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The State of Education and Artificial Intelligence After the Pandemic

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Abstract

The neologism of artificial intelligence and machine learning brought a myriad of conveniences and advantages into the education sector. These new and improved technologies have the potential to be the remedies to the predicaments that have emerged from the rapid transition into online learning and the problems that have existed with traditional learning. These predicaments vary from personalized learning experiences, administrative busy works, to increased overall student interaction. This article explores how artificial intelligence became the new normal in education and the recently revealed benefits of artificial intelligence and machine learning in developing automated solutions to these predicaments such as

Intelligent Tutoring Systems (ITS), dynamic schedules, automated grading, and increased personalized student interaction through chat-bots. Along with these solutions, some of the economical advancements that these technologies will bring include new research and investments in AI development, data collection and understanding, and increased jobs. These advancements are on a massive scale and will need to be addressed. By accommodating our resources into the advancements in this area we can make our education more versatile, engaging, and inclusive.

Keywords: education, artificial intelligence, machine learning, intelligent tutoring systems (ITS), Chat-bots, dynamic schedules, automated grading, I-it and I-thou, educational data, learning management systems (LMS), emergency online learning, remote learning, personalized learning

1. Introduction

The COVID-19 pandemic has been the cause of many drastic changes around the world in the past year, and one of the sectors most affected by these changes was education. Students were quickly transferred from face-to-face to online instruction and have had to adapt to new styles of testing, attendance, interaction, and assignments. As a result, many students have spent significant amounts of time interacting with computers and technologies. Artificial intelligence, which will be referred to as AI for the remainder of this article, is one of these technologies that has attempted to maintain and support the educational infrastructure during this time. Furthermore, this increasing reliance on technology has caused AI to become integrated in almost all of the educational applications, from learning management systems to chat-bots. With online learning becoming the new normal and AI having an increased role in this reality, it is important to analyze the current systems in place and the educational and economic contributions it brings.

2. AI and machine learning in education

Before delving into the potential of AI in education, it is important to develop a basic and fundamental understanding of AI and machine learning. However, because it is such an interdisciplinary field, definitions range from a multitude of disciplines such as neuroscience, psychology, economics, mathematics, linguistics, biology, and more. For one to be able to describe AI within the education sector, they must first rely on a concept within AI called machine learning (Luckin R. et al., 2016). Machine learning refers to the way certain computer programs and algorithms can learn from given data and analyze and learn the patterns within the given data. For this paper, AI will be described as “[The automation of] activities

that we associate with human thinking, activities, such as decision-making, problem-solving, learning …" (Bellman, 1978). This idea centers around creating a computer system that can learn and make rational decisions independently, and thus mimic human intelligence and reasoning.

The handwritten digit recognition problem is a classic case of machine learning which can help describe these concepts. This problem has an important role in automating the process of reading handwritten documents such as bank checks. A machine learning algorithm's first job is to learn to read. This can be done by feeding the algorithm a dataset. For example, the United States National Institute of Science and Technology (NIST) has a database of digits that can be used to train and test an algorithm (Grother P. J., 1995). These algorithms will typically use a form of a neural network, a computer system of virtual nodes which simulates neurons in a brain, to read and classify the digits based on their pixel values. Certain features like the location of the pixels, number of loops, etc. are identified by the algorithm, which is then used to make a guess. Weight values in the nodes of the neural network are adjusted based on whether this guess was correct or not, thus allowing the algorithm to learn and improve as it reads more digits. An example of an error rate recorded by a machine learning algorithm in the handwritten digit problem is 0.56%. As a comparison, humans are estimated to have an error rate ranging from 0.2% to 2.5%.

