional practices of teachers and

c) environment enhancement benefits to individual schools.

The need for such an appraisal stands in contrast with the common and increasing rhetoric whereby AI in education is assumed to be inevitable and where decisions about AI's deployment and its applications in schools are driven mainly by political and commercial gains rather than indepth understanding of human learning and development processes and of the impact (positive or negative) that different forms of technologies, including AI, have on human cognitive capacities. As an example of such impact, the ubiquitous usage of geographical navigation systems (a weakly AI application at best) may be already leading to a reduction in spatial orientation and navigation and in traditional map reading abilities in many, and especially in younger users habituated to daily digital enhancements. Other examples investigated in research include reduced situational recall caused by overreliance on cameras or scheduling assistants (see [4] for details).

Such changes in human competencies are not merely occurring at a superficial behavioural level but are increasingly investigated and observed at deep neural processing levels (ibid). Note that this evidence does not pre-judge whether such changes are desirable or not nor is it intended to moralise. However, it highlights a substantial gap in our collective awareness and knowledge and shows that there is still a paucity of research evidence and systematic investigations of how exactly different AI technologies and the ways in which they are applied in diverse contexts intervene and interfere with human learning, development, and functioning in the short and long term, and whether such interference is desirable.

The need for definitional clarity is therefore also of crucial importance to our differentiating between AI and other technologies. AI is a special case of technology. It is conceived of as technology that has agency through autonomy of inference and action. So, in principle, AI applications differ from other technologies in that they explicitly aim to act as agents in the human environments by either mimicking or adaptively tapping into human ways of thinking and behaviours. At the same time AI is now able to exceed some human capacities, for example by being able to derive patterns from large amounts of data at speed. This creates some unprecedented opportunities for the enhancement of human cognitive capacities. For example, complex data of students can be analysed to shed light on their learning behaviour patterns which can be used in turn to support teachers in fine-tuning and tailoring their pedagogies in a more precise, data-driven way. If relatively simple forms of AI can affect users' cognitive capacities, it is plausible to assume that more complex forms of AI that align explicitly with human thinking and behaviours will also lead to marked cognitive changes (for better or worse).

There may be a reluctance amongst policy makers and industry to seek definitional clarity such as proposed above and to dismiss calls for such clarity as over-cautious and unadventurous. I argue that such a dismissal is irresponsible and unethical. Education and

any educational tools employed, including AI, form part of interventions aimed to promote life-long cognitive and behaviour changes for individuals. It is assumed that those changes will be positive and that pedagogical designs as well as educational policies function to help rather than hinder learning and development of learners. However, in contrast with other comparable forms of intervention practices, such as medical interventions, which also explicitly target changes in human functioning and development, AI and more broadly technologies deployed in education are not subject to any substantial and independent scientific scrutiny or regulations. Like with medical interventions, which aim to improve the quality of life and wellbeing of patients along with marked commercial interests involved, educational interventions need to be evaluated substantially with respect to the benefits and risks that they carry for learners, their ethical grounding, and alignment with educational best practices before they are deployed at large.

Concluding remarks: what is your recommendation to Parliamentarians, how can they address the issue you have brought forward effectively

We have evidence that AI, understood as an active and adaptive agent operating in and as influencing human environment, does have a substantial potential for education. However, "AI in Education" researchers recognise the need for definitional precision which is crucial to understanding the challenges of creating AI systems that support best learning and pedagogical practices.

Based on the evidence provided, the following are my recommendations:

- There is a need for an orchestrated top-down reflection on what education system we are after and what learning we expect AI to support, before we assume that we are ready to deploy such systems in live classrooms. This top down reflection needs to take into account evidence about areas of AI's strengths as well as weaknesses, specifically as a cognitive and behavioural intervention mechanism. A dedicated parliamentary working group focusing specifically on questions related to shaping our educational system with the view to incorporate the best, and safeguarding against the unknown or harmful dimensions (if such are found) of "AI in Education", would offer a structured format to those reflections with the expectation of actionable outcomes.

