AI in Education

What are the current trends and topics in the research field of AI in Education?

Samuel Chazy

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International University of Applied Sciences

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Abstract

With the rise and advance of Artificial intelligence (AI) in this new era, AI has impacted and propelled learning in the educational field to a higher level. In this paper, I will present the kinds of AI technologies that are being implemented or under development, and I will highlight the trends and topics in the research field of AI in the educational field. I will then list and demonstrate some examples of AI technologies that are being utilized in education along with some case studies. Finally, I will conclude this paper with a brief observation about the current status of AI in the educational field, and where research should be focused in the coming years.

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1. Introduction

Artificial intelligence (AI) is slowly but surely becoming part of our everyday life, though it is difficult to define the meaning or give a clear definition of what artificial intelligence is today. AI used to be associated with intelligent machines and robots, but lately we started observing the use of AI in intelligent systems, programs, everyday utilities and many applications (Huang et al., 2021). As the technology advances, the processing power and speed of computers jumps forward enabling AI to reach unmatched levels of complexity by utilizing complex algorithms.

In particular, AI today is largely used in the educational field and is contributing to the teaching process helping teachers and students create an interactive and creative environment that fosters engagement and customized learning. Several AI applications advance the teaching process, enabling the educational field to be slowly reformed around the use and benefits of AI (Huang et al., 2021). Furthermore, the Covid-19 pandemic has accelerated the use of technology, encouraged distance learning, and fostered independent online educational web platforms.

It is worth noting that research identifies a gap of educational theories and models around the use of artificial intelligence in the educational field (AIED) (Tang, Chang & Hwang, 2021 in Zhang & Aslan, 2021). In addition, AIED is at an experimental level where we can still observe a gap between the proposed and the potential AI technologies, and what is actually implemented in schools (Zhang & Aslan, 2021).

In this paper, I will shed light on the latest trends and topics in AI research in education, in an attempt to contribute to the understanding of the most recent applications and technologies that are implemented in schools or through distance learning.

2. AI Technologies

Before attempting to demonstrate the various applications of AI technology in the educational field, I will first define a couple of important AI terms. Those definitions will guide the reader to understand the process or the tools which are implemented in those applications.

2.1. Machine Learning

The essential concept of machine learning is learning by finding meaningful patterns and structures from the collected sampled data. In the case of AIED, samples of data are collected from students and teachers alike. The data can be used to help students choose their majors or classes, by studying student's preferences, achievements, grades, points of strength, etc. As for teachers, the data can help them to perceive the understanding of a subject by their students, so that they can adjust or change their method or approach(Chen et al., 2020).

2.2. Learning Analytics

While machine learning finds meaningful patterns in data, learning analytics focuses on finding correlations between the different variables in the data to understand how one variable might affect another in a positive or a negative way. Learning analytics use techniques like data visualization, tables and graphs to help the viewer gain insight into the data. In the case of AIED, the teacher can find insights and view the critical competencies of students which will allow him/her to proactively make significant instructional decisions. Analytics can also predict the likelihood of students dropping out of school, paving the way for early intervention by the school or the teacher (Chen et al., 2020).

2.3. Data Mining

Starting with finding meaningful patterns in the data to finding correlations in the variables, data mining consistently digs into the data on a daily basis in an attempt to generate automated reports for developing essential associated rules, rules that are similar to a pattern discovery. In the case of AIED, data mining can help achieve personalized learning with the help of predictive modeling. Students can, with the help of AI, learn on their own and at their own pace their subject of interest, while the teachers adjust the teaching courses to fit the student's pace and interests (Chen et al., 2020).

Now that we understand the basic terms of AI, I will now list and describe the current trends in AI by structuring those innovations under two main themes. I propose the first theme to be "AI as a key player", where AI could perform and operate on its own without assistance. The second theme would be "AI at the service of the teacher", where AI can be used to assist teachers and institutions in delivering quality learning.

3. AI as a Key Player

Artificial intelligence for educational purposes can be helpful in taking off the mundane and administrative load from the teacher, enabling him/her to concentrate on what matters most, the student. Administrative tasks such as student's papers reviews, grading, and feedback can be automated using AI, and can, in my opinion, achieve better performance and give more accurate results than the teacher. I found that those AI technologies can be grouped under three categories, which are Intelligent Tutoring Robots, Chatbots, and Machine Learning.

