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Artificial Intelligence in education: Rise of the Machines

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Introduction

The arrival of the Fourth Industrial Revolution is not only providing humankind with new capabilities, but it is also changing the way we live, work and relate with one another. The following diagram best sums up why it is so different from the three Industrial Revolutions before it the confluence and convergence of emerging technologies are changing the world we know at lightning speed. One of the interesting analogies depicting the impact of this phenomenon is that the machine in the First Industrial Revolution was steam-based and the fuel was coal, whereas the machine in the Fourth Industrial Revolution is Artificial Intelligence (AI), fueled by the rapidly burgeoning data in the cloud. UNESCO (2018) depicts this age of big data in which people generate individual information footprints as resulting in an abundance of data, enabling human and societal behaviour to be objectively quantified, hence, easily tracked, modelled and, to some degree, predicted. This phenomenon surrounding information footprints is referred to as 'datafication' (Mayer-Schönberger & Cukier, 2014). While some may think that the title of this article may seem cliché or playing with pop culture, the Future of Learning, like many aspects of life, is truly driven by the Rise of the Machines (AI).

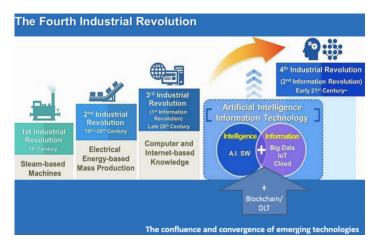


Diagram 1: The Fourth Industrial Revolution (Welsh, 2018).

A quick survey of the situation indicates that the convergence of high-speed mobile internet, artificial intelligence, big data analytics, and cloud technology is fueling the Robot Revolution at incredible speed across various industries between 2018 and 2022. In the Future of Work 2018 survey, the World Economic Forum estimated the impact on industries in the following chart.

The many faces of the robot revolution

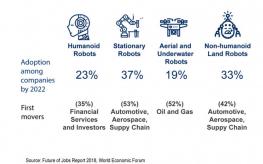


Diagram 2: The many faces of the robot revolution (World Economic Forum, 2018, n.p.).

This is supported by a study conducted by McKinsey Global Institute asserting that technologies such as Artificial Intelligence (AI) and robotics are driving the automation of jobs (Rapp & O'Keefe, 2017). McKinsey estimates that automation alone could boost global productivity growth by 0.8% to 1.4% annually. The following are jobs where automation can have the most significant impact.

The findings from the McKinsey report corroborate WEF estimates that by 2022, emerging occupations are set to grow from 16% to 27% of the employee base of large firms globally, while job roles currently affected by technological obsolescence are set to decrease from 31% to 21%. In purely quantitative terms, 75 million current job roles may be displaced by the shift in the division of labour between humans, machines and algorithms, while 133 million new job

roles may emerge at the same time. Not surprisingly, Data Analysts and Scientists, as well as Al and Machine Learning Specialists, emerged as the top two fastest-growing roles.

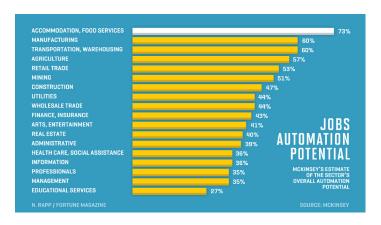


Diagram 3: Jobs automation potential (Rapp & O'Keefe, 2017, n.p.).

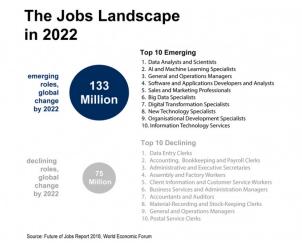


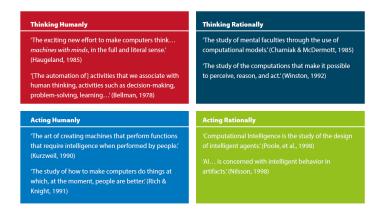
Diagram 4: The jobs landscape in 2022 (World Economic Forum, 2018, n.p.).

In short, Al is a thriving technological domain capable of changing every aspect of our social interactions - cuttingedge AI algorithms that learn, computing power and access to technology have increased across the world. The development and application of Artificial Intelligence (AI) are bringing imminent and rapid changes to almost every aspect of life (Siraj, 2017). In considering the impacts of AI on education, the relevant skills and knowledge needed in the future, there is an exigent need to look beyond the current trends, and identify the jobs and skills required to redefining intelligent in an Al-augmented world (OECD, 2018). In education, AI has started producing new teaching and learning solutions that are now undergoing testing in different contexts. While there are significant potential benefits, there are risks as well as opportunities with AI in and for education. As such, we need to proceed conscientiously and prudently into a new educational environment where Al is used to support learners and teachers, and where we also prepare learners for a future world in which AI plays an increasing role. As such, it is timely or even overdue to ask serious questions about what artificial intelligence in education (AIEd) is, the benefits, and how it goes about doing that. More importantly, we need a clear explanation of how AI can connect to the fundamentals of teaching and learning so that we can circumvent general-purpose technologies being used in ways that do not deliver the steep changes in learner outcomes.