- Following from the first recommendation and in light of the evidence related to technology impacting human cognition at deep neural levels there is a need for a concerted interdisciplinary research that leverages "AI in Education" and Educational Neuroscience research and methods along with relevant neighbouring disciplines of the Learning and Cognitive Sciences, and educational research and practice, as well as human-computer interaction. Funding which specifically targets such cross-disciplinary investigations is presently lacking.

- Following from evidence related to the specialised nature of "AI in Education" technologies and limited socio-cultural contexutalisation thereof, there is a need for

extensive evaluation of the “AI in Education” technologies, including their short and long-term impact on cognitive capacities, that spans a diversity of geographical, cultural and social contexts. This is particularly important given the emergent issues that are being identified with respect to AI and social biases that it tends to amplify through replication of inherently biased data and classification algorithms. Wide-ranging funding for international collaborations in this context is presently lacking.

- Given the cognate nature of educational interventions to other interventions aimed to effectuate physical, cognitive and/or behaviour change on humans, such as those employed in biological and psychological sciences, we need a mechanism for regulating and auditing the quality of the AI products for mainstream educational usage, which gives precedent to educational best practices and research evidence over rushed solutions and commercial interests, whereby no one seems to be accountable.

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[2] Heffernan, N. & Heffernan, C. (2014). The ASSISTments Ecosystem: Building a Platform that Brings Scientists and Teachers Together for Minimally Invasive Research on Human Learning and Teaching. International Journal of Artificial Intelligence in Education. 24(4), 470-497, Springer

[3] du Boulay, B. (2016), Artificial Intelligence as an effective classroom assistant, IEEE Intelligent Systems, Volume: 31 , Issue: 6 , pp. 76 – 8, Nov.-Dec. 2016

[4] Digital Technologies and Human Transformations: The Royal Society Workshop Report, 2019

Murray Morrison, CEO, Tassomai

I am the founder and CEO of Tassomai, an intelligent formative assessment software used across several hundred UK secondary schools (though not so much this week!). *On that point, though, we have been able to offer free use to all secondaries through the virus closure: currently we're supporting over quarter of a million additional students as they move to home study.*

Prior to building the platform, I taught science and mathematics, and I developed my teaching methodology by emulating the fast diagnostic feedback, interleaving and spacing processes more commonly used in non-academic spheres such as sport and music. But quickly I found there were limits to what I could do as an individual teacher. My objective, then, was to develop through continuous computational analysis, adaptation and corrective feedback a means by which students could themselves learn and develop without the need for heavy teacher workload or intervention; a platform that could adapt and personalise to each learner to give them the optimal learning output for each session of work and do so at scale.

At Tassomai we have undertaken considerable research and analysis of the educational impact of the platform, examining the educational efficacy of many different aspects of the program. This has taken place over many years and cycles, each time with increasing scope. Fundamentally, the research has taken place in the classroom and the content and the algorithms that serve it have developed iteratively in their scope. Each development has been led by researching with practitioners, asking the fundamental questions of - is this useful? Is this improving learning? Is this making it easier for you to teach? Is this adding value?

Conducting this R&D with teachers around the country has been key not only to its efficacy, but also its widespread adoption across a range of educational contexts. And while the

program in its current form analyses hundreds of thousands of students' knowledge and learning through around 2 million questions each day - and uses that data to predict student attainment and inform new pathways through content that optimise for each - we have still never used the term A.I. to describe the Tassomai platform.

And there is a simple, but important reason for that. I speak to and work with dozens of headteachers and classroom teachers each week, and while at present the term A.I. may sound incredibly exciting to venture capitalists, futurists and politicians, it leaves the majority of those teachers cold. Far from being fearful that A.I. will take away their jobs, the teachers I speak to on this subject see it simply as a label - a gimmick - a bit of marketing gloss.

