

What Could be the Role of Artificial Intelligence in STEM Education in the 21st Century?

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Introduction

The World has seen too many changes after industry age started in 18th century. During the first phase of industrial revolution, the use of machines in the factories instead of body power was really a revolution. The advent of machines with the use of coal increased the efficiency of those factories. The number of productions increased by using these plants. Besides, the second phase of the industrial revolution started in the 19th century shows us the use of technology in manufacturing processes. Clark (2014), Steam power in England certainly touched a number of areas in the Industrial Revolution. It was important in coal mining, on the railroads, and in powering the new textile factories. The steam engine itself underwent a long process of improvement in thermal efficiency, and in the ratio of power to weight, from its first introduction by Thomas Newcomen in 1707–1712, to the 1880s. The earliest engines had a thermal efficiency as low as 0.5%, while those of the 1880s could achieve thermal efficiencies of 25%. The steam engine was associated also with the widespread use of fossil energy in the economy to replace wind, water, and animal



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power sources in transport, home heating, and manufacturing. In the 20th century we saw the rapid changes in industry by using electricity and this was the third phase of the industry. Today, in 21st changes we feel have an ongoing process and in our daily life everything is changing very fast. This era is also called the fourth Industrial Revolution. Philbeck and Davis (2019), Framing the Idea of the Fourth Industrial Revolution in January 2016, World Economic Forum Founder and Executive Chairman, Klaus Schwab, published a book titled The Fourth Industrial Revolution. Since then, the term “Fourth Industrial Revolution” (4IR) has been used to frame and analyse the impact of emerging technologies on nearly the entire gamut of human development in the early 21st century, from evolving social norms and national political attitudes to economic development and international relations. The concept of the Fourth Industrial Revolution affirms that technological change is a driver of transformation relevant to all industries and parts of society. Furthermore, it highlights the idea that, at certain stages in history, sets of technologies emerge and combine in ways that have impacts far beyond incremental increases in efficiency.

We may say that those technology-based changes have showed themselves very much in the fields of education. It is known that both AI and STEM Education have gained popularity in education after 2000s.

STEM Education

Science, technology, engineering, and mathematics education has commonly been referred to as STEM education in the United States since the early 1990s (Sanders, 2009). For some scholars STEM is basically a replacement term for science or mathematics (Breiner et al., 2012). Other scholars think that STEM refers to a more integrated approach to teaching and learning that necessitates open connections between disciplinary content and practices (Honey, Pearson, & Schweingruber, 2014; Kelley & Knowles, 2016). Pitt (2009) states that while some people define any activity that involves any of science, technology, engineering or mathematics as a STEM activity, others address that intrinsic to the concept is some linking of two or

more of the component areas of learning, and that real STEM should be more than the sum of STEM's parts.

STEM education provides an experience that allows students to acquire knowledge and skills in science, technology, engineering, and mathematics in the course of solving real-life problem situations and use them meaningfully in their lives (Gonzalez and Kuenzi, 2012). This explains why we need to include STEM Education and its activities into the school curricula. STEM Education allows students to gain 21st century skills including to have required skills for their future professional careers. According to Chng, Tan, & Tan (2023), "While justifications have been made for emerging technologies' transformative potential in STEM education, the roadmap for their eventual implementation in schools is underexplored.

Artificial Intelligence

AI is considered to have effect all areas such as politics, culture, education, economy in modern society (Chen et al. 2020). These fields are being affected by AI and today it can be seen that its effect has increased. The term 'artificial intelligence' was first used at a 1956 workshop held at Dartmouth College to describe the "science and engineering of making intelligent machines, particularly intelligent computer programs (McCarthy et al., 2006). Since then, many developments have been developed in AI based technology platforms and tools (Dönmez, Idil, Gulen, 2023). Luckin et al. (2016) define AI as it is as computer systems that have been designed to interact with the world via abilities that we generally think of as human. AI can be divided into two primary categories. These are narrow AI and general AI (Russel and Peter, 2016). While Narrow AI is programmed to carry out special tasks such as online or facial recognition searches, General AI has the potential capacity to execute any cognitive task a human could do. Generative AI particularly refers to a class of artificial intelligence models that use existing data to prepare new content that mirrors the highlighting patterns of the real-world data (Gong, 2016; Relmasira, Lai

and Donaldson (2023). A diverse range of AI technologies are currently in use internationally. Besides, there is a growing recognition of the significance of AI in the context of labour and in terms of its impact on daily life (UNESCO, 2022).