3.1. Intelligent Tutoring Robots

Educational robots were specifically developed for the education field to analyze students' creative and application abilities because of their interactive and scalable characteristics (Miller, Nour bakhsh, & Siegwart, 2008 in Lu, 2020). Those robots are being used as part of a large scientific research on fields such as computer science, automatic control, psychology, and many more, and they are equipped with technologies such as voice recognition, emotion recognition, and human-like abilities. Some of these abilities are listening, seeing, reflecting on a subject and communicating back to the students (Yang & Zhang, 2019 in Lu, 2020).

It is fascinating to witness this coming transitional era where human-robot co-existence (Co-bot) is starting to integrate into society, and this will happen soon enough and in particular in the educational field (Eguchi & Okada, 2018). Pepper, one of the first Co-bots that is capable of reading emotions, is capable of providing teaching services to students at various stages of elementary school, middle school, and university. Pepper, available in few countries including Japan, France, United Kingdom and Taiwan, was introduced in China at the university of Ningbo as an ambassador who provided multi-language communication, courses and library information inquiry services. Meanwhile, at the university of Hertfordshire in the UK, tutoring robots are introduced to help children with autism, who responded in a positive manner to the interaction with the robots (Wood, Zaraki, Robins, & Dautenhahn in Huang et al., 2021).

Another example, Maker education is associated with STEM learning, an approach to problem-based learning which relies on collaborative and hands-on learning experiences. It integrates science, technology, engineering, and art among many disciplines. Maker education is used in robotics courses and competitions to teach students the essence of robotics skills and programming.

On the other hand, robot management education using robotic algorithm and intelligent learning systems are used to examine and evaluate test papers and analyze the learning process. This can help improve student's efficiency and take the load off the teacher to enhance the overall learning experience (Lu, 2020).

3.2. Chatbots

In the educational field, AI started with computer related systems, but as the technology got advanced, web-based and online platforms started to make their way into education. Chatbots, which today have human-like functions using natural language processing deliver personalized online learning to students and can assess a student's level of understanding (Chen et al., 2020). Chatbots can be used in administrative tasks to guide and give assistance to students for example, and they can also be used to provide a framework for the learning process. To that end, chatbots provide a conversation and a reflection on the various subjects with students.

The university of Cardenal Herrera (CUE) in Spain, uses a Chatbot for assisting students and for answering their queries. Although initially the Chatbot was used for administrative purposes, it was later used to predict student behavior and for giving them advice during their time of study. A study that the university carried out to assess the effect of this Chatbot on the learning process showed that there was a shift in focus as to what the students were really learning. It showed that students became more independent and responsible for their own success or failure, that the learning process became centered around the student's profile and needs, and that there was an increase of implementation of adaptive learning behavior (Galstyan, 2019 in Nitirajsingh Sandu. Ergun Gide, 2019).

On the other hand, a twelve-week experiment was done by researchers to compare the effect of interest in Chatbots partners compared to human partners. This experiment was done for a course in foreign language classes with 122 students. The study showed that the interest of students was quite high during the first week because of the newness of the situation and the technology used, but the interest dropped after only one week of study [Fryer et al. inZhang & Aslan, 2021]. While this drop was probably caused by putting the students out of their comfort zone, in my opinion, I think that the use of Chatbots should not be discarded, and it needs to be investigated further. Chatbots, can still deliver quality learning that would lift the pressure off the teachers' shoulders (Nitirajsingh Sandu, 2019).

3.3. AI Algorithms

AI in the educational field uses the power of mathematical algorithms by focusing on the practical side of artificial intelligence through the use of AI tools and models rather than focusing on the underlying mathematical structure of those algorithms. In general, in K-12 education, AI initiatives can be grouped under three categories. The first is AI-based tools that support the learning process, the second is AI-based tools that study the learning process, and the third is AI that supports administrative tasks. The objective of machine learning is to model and automate aspects of the learning process such as pedagogy, subject matter, context of learning and learning objects (W. Holmes, M. Bialik, and C. Fadel in Tedre et al., 2021).