The reputation of A.I. in education needs, in my opinion, to be rehabilitated before it is embedded. Embedding in the real school context is essential if A.I. is to realise its potential. Unfortunately, it is my belief that there are too many companies in the domain who use the term to attract hype and investment, but who have not attracted enough educators, nor early enough in their development, to make their product useful or genuinely impactful. The term I have recently heard being used to describe this situation is "A.I. washing" - that is, dressing up an unproven Education Technology without traction in the classroom, as more sophisticated than perhaps it is. There are tremendously exciting developments in education that will come as a result of research and development of artificial intelligence. I consider myself and the team I represent as innovators who are helping to move this front forward. But to reap the benefits of this technology, the industry - and those bodies that surround it - must quickly embrace the context of education and educators in its development. We must treat these terms preciously - not to allow them to be exploited for marketing gain.

At present, teachers and senior leaders are rarely part of the conversation when it comes to developing and researching A.I. in education. Advanced EdTech is something that is more often "done to" teachers than done with them.

If we can start to take our time, to put the evidence and impact of solutions at the heart of the message around them, we can - I believe - incentivise more companies to seek the partnership of educators early, develop efficacy first, build trust, and truly earn the label of "education A.I."

Professor Michael Thomas, Director of the Centre for Educational Neuroscience, Birkbeck

My expertise with AI is twofold. First, I use advanced computational methods, such as deep neural networks, to understand how the brain learns. Second, my research centre builds adaptive computer-based learning activities to improve children's educational outcomes – most recently, for maths and science in primary school[2].

What will you be talking about, and why did you choose this issue?

I am going to focus on children's experience of technology and opportunities for teaching and learning. (A parallel argument can be made about how AI might support teachers, for example in supplying appropriate personalised feedback to children, but I won't touch on that dimension here).

Main objective: Main evidence, concise and short, based on your specific professional background or expertise in the matter.

Although to some extent, we already have AI in the classroom, for instance in cognitive tutors (that is, games that teach specific content) and in children's use of search engines like Google, in my view, of greater longer-term significance is the experience of young children with technology today. This experience provides a glimpse of a technology-led revolution in education, one that could change (or at least, supplement) the teacher-fronted Victorian classroom of today into a kind of teacher-curated YouTube for education, or a teacher-curated virtual learning environment. Here, learning is not just personalised or adaptive, but controlled by the children themselves and driven in part by their self-guided exploration. Think Minecraft.

Think Roblox.

The sudden changes in education produced by the coronavirus pandemic throw this into starker relief. Many thousands of children have undertaken education at home. However, this has often felt like the Victorian classroom model, with teachers setting worksheets to be completed at home, and perhaps a little use of cognitive tutors, for instance on-line games for spelling or mathematics. Particularly for younger children, progress has depended in large part on monitoring and support from parents, leaving outcomes vulnerable to social inequalities and the risk of increasing the attainment gap.

The revolution I am raising is some way off, and importantly, *policy is not the driver of these innovations*.

Instead, progress is driven by the cultural and commercial technology ecosystem. Indeed, in my research centre, our recent experience of using school IT systems to deliver computer-based learning suggests school IT suites are becoming redundant, and we need to move to personal devices integrated into schools (though, if anything, UK schools currently seem to be moving away from Bring Your Own Device). Think of it like this: when you get on a plane, you are instructed to turn on Flight mode on your phone. When you enter school, perhaps you will be instructed to turn on Education mode, so you only have access to educational applications.

The policy solutions, therefore, are not prescriptive, they are regulatory. Policy needs to incentivise commercial developers, regulate the marketplace, and understand and mitigate the possible side effects of technology use in children, as revealed by research.