Pelletier et. al (2022) the continued growth of artificial intelligence (AI) is influencing every industry including education. AI has played a significant role in the advent of the fourth industrial revolution. In recent years, AI has gradually been revolutionizing education. Educational systems are adopting AI tools to support methods of instruction that benefit students. Since the covid-19 pandemic, AI for learning tools is viewed as a key technology having a significant impact on higher education. AI has the potential to deal with some of the biggest difficulties in education today, innovate teaching and learning practices, and ultimately accelerate the progress towards Sustainable Development Goal 4. But these rapid technological developments unavoidable bring multiple risks and challenges (UNESCO, 2021).

In figure 1, it is given the relationship AI with Machine Learning (ML), Neural Networks (NN) and Deep Learning (UNESCO, 2021).

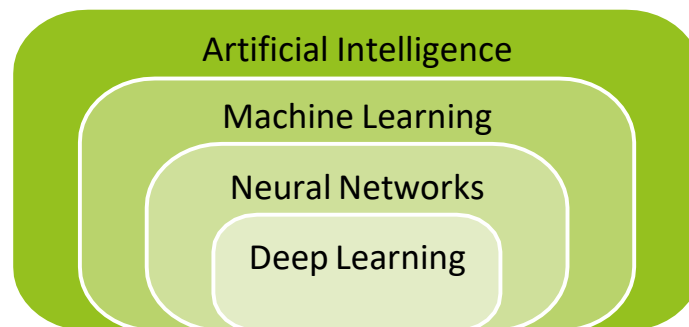


Figure 1. The relationship between AI, ML, NN and DL

Figure 1 reveals the relationship AI with its approaches which have been used in AI based applications. ML, analyses large amounts of data to determine designs and create a model which is later used to predict future values. NN is inspired by the structure of biological neural networks. DL refers to NN that consist of multiple

intermediary tiers. It has led to latest remarkable applications of AI. Within AI approaches, there can be seen some AI technologies to be used today such as Natural Language Processing (NLP), Speech Recognition, Image Recognition and Processing, Autonomous Agents, Affect Detection, Data Mining for Prediction, Artificial Creativity (UNESCO, 2021).

Teaching young learners about the basics of AI not only enhances broader skills such as critical thinking, meaning-making Xia et al (2022), and understanding of how computers function, but it also provides them with prospects to transfer that understanding to other contexts. As a result, AI has been identified as a critical skill for the next generation to succeed as future creators and innovators Ma et al. (2023).

The introduction of AI into educational fields might be traced to the 1970s. During that time, researchers were interested in seeing how computers might substitute for one-to-one human tutoring (Bloom, 1984). AI technologies have been used to facilitate the management and delivery of education. These systems have been facing applications are designed to automate aspects of school administration, building on Education Management Information Systems (Villanueva, 2003). Since 2000s AI has been used in educational fields with different purposes. Connor (2018) AI tools are used to address students' attention while teaching and learning process. Beside this, Harwell (2019) states that it is used for track attendance including predict teachers' performance (O'Neil, 2017).

Artificial Intelligence in STEM Education

Artificial intelligence (AI) is considered a STEM subject. Although AI is heavily based on computer science (CS), it is an interdisciplinary field that makes it transcend across subjects, including non-STEM courses. The transdisciplinary nature of AI further increases the interest it currently generates globally; that is, its key role in driving growth and innovation across industries, including the education sector. With the increasing utilization and relevance of AI in almost every facet of human lives, there have been calls to introduce AI into the formal K-12 curriculum

Touretzky et al 2019; Sanusi et al 2022). Rodrigo et al (2021) There is a growing trend of promoting STEM education for cultivating students' creative mindset and cross-disciplinary ability to create artifacts that solve problems of humankind and serve human needs. There is an increasing attention to the promotion of AI literacy education for cultivating students' ability to solve problems through the use of computers for automating parts of the problem-solving processes in a manner comparable with humans' processes. This creates an emerging need for planning curriculum initiatives across different educational sectors to meaningfully engage students in co-developing AI literacy and STEM knowledge for their success in the digital era. They also stated that the panel will provide an insightful discussion about an international perspective in relation to the role of AI in STEM education.