Machine learning is introducing new forms of applications to the classrooms. An ongoing research attempts to introduce media applications such as sound, images, and movies as a driving force for AI learning in schools (Tedre et al., 2021). In one study, algorithms were applied to predict undergraduate students' attitude towards educational applications of could-based mobile computing services. The algorithms collected data on the student's behavior through their information management with a high percentage accuracy (Arpaci, 2019 in Zhang & Aslan, 2021).

4. AI at the Service of the Teacher

While AI as a key player proposes automated and independent tools and platforms that serve the students by taking the heavy load off the teacher's shoulders, AI at the service of the teacher brings creative, empowering and next generation tools that can assist the teacher in rethinking the traditional methods of learning. In the following sections, I will group those tools under two categories: Intelligent Tutoring Systems and Contextual Learning.

4.1. Intelligent Tutoring Systems (ITS)

With the progress of artificial intelligence that we have witnessed in the last five years, AI has provided a powerful platform with pedagogical tools to the educational field. Simulation based learning and experiences have taken learning to the next level with technologies such as virtual reality, augmented reality, and mixed reality headsets. These technologies have immersed students in the proposed concepts of learning and given them an experiential walk-through in interactive simulations that gave them a profound understanding of concepts, such as taking medical students through surgical operations. In the same way, teachers are using Games that have an artificial intelligence component,

be it on screen or through the VR headsets to immerse the students in the learning process and achieve higher engagement (Chen et al., 2020).

The introduction of these Intelligent Tutoring Systems (ITS) has shifted the traditional teacher-student instruction model. The teacher can now be supported by a digital intelligent assistant that can be customized by the teacher with the specific learning objectives that the course requires. As such, these systems can propose personalized tasks and activities to each student, record their performance and behavior metrics, and provide insights to the teacher. Just then, the teacher can approach each student separately and propose a different learning model that can suit and motivate the student. The process of collaboration between the teacher, the student, and the intelligent systems was recently made possible through the introduction of technology and digital tools to the schools, and the widespread access of smart devices including smart phones and tablets within the reach of students even for the younger ones (Kokku et al., 2018).

Another path where ITS helps the educational community is in strengthening academic integrity. Programs for checking plagiarism, proctoring, and online supervision of students such as Grammarly, TurnItIn, and Unicheck are only few of the many applications available to help the teachers and students avoid mistakes and cheating patterns (Chen et al., 2020). In the below sections, I will group the tools of ITS into four categories, Intelligent tutors or agents, Teaching Assessment, Virtual Classrooms, and Smart Campuses.

4.1.1. Intelligent Tutors or Agents

Intelligent tutors or agents deliver personalized targeted content and give guidance and feedback to students, and thus are called Teachable Agents (TA). In one study in Sweden, researchers studied the gazing behavior of students while they were trying to understand a Teachable Agent based math game. The outcome of the study was significant because it indicated that the students saw the Teachable Agents as independent entities, and therefore, researchers suggested that Teachable Agents can be great facilitators for learning tasks that the students can not accomplish independently, a process referred to as metacognitive scaffolding (Gulz et al., 2020 in Zhang & Aslan, 2021).

According to their website, DeepTutor (DeepTutor, 2022) is an intelligent tutoring system developed by the Institute for Education Sciences in United States, that promotes the understanding of complex science topics. Deep interaction with the students is possible through the use of a Natural Language Processing representation called the latent semantic logic form (SLF), which is an advanced dialogue management technique. LSF uses Learning Progressions (LP), which is a framework

developed by the science education research community, to demonstrate the path to mastery for students. LPs can model a task domain, track the knowledge state, and give feedback to students (Chen et al., 2020).

4.1.2. Teaching Assessment

Artificial intelligence is a great tool for teaching assessment because it can use prediction algorithms, image recognition and computer vision to its advantage. AI is capable of not just automatically correcting the test papers, but also generating test questions (Li et al., 2018 in Huang et al., 2021).