What is Artificial Intelligence (AI)?

Since 1956, the field of artificial intelligence (AI) has continued to capture the imagination. While AI has been around for nearly 60 years, there had not been significant breakthroughs until recently, due to sweeping changes with the advent of big data, economical access to computing power and advances in Machine Learning (Luckin, 2018). It can be challenging to define artificial intelligence (AI) as what AI includes is continually shifting. While there is no conclusive definition of AI, McCarthy (2006), Zhong (2006), and ITU (2018), among others, provide a clearer description of AI. Adapting Russell & Norvig's (2010) work on AI, UNESCO (2018) categorised the different dimensions of AI using the following table.

Table 1: Different Dimensions of AI (UNESCO, 2018, p. 8)



UNESCO (2018) recounts that research in AI has focused mainly on learning, reasoning, problem-solving, perception, and using language, classifying AI into two types: data-driven AI through Machine Learning and knowledge-based AI. The current success of AI is mostly due to developments in data-driven AI. The following table summarises these developments:

Table 2: Developments driving the success of AI

Deep learning	A specific subfield of machine learning - a new take on learning representations from data that emphasises learning successive layers of
	increasingly meaningful representations. In deep learning, these layered representations are (nearly always) learned via models called neural networks structured in literal layers stacked on top of each other.
Data mining	In computer science, data mining is the process of discovering interesting and useful patterns and relationships in large volumes of data.
Learning analytics	Learning Analytics (LA) is an emerging discipline seeking to improve teaching and learning by critically evaluating raw data and generating patterns to characterise learner habits, predict learner responses and provide timely feedback.

Will AI take over from humans?

The school of thought originating from Vernon Vinge is based on the concept of the singularity, the point at which an Al-powered computer or robot becomes capable of redesigning and improving itself or of designing Al more advanced than itself (Vinge, 1993). Inevitably, Vinge argued that this would lead to AI far surpassing human intelligence, understanding, and control, and to what Vinge describes as the end of the human era. More recently, Stephen Hawking, Stuart Russell, Max Tegmark and Frank Wilczek have also cautioned about the potential dangers of AI becoming too smart (Hawking et al., 2014). Unfortunately, science fiction films such as The Matrix and Terminator have shaped our limited understanding of Al. This is largely because most people have only a very limited and inadequate knowledge of machine learning, neural networks and artificial intelligence. However, it is essential to note that significant advances in 'general Al' – Al that could perform any intellectual task that a human being could - would be necessary for any singularity to occur. At this point, general AI does not exist. Al programmes are only as intelligent as we programme them to be. Computers can be programmed to process information in specific areas that go far beyond human capacity (Tegmark, 2017). A case in point is that while the best chess player in the world stands no chance against a modern computer programme, that programme would be useless against a child in a game of identifying people. Humans, even the very young, possess a general intelligence across a broad range of abilities. However, AI is getting more sophisticated, and it is already having a profound impact on our economy. Al research such as Google's Deep Mind has started to break new ground.

Harari (2017) argued that AI goes far beyond the fields of engineering or science, and is of strong political interest. As such, it should be among the most critical items on our political agenda. When science becomes politics, scientific ignorance becomes a recipe for political disaster. Tegmark (2017) seeks to rectify the situation through his book, Life 3.0 by conceptualising a political and philosophical map of the promises and perils of the AI revolution. Instead of advocating any one agenda or prediction, Tegmark provides a broad spectrum of various possibilities, reviewing a wide range of scenarios concerning the impact of AI on the future of work, warfare and political systems.

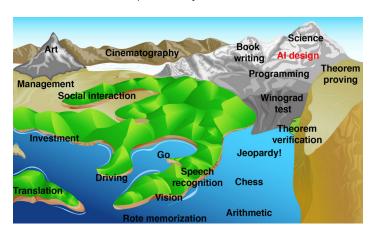


Diagram 5: The future impact of Al. Adapted from Tegmark (2017).

Conversely, another school of thought advocates for more effort on reconceptualising the Human Intelligence (HI), rather than worrying about singularity or general AI. The next section provides some perspectives in understanding HI and how humans can work with AI.

