Academic Education Publishing House

Higher Education and Practice Vol. 2 No. 1, 2025

Evolution of Education: The Introduction of AI Technology

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Abstract: Following the increasing digitalization of the world, AI technology is now more advanced than ever, to the point where it is more intertwined with our lives than we think it is. Originating from a simple hypothetical question by Alan Turing in the 1950s, it has advanced rapidly to become useful systems and programs in most fields. Undoubtedly, it has also made its way into the educational field in the form of educational tools meant to assist pedagogy and learning. However, as it is still considered a relatively new type of technology with much room for improvement. As such, there have been multiple reviews of AIEd (Artificial Intelligence in Education). Thus, a semi-systematic review of various literature work has been carried out in this paper in hopes of providing insight regarding how the introduction and subsequent integration of AI technology in education has caused the educational field to evolve in potentially new directions. The publication dates of works gathered range from 1960 to 2024 for a more complete and well-rounded analysis of the main trends AIEd brought about for educators and learners alike. The selected works for review are then split into decades for a more detailed analysis and the main direction of evolution of evolution is noted for each decade. The changes and differences in evolution direction are also noted through comparison.

Keywords: AI in Education (AIEd), Educational Evolution, Semi-Systematic Review, Technology Integration

1. Introduction

As the world makes its way through the digital era, more and more technology has been discovered and developed. As of 2024, AI is far from a novel concept. Having been developed in the 1950s, it went from being a hypothetical question (TURING, A. M., 1950) to a form of technology slowly integrated into all aspects of human life, including education. Before diving into the review of AIEd, understanding just what exactly AI technology is will help to set the context for the analysis below. The abbreviation "AI" stands for "Artificial Intelligence". "Intelligent" is defined as the ability to gain and apply knowledge in the situations which call for it. This undoubtedly opens up endless possibilities. Hence, many have sought to integrate AI technology into the educational field and that is how the field of Artificial Intelligence in Education (AIEd) came to develop. There have then been quite a few reviews on how AI technology is applied, used and integrated into educating learners throughout the years[15] and even the centuries (Goksel, N., & Bozkurt, A., 2019). Considering the speed at which AI is developing, the authors deem it necessary to conduct reviews on the literature works on AI technology from 1950 to 2024 in order to determine the direction in which the educational field is developing so as to provide further insight for the relevant professionals.

2. Methodology

This paper seeks to analyse the evolution (of the educational field) brought about by AI technology, and to infer future directions from said analysis. The selection criteria were:

(a) Does the paper discuss AI technology in the educational field specifically or involved AIED?

(b) If it is a research article or a paper of other types, does it provide information or an analysis on how AI affects education?

(c) If it is a review article, does it review the effects of AI technology on education or something along the lines of that?

Thus, a semi-systematic review approach was adopted. A semi-systematic review approach is typically used to review qualitative data in order to ascertain the existence of a trend in a specific field. Rather than analysing published

quantitative data in order to obtain new sets, this method allows authors to focus on theoretical models and to look at how exactly the research in a field has progressed over time (Hannah Snyder, 2019). A total of 100 articles were then gathered, ranging from research articles to literature reviews, some being gathered from the citations.

During the search, the keywords 'artificial intelligence' and 'education' were used in conjunction using the Boolean Search approach (MacFarlane, A. et al., 2022). The works for review were gathered from Google Scholar and Elsevier ScienceDirect. ScienceDirect provides access to articles from journals published by Elsevier, with many being indexed in Scopus and even the Web of Science SSCI and or SCI. Journals indexed by these databases are known to be of high quality, so the standards of the works are guaranteed.

There had not been a specific time period from which to select the papers for review, so the authors were open to gathering studies from the 1950s (when AI technology was still deemed new) to current century. With the earliest paper gathered being published in 1960 and the latest in 2024, the authors were allowed to gain deeper insights on how AI has caused the educational field and professionals to progress and improve so far.