RealSkill Institute, according to their website, addresses soft skills such as decision-making, self-motivation, and work ethic, skills that fall outside traditional academic pursuits but are necessary for career success (RealSkill, 2022). One of the objectives of RealSkill is to improve IELTS and TOEFL through smart correction and oral practices. While students can learn and take those tests on their online platform, RealSkill AI tools can score the tests with precision by going over each and every sentence to analyze the content (Deloitte, 2019 in Huang et al., 2021).

According to their website, E-rater (E-Rater, 2022), is an online engine developed by The American Educational Testing Service (ETS) to identify features related to the proficiency in student's essays writing, to score tests, and to give feedback to the students. E-rater can specifically evaluate the structure, grammar, and overall score of essays so that students can improve their writing skills (Huang et al., 2021).

4.1.3. Virtual Classrooms

With the advance of Virtual, Augmented, and Mixed Reality as technological tools of the future, virtual classrooms are being proposed as an innovative teaching environment that can virtually simulate many subjects in education that are otherwise difficult to explain in real life. Subjects such as occurring natural phenomena, material transformation, or cellular composition can be presented in a smart virtual classroom because those environments can add multi-dimensions to the presentations stimulating students' senses and thus making abstract theories intuitive and visually appealing (Huang et al., 2021).

4.1.4. Smart Campuses

The Covid-19 pandemic has accelerated the formation of smart campuses in favor of students and teachers. AI plays an important role in managing the smart campuses which are becoming a trend in the educational field through the use of intelligent systems such as face recognition and sensing technologies (Zhou 2020, An & Xi 2020 in Huang et al., 2021). These systems use big data collected from the cameras and sensors at the smart campuses to analyze and report back to the teachers or to the educational institution. Analyzing the data could be used to enhance campuses' safety, report operational problems in the educational system, and help in allocating campuses' resources efficiently (Liu, Ma, & Jin, 2018 in Huang et al., 2021).

Face recognition might be one of the core technologies used in smart campuses, because it can be used, for example, to check student's identity cards and certificates to avoid fraud (Zhou, 2020 in Huang et al., 2021). At the library, Face recognition can be implemented as a system for borrowing and returning books which makes the process autonomous and thus increasing efficiency of staff and reducing cost of labor (Upala & Wong, 2019 in Huang et al., 2021). In canteens, face recognition can be implemented to automate the check-out process at the counters, where the identity of the person can be instantly checked, and the price of plates and beverages calculated (Ramdani, Virgono, & Setianingsih, 2020 in Huang et al., 2021).

On the other hand, infrared fences and sensors can be deployed to avoid intrusion or students trespassing boundaries. At any point in time, if the sensors detect an intrusion, an alarm will be triggered at the institution's security office, which can in return inspect the violation or call the police (Muhamad, Kurniawan, Suhardi, & Yazid, 2017 in Huang et al., 2021).

4.2. Contextual Learning

With the introduction of AI in the educational field, the traditional learning approach of one-fits-all, is slowly fading away in favor of a more targeted and customized learning. The reason behind this change in approach is that every student has a unique context based on the previous acquired knowledge about the subject which usually relates back to their social and economic background. This targeted learning can focus on the curriculum and content according to the student's needs and capabilities, or it can focus on giving the student a more enjoyable learning experience, and thus fostering engagement (Chen et al., 2020).

According to Knewton's website (Knewton, 2022), Alta is an adaptive learning technology platform that delivers customized learning to students in higher education. It delivers real-time feedback to students using machine learning algorithms while adapting and customizing the content seamlessly to the student's needs. The algorithm deciphers the type of learning style which is more appropriate to the student from the different available styles, including a visual, auditory, reading and writing, and kinesthetic learning styles (Chen et al., 2020).

Cerego, on the other hand, takes contextual learning to a whole new dimension. Cerego can help students create their personalized online courses instantly, boost their skills in any chosen subject, track their progress in real-time, and most importantly to stop forgetting what they have learned using Cerego proof AI techniques (Cerego, 2022). This AI platform targets students of all ages from early childhood till university graduate levels while utilizing adaptive educational systems, intelligent tutoring systems, Natural Language Processing algorithms, and cognitive science (Chen et al., 2020). Cerego provides intelligent reminders at the time that the student is set to forget the material, then it sends different question styles to challenge the brain. This method insures long-term retention of the material by the student.

iTalk2Learn is a collaborative European project that was created as an open-source intelligent tutoring platform to support students aged five to eleven in the subject of math learning (Italk2learn, 2022). It has a more intuitive approach to mathematics by using machine learning, intelligent tutoring systems, Natural Language Processing, and educational psychology. Using this platform, intelligent tutors interact with students through speech to identify challenges that the students are facing such as fractions and they propose alternative paths or approaches to guide the students (Chaudhry & Kazim, 2021).