Figure 1. NIST Handwritten Digits (Grother P. J., 1995)

2.1 Benefits of AI

Artificial intelligence (AI) has already made a profound impact across various industries, but the events of COVID-19 have helped propel its influence even further, especially in the education sector. A recent report from 2020 shows that AI investments in education totaled $295.4 million — still far less than investments made in AI in industries like banking, retail, healthcare, and telecommunication, which averaged more than $2 billion each. (Soohoo S., 2020). However, the forced migration of education from in-person to online as a result of COVID-19 created an unprecedented demand for automated educational systems. As a result, students gained a more personalized learning experience as deadlines became more relaxed, problems allowed for more trial and error, grading

became more fair as human error and judgment was removed from the system, and learning could occur at the student's pace as they could search and revisit class material at any time. More advanced systems could analyze graded material like quizzes in order to detect certain knowledge gaps of a student (Lynch, 2020). Coursera, an educational tech company, is an example of the increased investment and growth in this industry in the past year, as the public company opened to the markets in early 2021 with a market cap of $5.9 billion USD (León 2021). This article will expand upon specific AI systems and their benefits that have helped to generate this increased investment.

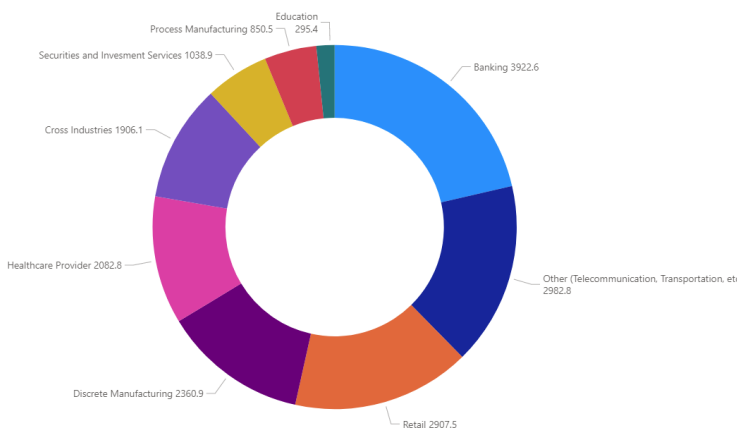

Figure 2. Worldwide Cognitive / AI Spending by industry. (Soohoo S., 2020)

2.2 Personalized learning

One advantage of using AI in education is its potential to personalize learning. With the help of AI, class curriculum can be uniquely modeled and distributed to each student based on their strengths and weaknesses, making the learning process more efficient and flexible. Moreover, students can quickly

skim through material they are already familiar with, allowing them to spend more time focusing on new or challenging material. Thus, rather than having to follow the class, each student can learn at their own pace. This revolution of increased individualism in education is a message conveyed by the Organization for Economic Co-operation and Development (OECD) in order to improve the industry, and AI is a fundamental tool to help reach this goal (Lynch, 2020).

2.3 Intelligent tutoring systems

An Intelligent Tutoring System (ITS) is a type of modern AI tool that helps to achieve the goal of personalized education. An ITS helps students learn by providing step-by-step tutorials that guide them through their course content. The ITS is able to adapt its teaching method to individual student needs by creating a understanding of the student's general grasp of the material. It is also responsive to the student by analyzing the student's performance and providing guidance and feedback when necessary (Holmes et al. 2019). One of the challenges of an ITS is that it must determine when to provide guidance and how much guidance to provide, as giving no help or too much help can impact how much the student learns.

There are three primary approaches to ITS: the domain model, the pedagogical model, and the learner model. The domain model is the simplest of the three, as it only contains knowledge of the learning material. As a result, there is no personalization in this approach as the system can only provide learning material based on what it knows. The pedagogical model expands on this model by acquiring personal data about the student, allowing it to provide hints and tips to the student while learning. It can also determine what and when the student needs to review certain concepts. The learner model tracks the students' performance, adjusting curriculum and lessons based on properties like grades and emotional states (Holmes et al. 2019). This type of ITS is built off neural

networks, allowing them to improve at providing a better learning experience by identifying patterns in the student's learning ability, something that would be hard, if not impossible, for humans to identify. As a result, ITS helps simulate a one-on-one tutoring experience, an effective teaching method that is not feasible in an in-person classroom environment.