These risks include:

- Screen time addiction and intolerance of boredom
- Displacement of other activities (e.g., homework, play)
- Social media bullying
- Unreliable information
- Sleep disruption
- Violent or otherwise age-inappropriate content
- Data protection issues

We know computer games can be powerful tools for changing behaviour[3]. But deliberate attempts to create games that deliver learning, as it were to *gamify education*, have so far been poor because they focus on content and not on the game mechanics (which are understood much better by well-resourced commercial game developers).

This is where government incentivisation may be effective, to encourage commercial developers to produce engaging and powerful educational games and learning environments.

There will be change. “AI in Education” can be enabling – think of the great essays you can

write now that you have Wikipedia. But it can be *de-skilling*: as drivers rely on satnavs, it makes our navigation skills poorer. In the same way, as we come to rely on retrieving knowledge from the Internet, our ability to memorise facts may become poorer. And we need *new skills* – optimal ways to search for information on the Internet, for example, or ways to establish the trustworthiness of information, or ways to mitigate tendencies for on-line aggression.

Concluding remarks: what is your recommendation to Parliamentarians, how can they address the issue you have brought forward effectively:

In short: (1) AI can enter the classroom in different ways, and there is great potential, perhaps even a revolution in education available. (2) We need to be mindful of the possible side-effects and risks. (3) The best policy approaches are likely to be regulatory enhancement of commercial activities in the education sector, rather than prescriptive approaches.

Notes:

1. http://www.educationalneuroscience.org.uk/

2. See http://unlocke.org/. Sample reference: Wilkinson, H. R., Smid, C., Morris, S., Farran, E. K., Dumontheil, I., Mayer, S., Tolmie, A., Bell, D., Porayska-Pomsta, K., Holmes, W., Mareschal, D., Thomas, M. S. C., & The UnLocke Team (2019). Domain-Specific Inhibitory Control Training to Improve Children's Learning of Counterintuitive Concepts in Mathematics and Science. Journal of Cognitive Enhancement. Published online 12 December 2019. https://doi.org/10.1007/s41465-019-00161-4

3. Altarelli, I., Green, C. S., & Bavelier, D. (2020). Action video games: From effects on cognition and the brain to potential educational applications. In: M. S. C. Thomas, D. Mareschal & I. Dumontheil (Eds.), *Educational Neuroscience: Development Across the Lifespan*. London, UK: Routledge Publishers.

Germán Bencci, Founder and CEO, Code your Future

Code Your Future is a Non-Profit Organisation that has been training people from refugee and disadvantaged backgrounds for three years now. By teaching them programming we increase their opportunities for employment and for starting a new life. Before that, I have been working in the tech sector for many years. I then decided to dedicate my life to create more social impact.

Today I would like to talk about the experiences we made at Code Your Future of helping people become proficient and start careers in programming from practically zero skills. We have worked with people who in the very beginning had never written a line of code. Twelve months later, they are full-stack developers and are contributing to some of the biggest tech companies. There are a few things I wanted to share based on that experience.

The first aspect I would like to stress is that many people do not have the digital skills to run a lot of services that are needed to teach anything else. This group also includes a lot of young people. We have come across many applicants at Code Your Future who did not own a laptop. This might sound a little bit unreal – yes, everybody owns a smartphone nowadays, but if you don't have a laptop and if you don't have a working environment, it is very difficult to become familiar with digital tools. People do not know what "browser" means, or what a "link" is, for example.

Second, how can we make people more aware of what AI is? I was looking at *Elements of AI*. One of the first question it addresses is: "What is AI?". It talks about how difficult it is to define it. AI is involved in our everyday life. There is for example the proliferation of voice recognition devices. It is such an exciting way of explaining people all the capabilities and possibilities of

AI. I think we need to start to offer opportunities to make people aware of how AI is already integrated into our day-to-day lives. It is not anything abstract, far away services. Instead, we are using it if like it or not.