3. Findings and Discussion

3.1 AI Technology in Education from 1950 to 1999

At the start, AIEd was mainly used to assist teachers with their tasks. The invention of automatic graders only supported that fact (Jack Hollingsworth, 1960). Machines were created to lessen teachers' burdens by taking over a part of their job, especially grading. Later, education seems to have developed such that student independence is encouraged instead of reliance on a teacher. An example would be a system known as the PLATO (Programmed Logic for Automatic Teaching Operations) [4]. Here, the student is in charge of the sequence of the learning materials as well as the pace at which they go through the materials. Should the student get a question wrong, instead of having a teacher reveal the answer to them, additional materials are provided upon request.

Education has focused more on attaining knowledge from words and text. However, with the birth of LOGO, the method of learning through visuals has been introduced into the field on a larger scale. Having been brought into existence by Seymour Papert and others from Bolt, Beranek and Newman in the late 1960s[11], it encourages the absorption of knowledge through stimulation and imagination. For example, students were given a type of robot named "Turtle" (Papert, S. A., 2020), developed a few years later (Catlin, D., Blamires, M., 2019). In order for it to move to the students' will, they will have to 'place themselves in the Turtle's shoes' and imagine or plan the steps it has to take in order for the desired shape to be drawn. Only then can the students give commands accurate and specific enough to get the results they want.

Throughout the next few years, AIED was developed and programmed to take up the basic features a teacher has. In a sense, it was mainly programmed to be a non-living teacher. For example, one of the first projects was "for a study of computer assisted instruction" to be conducted (Annett, J., 1976). 'Computer assisted instruction' (CAI) is defined by Britannica as "a program of instructional material presented by means of a computer or computer systems." (Britannica, T. Editors of Encyclopaedia, 2023) It could be understood as the passing on or presentation of the educational content to be taught via a digital device or system. The computer (or system) would then "replace" the teacher's role in providing feedback and in a more personalized way.

Thus, instead of developing systems to help teachers with manual tasks such as grading papers, research is carried out with the goal of creating AI with the fundamental features of a teacher. These are then known as Intelligent Tutoring Systems (ITS), referred to as "computer systems that are as effective as intelligent human tutors". (Anderson, J. R. et al., 1985). The earliest one to be created, in 1970, was named SCHOLAR [5]. Just like a human teacher, it is able to gauge the extent of the knowledge held by the student through quizzing, determining the extent to which the student's answer is correct and taking note of the time taken for a reply to be received. However, it is ultimately dependent on the content the teacher codes into it.

The 1980s then saw the rise of knowledge-based systems aiming to provide humans with an 'artificial consultant' as capable as a reasonably

skilled human. Examples would be SOPHIE[10] and GUIDON, which guided students through feedback and helping to clear up their confusions (William J. Clancey, 1987). As the decade went by, Woolf, B. (1991) noted that such AI systems were allowed and more able to solve real-life problems instead of hypothetical ones. Systems like PROUST would then be unique in the sense that there are no pre-determined sets of questions that they can answer, but rather the system is expected to apply the information it 'gained' by identifying the errors in students' works. There was also a reversal in the roles where the students were encouraged to learn through teaching the system instead of being the traditional learner (Michie, D. et al., 1989).

3.2 AI Technology in Education from 2000 to 2010

When the world entered the 21st century, a greater emphasis was placed on the transmitting of information via visual graphics, which took the world by a storm. The generation growing up with such information technology integrated into their lives was dubbed "the Net Generation" (Oblinger, D. G., & Oblinger, J. L., 2005). Back then, video and computer games were all the rage, and visual entertainment such as films started to grow in popular as well. Consequently, there was a need for new education methods to be created.

Game-based simulation was then gradually implemented into the educational field. No longer do the students have to rely on their imagination to create the learning area; the simulation provides all they need except for the solution to the problems on the screen, further increasing the independence they have from their educators (Taradi, S. K. et al., 2005). Naturally, there were concerns that the excessive use of games in learning might lead to a game addiction or that students might misuse the simulations provided for their own entertainment[2]. However, military uses have found that learners retained information for a longer period of time and were able to use the knowledge gained more efficiently and accurately in the appropriate scenarios (Belanich, J. et al., 2004). Research have also shown that such worries are relatively unfounded as learning was more effective and faster when learners have their attention captured by a teaching media they were interested in [1], even leading to an increase in social interactions between students (Jayakanthan, R., 2002).