Human Intelligence (HI) and Artificial Intelligence (AI)

Luckin (2018) advocates that machine learning and HI focus specifically on reconsidering HI due to the sophisticated AI that now permeates much of society. As humans are adept in developing significant tasks and activities, including creating and sustaining cultures, crafting and sharing art, and developing social relationships, Siemens (2019) asserts that Al should ideally function to augment HI by having machines do things that it is much better at than anything humans can do. Conversely, Luckin (2018) describes intelligence as "aligned with intellect, with complex cognitive processes, with the understanding of the knowledge, skills and abilities both of others and ourselves. It is our intelligence that enables us to learn, to apply our knowledge, to synthesise what we know to solve problems, to communicate with others, to make decisions to think, to express and learn from experience."

Luckin suggests seven elements of human intelligence:

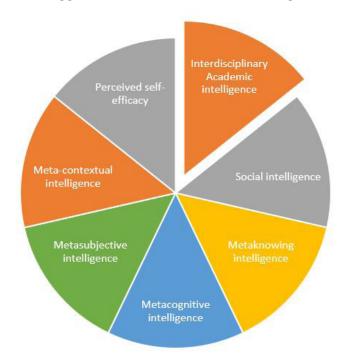


Diagram 6: Seven elements of HI (Luckin, 2018).

Luckin indicates that the machine cannot contextualise and make sense of subjective knowledge (that humans are adept in), and it is embodied in our meta-subjective and meta-contextual intelligence. Relatedly, as human knowledge is deposited within culture, Al cannot understand culturally-embedded aspects of being (Siemens, 2019). Moving forward, rather than working together with machines, humans will need to think and learn with machines. Siemens asserts that the new world order is one where 'what we know is less important than how we are connected to ongoing knowing' - a context where sensemaking, meaning-making, and wayfinding become the primary knowledge activities (Siemens, 2017; Siemens et al., 2020). The next section provides an overview of how Al could possibly add value in education.

Artificial Intelligence in Education (AIEd)

The development and application of artificial intelligence in education (AIEd) has been the subject of academic research for more than 30 years. It brings together AI and the learning sciences to advance the growth of adaptive learning environments and other AIEd effective tools (Luckin et al., 2016). In recent years, the rapid progress in AI has enabled experimentation with different models of AIEd, fulfilling the promise of transforming education by creating adaptive learning systems that could personalise learning. Given the emerging AI technologies, there are an increasing number of studies (Laanpere et al., 2014; Luckin et al., 2016; Mayer-Schönberger & Cukier, 2014; Montebello, 2017; OECD, 2018; UNESCO, 2018) indicating how AI can help improve learning opportunities and outcomes for students.

While there is a growing body of literature in AlEd and models, Luckin et al. (2016) propose a seemingly robust theoretical framework that encapsulates three critical models at the heart of AlEd: the pedagogical model, the domain model, and the learner model.

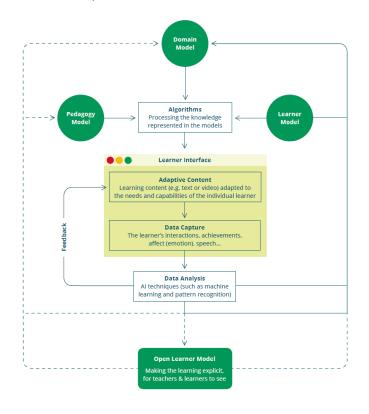


Diagram 7: Three critical models at the heart of AIEd. Adapted from Luckin et al. (2017).

This framework consists of (1) the learner model (knowledge of the individual learner), (2) the pedagogy model (knowledge of teaching), and (3) the domain model (knowledge of the subject being learned and the relationships between the different parts of that subject matter). AIEd algorithms process that knowledge to select the most appropriate content to be presented to the learner, according to their capabilities and requirements. Also, the in-depth data analysis using machine learning and pattern recognition is paramount in providing valuable feedback for learners finetuning the adaptive learning content.

Conclusion

It is evident that AI will continue to make substantial contributions to how students engage with knowledge, develop academic knowledge related skills and learning experience in their education in terms of personalised learning. This will result in human teachers reinventing their practices to support students to nurture and monitor the other aspects of human intelligence described by Luckin (2018). This is corroborated by Siemens (2019) in that appropriate synergy of AI and HI so that humanwork such as culture, 'being-ness', and social-emotional learning permeates as lifelong learning.

At this juncture, it is difficult to predict what AI will bring to our futures given the rapid pace of development. Still, we need to support active citizens of the future in harnessing and engaging with AI, grounded in transparent, ethical practices for education and society at large.

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