The third aspect I would like to mention is that we at Code Your Future learnt that we cannot teach people AI unless they have a foundation of programming skills. The basic knowledge the school is teaching – about software and programming and basic data structures – without this foundation there is no point of talking about advanced things. There are many ways how this can be taught in a very interesting and engaging way. However, we have to bear in mind that we cannot detach one thing from the other.

The fourth thing that I would like to mention is how to get people engaged and excited. This is by using APIs. APIs allow us to make connections with a lot of exciting tools that in the background are doing loads of very intelligent things. For example, these are used for NLP, computer vision and sensory analysis. Through these connection people can realise what can be done.

Finally, using a lot off the shelf cloud technologies can make people really excited about learning AI skills. These are the five recommendations we would give for teaching AI in an educational environment.

Shirin Bahai, Primary Science and Teacher Education Lead Practitioner – LP, Harris Federation

I have worked in the primary education as a physicist, an educator, a leader and as a researcher across a variety of fields including teaching & learning, curriculum, pedagogy and assessments, as well as teacher training for almost 20 years. I have been working with academics and professionals to develop science education in the primary phase and for the past few years I have been studying cognitive processes in primary science education as part of my PhD at the UCL Institute of Education. I am delighted to share my experiences and views, and address the followings in regards to the application of “AI in Education”:

In general, primary pupils have significant abilities to use their imagination and curiosity to learn and develop knowledge and thinking across all the National Curriculum subjects. They enjoy being at school and highly appreciate their learning experience. However, since pupils have various backgrounds including educational/social history, mental/ physical health and language and emotional difficulties, teachers experience great challenges in teaching and learning regardless of the amount of effort and hard work that they invest on planning and delivering the lessons. This is due to the limited time of teaching and providing the evidence of learning for monitoring and assessment purposes.

On the other hand, the current traditional way of teaching can be improved in order to reach the full potential of the pupils and prepare the young generation to deal with the world’s future issues and problems. The young students are very confident in using the technology in order to process the information and access new learning, yet, we need to offer the pupils an opportunity to use their skills in applying the information productively and take the ownership of their own learning. By applying AI learning, some of these challenges will be reduced. This includes challenges such as understanding abstract concepts, knowledge constructions, saving time and other difficulties that affect the outcome of the pupils’ learning.

There is an urgent need for teachers to be educated about the application of AI and to adapt a new culture of teaching and learning in schools and open up their views towards using this tool in educating the young generation. Schools are advised to participate and contribute in developing the application of AI in lessons effectively, and work with the academics to understand the benefit of AI in the teaching practice better.

There is also a need to widen the perspectives within the education system, towards reviewing the assessment and monitoring methods, to a more relevant model that includes technology/AI, in order to help the assessors in identifying the students' real capability in thinking and learning.

1. What are the practical steps of embedding AI into curricula?

From learning points of view:

- Children enjoy taking ownership of their own learning. Research illustrates better learning can take place when thinking is navigated by non-authoritative sources.
- Knowledge building is the fundamental pillar of learning. There is not enough time in the primary timetable to develop the prior knowledge and AI can be used to fill the gaps in students' knowledge and experience.
- Many studies imply that higher order thinking and curiosity depends on the amount of knowledge and experience of the learners. The current traditional ways of teaching are designed to present the evidence of learning to fulfil the assessment criteria. AI can be used to increase the prior knowledge of the children outside of the school as well as during the lessons to support the learner's thinking processes and encourages the element of curiosity.
- Since the current system of assessment and monitoring assesses learning by using the measurable evidence in the books or the test results, using AI in demonstrating the thinking and learning of the students in a different format of assessment can expand the educators' views about the capacity of the students' thinking and learning from different perspectives.

From Teaching point of view:

- AI can be a tool for teachers to increase their subject knowledge.
- AI can be used to improve the teaching approach - effective pedagogy to connect to the children's thinking and understanding in a deeper level in the limited time of the teaching.
- Teaching abstract concepts such as physical science can benefit from AI tools to support the children's conceptual understanding. For example, the concept of energy and forces, evolution and genetic and chemical interactions in STEM education can use this tool effectively in primary science education.