Despite the earliest use of virtual classrooms being in the 1990s, they became more prevalent in the 21st century and were then defined as those which are accredited by the state and deliver their materials through the Internet (Clark, T., 2000). But before implementation can occur, there has to be a system competent enough to deliver the materials as desired. B. Cheung et al. (2003) then discusses the implementation of intelligent tutoring systems (ITS) for distance learning. It was through this system, named SmartTutor, that learners would be able to personalise their lessons. In light of this, the creation of Virtual Learning Environments (VLEs) would then make more sense. These environments are then said to allow learners to learn at their own pace while still being able to connect with their peers[7] and so VLEs are a type of digital classroom.

Learner independence seemed to have increased most with the existence of chatbots, first known as chatterbots (Michael L. Mauldin, 1994). Back then, it was created as an AI game player, but its abilities to hold conversations with humans means that it is able to ask and answer questions, making it possible for utilisation in the educational field. However, what makes chatbots stand out most is how engaging and personalised it truly is.

When it came to younger children, the main teaching method was for the child to teach educational programs the concepts provided and for them to learn from the mistakes of the system. These systems were known as Teachable Agents (TA), defined as "an instructional technology that draws on the social metaphor of teaching a computer agent to help students learn" (Chin, D.B. et al., 2010). Here, the children were taught to create concept maps (the 'brain' of the TA) and insert nodes and links according to what they have learnt prior to the teaching. Then, they take up the role of teachers by evaluating how well the TA has done by grading the test taken and determining whether or not to add more nodes and links, which act as the knowledge to be learnt in this scenario. Thus, the 'jobs' of a teacher taken up by the students are grading and evaluation, further supporting the observation that the method of 'learning-by-teaching' (Annis, L. F., 1983).

3.3 AI Technology from 2011 to 2020

Ever since the discovery of the shortening

attention span of students in the previous decade, more attention has been paid to the need for a change in pedagogy methods. Virtual Reality (VR) has been a rather good solution thus far. Far from a novel concept, Virtual Reality is a type of technology that helps to immerse the user into a non-existent world. Simulations can thus be made for multiple purposes (such as training) and fields. Hence, Virtual Reality has also been used in the educational field to teach learners of various ages or even professions. For example, Virtual Reality has been used to teach teachers and help with the learning of pedagogy (Huang, Y. et al., 2023) and has been reported as being useful and helpful to a certain extent.

Despite AI technology being introduced into the educational field in the 1960s, it is during this decade that AIEd truly became more prevalent and popular. Thus, aside from visual learning being taken into consideration, due to the widespread integration of AI into the educational field, the familiarisation of students with AIEd is also being prioritized. There have been suggestions and discussions for introducing students to AI at an age as young as possible and for this, programs have also been designed. Scratch, for one, is designed for people of all ages to learn programming (Resnick, M. et al., 2009). It raises the interests of learners by having them learn the concepts as they make their own projects for sharing on the platform and is noted to be efficient at teaching core concepts in STEM[8]. For example, ReAct! is designed to teach AI planning and has also been shown to be effective in both teaching and learning (Dogmus, Z. et al., 2015).

However, attention has been drawn to the fact that usually, there are less studies being done for K-12 grades when compared to higher education (Means, B. et al., 2010). Due to the introduction and integration of AI technology in education, traditional methods are no longer ideal in helping K-12 students learn the relative computing concepts efficiently[14]. It is also to be noted that K-12 students, despite being categorized into one group, can be split into primary/elementary and middle/secondary levels. Those in the former learn better using vivid and solid descriptions since it allows them to make use of their active imagination to visualize what they need to understand. Imagination has indeed been proven to enhance learning and is a core part of elementary students' learning process[12]. On the other hand, the latter group has been noted to learn more efficiently with visual simulations instead of having their imagination evoked[9]. These crucial differences have been brought into light more than ever due to AIEd and may pose a challenge for the educators. Thus, to further assist with this, national guidelines have been developed by the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA), which undoubtedly help educators understand how to better introduce K-12 students to AI (Touretzky, D. et al., 2019).