2.4 Exploratory learning environment

Exploratory Learning Environments (ELE) are another application of AI in education. ELEs function by providing the student with hands-on experiences that teach broader concepts rather than just telling and describing it, and uses artificial intelligence to . While this method is less structured, it provides a more student participation in the teaching method (Holmes et al. 2018). Overall, ELEs trade some control and structure in their teaching process for a more self-centered, interactive learning experience.

2.5 Chatbots

While ITS and ELE's focus on the content delivery of the knowledge, AI chatbots assist with the interactive classroom elements. Virtual assistants have risen to prominence in other industries via phone systems and websites that offer basic customer support, and these technologies have recently garnered interest in education as well. For example, The Common App, a college admissions website, provides a chatbot named Oli which guides students through the admissions process (Sandoval 2018). Resources like this have helped significantly during the pandemic, when students lack access to in-person college admissions guidance. Chatbots can also assist students by providing them with administrative guidance in a class such as test details, due dates, grades, etc. (Sandoval 2018).

2.6 Administrative benefits

AI and machine learning can provide positive benefits for teachers as well, aiding them in administrative tasks. The handwritten recognition problem mentioned in the beginning of the paper is an example of an AI tool that can help teachers with paperwork. Many teachers are buried under paperwork, which causes a decrease in their effectiveness while teaching in class. Due to this problem, about substantial number of teachers are not inspirational. Artificial intelligence can help alleviate the time spent in these time-consuming tasks, allowing them to dedicate more of their time towards the student and class. Research from McKinsey and Company gives a breakdown of the main tasks teachers perform during work. The data indicates that 51% of teacher working hours are not going towards direct student interaction but rather towards preparation, administration, and evaluation, all of which are activities that AI programs can perform. Giving teachers more time to interact with students can help with one of the primary challenges with online learning.

2.7. Student interaction

It is a common assumption that the richest learning experiences are provided by one-on-one, in-person teaching, but recent university research has offered surprising proof to the contrary. Televised course content was one of the first forms of remote learning to challenge these conceptions. Critics warned that such systems would not be able to retain students' retention, attention, focus, participation, engagement, and involvement. But the research conveyed a different message — that retention and learning through televised content was more effective than through printed material, though more mental effort was required in the latter (Beentjes 1993).

Similar concerns regarding student retention have been voiced during the transition to online learning. As a result, two universities developed different AI programs to help measure a student's involvement in an online. The first method involved tracking students' mouse clicks and movements to measure their attention or distractedness. Researchers at the School of Computer Engineering and Science at Shanghai University used algorithms and programs to collect the data from an online learning system called Virtual Learning Environment (VLE) (Hussain M. et al., 2018). After collecting the data, they were able to create a machine learning algorithm that could put these data points into different patterns. The collection of the data they acquired were a combination of mouse movements, hoverings over the learning environment, and clicks on buttons in the website. After intensive sessions of training of the machine learning algorithm, the AI was able to create predictive models which they used and tested on new data to improve the quality of the predictions that the AI made (Hussain M. et al., 2018). The researchers at the university were able to correlate the predictions made by the AI to the students' overall success throughout the courses that they were taking.

The second AI-based method for measuring student engagement involved reading students' facial expressions and body language as they participated in course content in order to predict their level of participation in the classroom. Data was collected using cameras that were attached to the students' devices to analyze their engagement through AI. An academic instructor named Vladimir Soloviev from The State University of Novi Pazar created an AI that analyzes the footage from cameras around the institution to provide the university with more information about the time intervals in which students are most focused in their classes. The program he developed was in a cloud feature so that it could be used with a large number of students at the same time. He conducted a multitude

of tests to prove his experiments and was able to perfect his AI algorithm to have 86% accuracy with its predictions. Converting this technology for online education can help to monitor students' interaction through their camera without the need of an instructor.

These studies do not directly fix this issue of students' lack of engagement, attention, retention, focus, involvement, and engagement in a class, but they do provide a means to measure these properties in order to adjust and improve the online educational experience. More studies need to be performed to see if these methods monitor student engagement parameters, and other potential ways to measure a student's engagement. But these two approaches give an indication of AI's potential role as a supplement to instruction rather than a complete replacement of the teacher.