While there is agreement about the importance of AI lessons in schools across grade levels, less attention has been given to teachers and teacher education programs. The learning process of AI education requires students to combine knowledge from different fields. Hence, incorporating AI learning into STEM education is worthwhile at this moment because STEM education focuses on interdisciplinary learning experiences. Previous studies have identified the trend of incorporating STEM integration into education to foster future citizenship in science (Li et al., 2020). For the next generation, we can need to focus more on new kind of jobs due the developments seen in the technology and its fields. To be able to equip today's young people we should donate our students with 21st century skills such as creativity, critical thinking, entrepreneurship, efficient problem-solving, communication and including Chiu and Yeping (2023) AI literacy, leaderships and collaborative skills. STEM Education and AI education can be stated as they are global educational initiatives for K-12 (Casal-Otero et al., 2023; Chiu et al, 2022).

Relmasira, Lai and Donaldson (2023) states that while experiences exposing students to AI are valuable, education alone does not equip them with the required knowledge and skills to understand, use, and evaluate AI technologies in an ethically appropriate manner. Triplett (2023) The application of Artificial Intelligence (AI) has become increasingly significant in various sectors, such as healthcare and education. Within

STEM (Science, Technology, Engineering, and Mathematics) education, AI has played a crucial role in facilitating personalized learning, advanced analytics, and instructional automation. Despite the potential advantages that AI offers to STEM education, there is a lack of comprehensive and empirical studies that thoroughly examine the real impacts, integration challenges, and pedagogical approaches associated with its implementation in this domain.

With the development of computer science and computational technologies, automatic, adaptive, and efficient AI technologies have been widely applied in various academic fields. Artificial Intelligence in Education (AIED), as an interdisciplinary field, emphasizes applying AI to assist instructor's instructional process, empower student's learning process, and promote the transformation of educational system (Chen et al., 2020; Holmes et al., 2019; Hwang et al., 2020; Ouyang & Jiao, 2021). But existing literature review of AIED has mainly focused on the trends, applications, and effects of AIED from a technological perspective (Chen et al., 2020; Tang et al., 2021; Zawacki-Richter et al., 2019). It is seen that AI could be applied in some fields of the education. At this point, we can include AI into STEM Education. Although AI has the potential to enhance the instruction and learning in STEM education (Chen et al., 2020; Holmes et al., 2019), the development of AI-STEM requires a better fit between AI technologies and other system elements in STEM education. Since STEM education contains interdisciplinary knowledge and learning contents from different subjects, AI is usually restricted in specific learning contents or courses (Douce et al., 2005). It can be claimed that there are some challenges to adapt AI into STEM Education curricula with required contents. For instance, when AI is applied in STEM education, the role of instructor is expected to shift from a leader to a collaborator or a facilitator under the AI-empowered, learner-as-leader paradigm (Ouyang & Jiao, 2021). However, this review found that the instructor-centered lecturing mode was the most frequently used instructional strategy in AI-STEM studies, while other student-centered instructional strategies (e.g., the project-based learning, collaborative learning, gamebased learning) appeared infrequently. One of the reasons centers on

the complexity of integrating technology and pedagogy in STEM education (Castañeda & Selwyn, 2018; Jiao et al., 2022; Loveless, 2011). For example, ITS and automation techniques are usually designed based on behaviourism (Skinner, 1953) to support instructor's knowledge delivery and exam evaluation, which may be challenging for instructors to use when integrating it in the student-centered instructional strategies.