AIEd can also help with learning through images in the medical field. Through training the AI tool using a reliable system, it can already generate relatively accurate heatmaps and help the students to apply their knowledge to real-life medical cases (Cheng, C.-T. et al., 2020). This is also noted to free up more time to allow the educators to focus more on customising their lessons to help the students with their weaknesses (Zawacki-Richter, O. et al., 2019). This represents a substantive change in the educational field as it further solidifies the fact that education is gradually become more inclusive of the various learning styles, especially visual learning. Thus, the educational field is (and the pedagogical field will eventually) starting to deviate even more from the traditional teaching methods to more flexible and adaptive ones. More students will then be catered to, subsequently raising the academic performance of learners.

3.4 AI Technology from 2021 to 2024

Technically speaking, it is safe to say that AI technology and the educational field are rather closely intertwined, to the point where there is a goal to have the younger generations master the various use of AIEd from a young age. This is explainable considering how personalised AIEd has made learning for learners[13]. Self-studying has become even more possible than ever since AI technology such as ChatGPT can help to gather the relevant information. Indeed, there is a danger that the information collected may not be the most relevant or accurate (Zhang, B., 2023; Akgül, S. B. et al., 2024), but it is sufficiently reliable for students to learn and gain knowledge without the guidance of a teacher. This is further supported by the fact that its accuracy is increasing with each 'evolution' (Chow, R. et al., 2024) Education now could

then be described as 'AI-Empowered, learner-as-leader' (Fan Ouyang, Pengcheng Jiao, 2021).

Aside from personalised learning, Educational Robots (ERs) are also being introduced into physical classrooms. Naturally, these robots are designed to help teachers teach their students more efficiently. Thymio, for example, was invented to help teach programming to young students (Mondada, F. et al., 2017). Aside from being a tool for teaching learning materials, robots can also be designed to teach learners about AI technology, such as the Robobo robot[3]. On this aspect, research also has been and has to be carried out on whether or not AIEd is suitable for educational use in various age groups[6].

Generative chatbots such as ChatGPT have also been all the rage in this period of time. It is an AI model that converses with the user (OpenAI, 2022). It is also very much capable of answering questions through the collection and compilation of the relevant or necessary information which it thinks will clear up the user's confusions. Aside from allowing the users to get an answer for their enquiries efficiently even without a human teacher, such models are noted to widen the scope of knowledge gained and to help facilitate innovative learning too[16].

From the analysis above, it could clearly be seen that education is evolving such that AI technology is no longer a mere tool to advance the field but rather is included as part of it. However, there is also the risk that students could use AIEd to 'think for them'. Occasionally, there are news of students using AIEd such as ChatGPT to complete their assignments in their stead. In return, educator and educational institutions have to rely on technology specially invented to check if the student has relied on AIEd for less-than-ideal means, such as Turnitin (Mphahlele, A., & McKenna, S., 2019). With these technology in their hands, there is thus the risk of a gradual decrease in critical thinking skills in future students, which is something that educators should take into consideration.

4. Conclusion

To conclude, the educational field has gradually allowed learners to have full control over their learning pace and allowed for the digitalisation of the learning environment. Aware that there have been extensive research and review regarding the applications and emergence of AI in Education (AIEd), it is hoped that this paper will help to provide some insight as to how education has changed ever since the first introduction of the technology into said field. The articles analysed in the review have also been incredibly helpful in determining the previous, current and future directions in which the educational field is potentially developing.

It is to be noted that this paper focuses on the influential categories and types of AIEd as a whole rather than analysing each and every system or program introduced into the field. Consequently, there is still much research to be carried out on the individual systems presented and how they affect education. Also, the evolution of the education each age group was not discussed here. Due to the difference in mental age, there is also a need for more review on how the education of each age groups has changed or developed due to the integration of educational AI technology. Also taking into consideration how rapidly Artificial Intelligence in Education (AIEd) is developing and being invented, this article calls for research to be done on the more recent AIEd applied and used.

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