In the next sections, I will group the tools under Contextual Learning into three categories, Expert Systems, Visualizations and Virtual Learning Environments, and Adaptive Learning.

4.2.1. Expert Systems

To reach the full potential of learning management systems, researchers suggest that institutions should start using holistic expert systems in pedagogical planning (Dias et al., 2015 in Zhang & Aslan, 2021). In Taiwan, researchers studied the effect of a fussy expert system on elementary students and found out that students in the experimental group performed better than the control groups. Students were split into multiple groups to test the achievement in a mathematical learning area. In the expert system group, the cognitive status and the online behavior of students were recorded and analyzed

using the fuzzy membership functions and inference rules (Hwang et al., 2020). Researchers concluded that using expert models in math reduced the learning anxiety among the students.

4.2.2. Visualizations and Virtual Learning Environments (VLE)

The potential benefits of VLE in the educational field are rising over time as the technology itself becomes advanced. Harvard university used the River City project to test student's performance (Gibson, 2007 in Ijaz et al., 2017). They found that virtual simulations can increase students' motivation especially the low performers. In one of the science classes that used the River City project, researchers observed that students who have previously given up on learning were motivated by the use of this technology and they became high achievers. The study concluded that VLE propelled students regardless of their academic history (Ijaz et al., 2017).

In another experiment in the United States, Smart glasses were used to help students with autism disorder (ASD) because researchers believed that students suffering from ASD did not have the proper educational tools to meet their needs. Researchers were concerned whether students with ASD would accept wearing smart glasses, but they were surprised to find out that those students have used the glasses for a considerable amount of time during the experiment, and they have even described the experience as enjoyable (Keshav et al., 2017). This finding demonstrates the potential impact of smart glasses on students with ASD and what this technology can offer them.

4.2.3. Adaptive Learning

To plan the best path for students, adaptive learning systems are used to analyze students' abilities and collect data about students' learning behavior (Huang et al., 2021).

DreamBox, is an intervention tool to manage student's growth (DreamBox, 2022). Teachers can tailor the assignments to students' needs and based on the retrieved data analysis from the platform, teachers can intervene. The data helps in identifying and then predicting the learning paths of students and how far they are from their objectives. All of this is done in real-time which makes adaptive learning in this case study an effective approach (Huang et al., 2021).

Similarly, IBM Watson Education (IBM Watson, 2022) propose cognitive learning that is personalized to each student by helping teachers get insights into the learning styles, find students' preferences, and their motivational levels. Watson's cloud classroom helps teachers understand student's needs and search for learning content such as lesson plans, tests, and worksheets on a

friendly-user interface. This interface provides mastery for the students, learner analytics, and a cognitive learning library that serves as a recommender engine for teachers (Huang et al., 2021).

5. Conclusion

In this paper, I have discussed and listed many of the AI tools, methods, and platforms that are either being implemented today as a tool or as a research to test the effectiveness and measure the results. However, it is clear that AI in education is still at its early stages, though it is showing very promising results when it comes to taking off the workload from the teachers' shoulders, and as to proposing alternative and adaptive methods or approaches to learning (Chaudhry & Kazim, 2021).

In my opinion, there are many initiatives and experiments done on the online and distance platforms, but fewer on campus with a focus on the existing brick and mortar academic institutions, including K-12 schools and higher education. This discrepancy is due, of course, to the Covid-19 pandemic which accelerated the online and distance learning, but as soon as the pandemic is over, I believe that we will come to realize that the academic institutions which hold the fort of education have been neglected by those trends and advances. Finally, in that sense, I think that the novelty and advances that were introduced in the online platforms should be merged or integrated seamlessly into the educational schools' curriculum.

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