To be able to deal with those mentioned challenges there can be used some technology-based apps and tools. If the AI based apps can be used in harmony with the other technological tools and apps, the challenges of integrating artificial intelligence into stem education can be overcome. Chng, Tan, Chee and Tan (2023) On the surface, the fast-paced development of new technologies that can help address educational issues seems like a blessing, but this deluge of new technologies presents an unexpected conundrum for educators in reality. To begin with, the incorporation of any new technology into an existing curriculum requires substantial reworking and attention to detail. Also, teachers need to be adequately trained to be able to use these new technologies in classrooms effectively. As well, the deployment of new technologies might require infrastructure or resources that schools lack. Therefore, given the significant amount of investment in effort and resources in deploying a new technology, it is impractical for educators to adopt every piece of emerging technology that comes with every wave of technological innovation. With this in mind, this review aims to examine the use of emerging technologies in schools to deepen our understanding of how emerging technologies can be deployed, unpack the educational role of emerging technologies, and understand the inherent value that emerging technologies bring in transforming teaching and learning.

Jang, Jeon and Jung (2022), in their study, revealed the relation between STEM Education and AI. They looked for research trends in both STEM Education and AI which were done between 2019 and 2022. STEM, STEAM and AI Education were used to determine the latest trends in those fields. During this time, they benefit from some concepts, as keywords such as AI, Machine Learning, Deep Learning, Higher Education, Big Data, STEM, STEAM, Technology, Internet Things and e-learning.

They found that some concepts' occurrences were higher than the other keywords. For instance, AI Education 617, Education 172, Machine Learning 150, Deep Learning 71. Besides, they also prepared the analysis of the articles about AI education and STEM from 2019 to 2022. The detailed figure is given below.