It can be used for formative assessment; most of the marking takes place after the lesson and students respond to the marking after the lesson.

Black's (2009) study about Formative Assessment demonstrates how the students' understanding varies with the amount of information provided by the teacher as well as the activities in which they are involved.

- AI can be used as a tool in independent/group-work during the lessons.
- It can be used as a collaborative tool between teachers to communicate effectively in order to improve planning and allocation of resources to reduce the workload of the teachers and save valuable time.

2. How should AI be introduced to different age groups and students with different needs and abilities?

- Lower attaining pupils can benefit from extra support both visually and auditorily by working on a structured and tailored programme.

- Pupils with difficulties such as English as a second language and SEN benefit from the guided support using AI independently.

- Higher attaining children will benefit from extending their knowledge and moving on with learning without being held back by the slow pace of the class.

- Younger children like EYFS and KS1 pupils rely on the guidance of the teachers in using the practical and visual resources to learn and understand any concept, e.g building language. AI is able to navigate the pupils in the absence of the teachers in one-to -one teaching format. For example, some phonics App support the children to develop their reading by visual-verbal support.

- Children are coming from different background and teachers must face a variety of challenges to achieve conceptual understanding in the class. AI can be used to fill the gaps in the children's prior knowledge and experience and support the teachers in this journey.

3. How can we adjust current curricula to the new needs that emerge in a world with AI technologies as well as to the realities of classroom teaching?

- The current curriculum is led by the knowledge and sequential learning journey that is built through the step by step teaching of the concepts within a curriculum topic. Teachers have limited time and subject knowledge (as in primary they need to be

experts in teaching all the subjects) to build a strong foundation for the conceptual understanding of their learners. A structured programmes such as AI, can support the educators and learners in this journey by navigating the students according to the learning concepts and teaching approach to build their knowledge in order to reach a deeper understanding of the concepts. Examples: Itza media and Avatar are two AI focused products (in the testing stage), which I am collaborative with and they both aim to support the children's thinking and learning independently.

- It can support the teachers to monitor the outcome of the teaching, to consolidate the Learning Objectives as well as extend the students' learning, e.g. using iPads to move forward with the semi- guided learning activities instead of answering the teacher's pre-made questions.

4. How could students as well as society as a whole benefit from an early AI education in the long run?

- Currently there seems to be a lack of deep connection between the students and teachers, as a result of some kind of division that we experience between the education that the pupils receive inside the school; where teachers are responsible for the teaching and learning as the main authority; and outside world of the schooling system, through networking and online connections; where different set of learning from various resources takes place. Teachers are hardly understanding or are in control of the thinking processes, which formed as a result of the outside of school's learning. Therefore, we are teaching groups of complex students who have the abilities to adjust their thinking in different ways, and since the schools are not equipped to apply the same tools to communicate with them, we seem to be missing the opportunity to connect with our students in a deep level, as we are simply not part of their world of thinking. Applying AI in the teaching and learning in schools will provide a platform for the teachers to understand the students from various angles and it can build a bridge in our communication with the young generation.

- Topics such as Climate change and Global warming, which are the current issues and need to be addressed by the young generation in future, are viewed as urgent matters in the STEM education. However, the time specified to teach these significant learning objectives is very limited in the lessons. Using AI, as the Key tool to building the knowledge behind formation of these issues, can be viewed as a practical solution to build the students' thinking in order to understand the core of the issues.

- Since thinking is a social construction product (Vygadsky 1978), AI can be used to support the problem solving process though collaborative and creative thinking in the absence of the teachers or other students in complex topics such as Biomass, Climate change or understanding the sustainability.

- The young generation have the right to access the necessary tools and knowledge to be prepared to address the future issues in However, I am not convinced that schools are well equipped with the up-to-date facilities including AI tools, to support this preparation procedure.

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