3. Economic effects

The rapid transition to online learning also had economic ramifications, especially for lower income families (Schellekens 2020), thus it is important to consider the economic implications of educational AI and whether it will be a detriment or a benefit. While there is not much data available regarding AI's economic impact on the education sector, research on its impact on other sectors can be used to model and infer an answer to this question. In Japan, AI has already become integral in robots and information systems, and reports show that its inclusion has brought "...increased productivity, enhanced quality, improved working environments, energy savings, and the holding down of increases in labor costs" (Nagao 1986). The same report also mentions plans for computer-aided instruction in early schooling and in universities as a solution for many day-to-day tasks.

One common concern with AI is that these systems will take away jobs and lead to increased unemployment. But AI

automation has caused no particular labor problems in Japan, though, it is stated that the results are mixed and that the potential for the labor-force to decline exists, but the labor problem that AI creates remedies itself because there will be a lot more jobs that are created for AI. The possible labor problem wont exist is supported by the fact that the male labor-force rate is already on a downwards trend in the United States (Furman and Seamans 2019). However, it is important to note that increased investment in AI creates more jobs and products, thus the consensus among researchers is that the impacts of AI on employment are mixed and require further study.

4. Challenges

While machine learning and AI have the potential to address some of the challenges that modern education institutions face, they do come with unique challenges of their own. Peru's Department of Education has enumerated some of these challenges in a report on the issue. The first challenge comes from the public view on AI development. People hesitate to adapt to new things they are not familiar with, and AI can be misunderstood as a force for mechanization and automation as opposed to personalization. Public policies will need to create the right ecosystem for AI that serves sustainable development. The second challenge is to ensure equity for AI in education. Developing countries still struggle to access resources and technology, making it harder for them to fund and sustain an AI education system. Before taking this approach, a basic technological infrastructure must be established. The third challenge is to prepare school staff for AI and machine learning technology. Teachers must learn new digital skills if they are going to use machine learning in a meaningful way, and AI developers need to be able to communicate how school teaching systems work in order for them to be implemented

effectively. The fourth challenge is to create quality data systems. AI programs require the vast collection of data in order for them to adapt and learn in real-time. This leads to the fifth challenge, which regars the ethics and transparency of data collection. AI and machine learning come with ethical concerns regarding access to personal student information, personal data, and data privacy. These five challenges will need to be addressed before any true AI revolution in education can occur.

5. Future steps

Government policies have focused on three R's when it comes to the future educational learning: relief, recovery, and rebuilding. This three R's method has been also been applicable during pandemic as well. The relief stage provides support for poor families by giving them access to necessary technologies like laptops and WiFi to ensure the student can attend online classes. This stage is where many governments are at as the technological gap between rich and poor countries remains vast (Utoikamanu). Closing this gap is the first step government and education institutions need to take in order to provide the infrastructure necessary to allow online education to succeed. The recovery stage focuses on making up for lost time. Many students learned approximately 50 percent of a usual school year curriculum during the 2020-2021 academic year, thus it is important to make up for lost time (citation here). Lastly, in the rebuilding stage, policymakers should take steps to create a new system and infrastructure that can support the online education system in case another pandemic or similar situation were to occur.

6. Conclusion

The unexpected appearance of COVID-19 has caused the education sector to shift online, which has created many challenges for teachers and students alike. However, it also accelerated the development of new tools that can be utilized to make online learning more engaging and more efficient. AI-supported ELEs and ITSs make it possible to improve the education systems around the world and close the existing educational gaps between socioeconomic classes. Both artificial intelligence and machine learning technologies will drastically reduce the amount of time-consuming work that teachers must deal with and allow them to focus more of their time on student interaction. Also, with the help of ITS, students will have the opportunity to get help on topics they are having troubles with without any obstacles. It is crucial that we create the right environment for these technologies and introduce these systems to our education institutions. If we are able to allocate our resources for the improvement of artificial intelligence and machine learning in the education sector, this could result in a massive change to our struggling education systems.

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