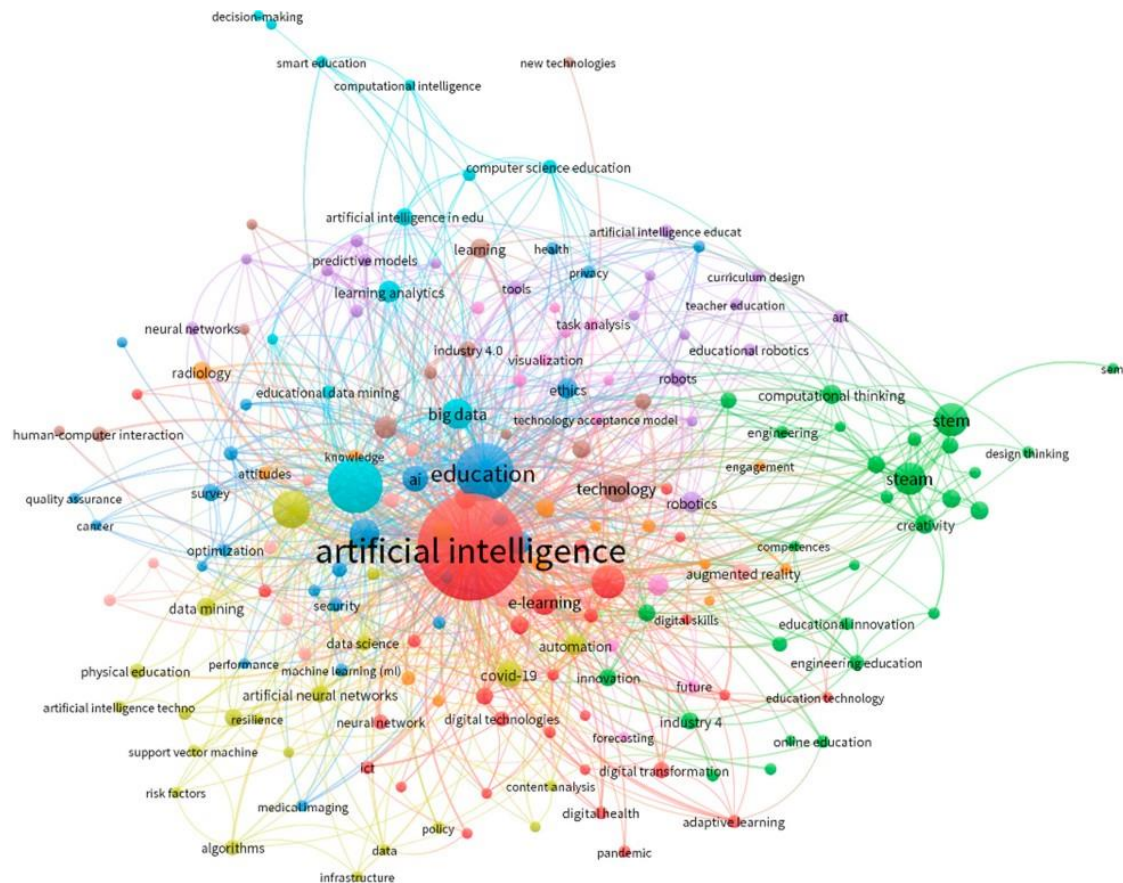


Figure 2. The analysis of articles about AI education and STEM from 2019 to 2022

In figure 2, it is seen that many related concepts for STEM and AI Education are given. In relation with AI, machine learning, security, data science, data mining, neural networks, vector machine, human computer interaction and automation are related subjects under AI Education. Within STEM, there are some concepts such as education, technology, Industry 4.0, engineering education, design thinking,

computational thinking, innovation, robotics, engagement, online education, adaptive learning and new technologies.

To be able to prepare a curriculum/educational programme based on both STEM Education and AI it should be included all details within those two fields. In this context, the relation between STEM Education and AI should be addressed very well and the content of them could be included into the curriculums/educational programmes. For making this, we can benefit from some tools and instruments as given below.

Hardware and Technical Materials

Within this category both AI and STEM based tools can be used together. The hardware includes computers, laptops, tablets, internet access. By using those materials some robotic and electronic kits/devices can be used. Within this context, it is known that some technological devices such as Lego Spike Prime, Lego Mindstorm, LEGO EV3, Raspberry pi27, Arduino are being used in STEM Education based curriculums and educational programmes.

Software

To build IT storage infrastructure and reducing storage costs, UNESCO (2022) the Ubuntu open-source operating systems were used by some curricula as less expensive to other operating systems.

Programming Languages

It is understood that some important programming languages are widely used in STEM Education based programmes. Those programming languages are Python, Micropython, Javascript, C++, HTML, Scratch.

Databases: Databases are used when the development of data-dependent AI tool is necessary. It is simply because that learners might be able to test the programs and optimize the algorithms such as ImageNet and Coco.

Tools for learning AI techniques

Some tools can be used within AI to facilitate learning process and make understand AI. Following tools can be given as examples regarding AI; Keras, OpenVINO, Teachable Machine, TensorFlow and MachineLearningForKids.

Discussion and Conclusion

In this study, the relation between STEM Education and AI is being tried to address within educational context. In recent years, the importance use of AI and STEM Education continue to increase all over the world.

It is seen that some international organisations such as European Union, UNESCO have been focusing on those two fields. Besides, countries have also been using and including them into educational curriculums. Although these significant efforts to be done in curriculums, it can also be said that the expected outputs have not been seen for those countries which developed STEM Education based curriculums. To be able to address this challenge, it is recommended that AI and STEM should be given into educational curriculums with harmony.

Jang, Jeon and Jung (2022) found that STEM-based Artificial Intelligence in Education (AIED) program had a positive effect on K-6 pupils' creative problem-solving ability and basic literacy and attitude toward AI. Based on this study, we can claim that policy makers and educational officials should include STEM-based AI contents into curricula and also prepares original curriculums that comprise STEM and AI. It is also recommended to add "A" into STEM so that students can enhance their creativity after teaching and learning process. By using AI in STEM curricula can enhance students' 21st century skills and prepare them for their future professional career. Hence, they can be equipped with necessary skills which

business world will need in the near future. Although countries have some important experiences with the use of AI and STEM Education. There is still long way to go for those two fields. Therefore, all stakeholders should work together to increase the efficiency of the AI in STEM Education for students within K-12 level.

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