

## Education with AI & Machine Learning in a Post-Pandemic World

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### Abstract

The shift from the 20th to the 21st century has brought about a multitude of technological developments, particularly in the education sector. However, the recent COVID-19 pandemic has created substantial obstacles for students, not limited to but including economic difficulties, the digital divide, and lack of resources. Nevertheless, the pandemic also allowed for the flourishing of artificial intelligence (AI) & machine learning technologies, which can be utilized to mitigate these issues in education. This paper explores how AI & machine learning have been used to innovate current education institutions — including programs such as Educational Data Mining, Intelligent Tutoring Systems, and Adult Learning Systems among others — as well as the drawbacks to this approach and potential future applications for these technologies. Naturally, as a developing field there are many objections surrounding these technologies due to concerns such as data privacy, loss of soft skills, barriers to implementation, and more. But in spite of this resistance, many AI-driven educational initiatives have thrived. By analyzing past successes and failures, we hope to provide guidance for better employing these technologies in education in the future.

**Keywords:** Artificial intelligence, machine learning, exploratory learning environments, educational data mining, intelligent tutoring systems, adult learning systems



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## Introduction

In order to begin to understand the current state of AI and machine learning, it is important to have a concrete understanding of what these technologies are. Different fields have different definitions for each term, so the lay person can easily become confused. For the sake of clarity and cohesion throughout the article, AI will be defined as “the ability of a computer or computer-controlled robot to perform tasks commonly associated with intelligent beings” (Copeland, 2021). Relatedly, machine learning will be defined as the “discipline concerned with the implementation of computer software that can learn autonomously” (Hosch, 2009). It is crucial to note that these two technologies are not synonyms for each other even though they are commonly used as such. Specifically, machine learning is a subclass of AI: every instance of machine learning can be considered to be AI, however, not every instance of AI uses machine learning. With the increasing significance of these technologies in our everyday society, it is critical to analyze all their benefits, drawbacks, past implementations, and potential future applications for education.

### 1. Benefits of implementation of Machine Learning in Education

There has been a growing interest in finding alternative teaching and learning methods for schools and students in the last few years, which has resulted in a boom in popularity in services such as exploratory learning environments, educational data mining, intelligent tutoring systems, and adult learning services. Machine learning has allowed for teachers and learning institutions to better help individual students by personalizing learning to each student’s unique needs. When one-on-one attention from an instructor isn’t feasible, AI tools can nonetheless provide the benefits of personalized learning via algorithms that tailor coursework to each student’s individual progress and learning style (Bisen, Arslan, et al., 2021). The insights provided by machine learning technologies can help teachers optimize learning through not spending too much time on subjects that students already feel confident in. These services have risen in popularity because of their ability to cater to both teachers’ and student’s specific needs thanks to machine learning.

#### 1.1 Exploratory Learning Environments

Exploratory learning environments (ELE) are a form of AI that can help students learn more effectively. Instead of feeding them information, the AI instead encourages discovery by making lessons unstructured (Amershi & Conati, 2006). This can help a student engage in a deeper understanding of the lesson instead of just memorizing information that is given to them. However, it has proven difficult in the past to include exploratory learning environments in the classroom. It was difficult to include them because there was no way for the program to access prior knowledge on student learning styles. In order to combat this problem, the ELE will focus on getting data on the student, and then will start to aid the student while in class (Lallé & Conati, 2021). This is the new framework that is being applied in Massive Open Online Courses (MOOCs). It is currently being used successfully in many universities.

## 1.2 Education Data Mining

According to the SAS Institute, “[d]ata mining is the process of finding anomalies, patterns and correlations within large data sets to predict outcomes.” Educational data mining (EDM) is similar to data mining in that it uses data to predict outcomes, but instead it is implemented in education. By implementing data mining into education, schools can find patterns about a student’s past classes and determine how to address problems. For example, using data mining, schools could see if a student had struggled in certain classes in the past, or even specific areas in classes, and give them additional resources. Additionally, EDM also helps educators predict student knowledge levels, potential dropout rates, and make guesses regarding their motivational needs. Schools can study the patterns of previous student outcomes and compare them to current students in order to find a correlation that helps them address the students who are struggling. EDM can also help schools determine which classes they should give students according to their strengths. By looking at a student’s history with certain subjects, schools can make sure students who are proficient in certain subjects don’t have to waste their time in classes that they don’t need in order to succeed in more advanced ones.

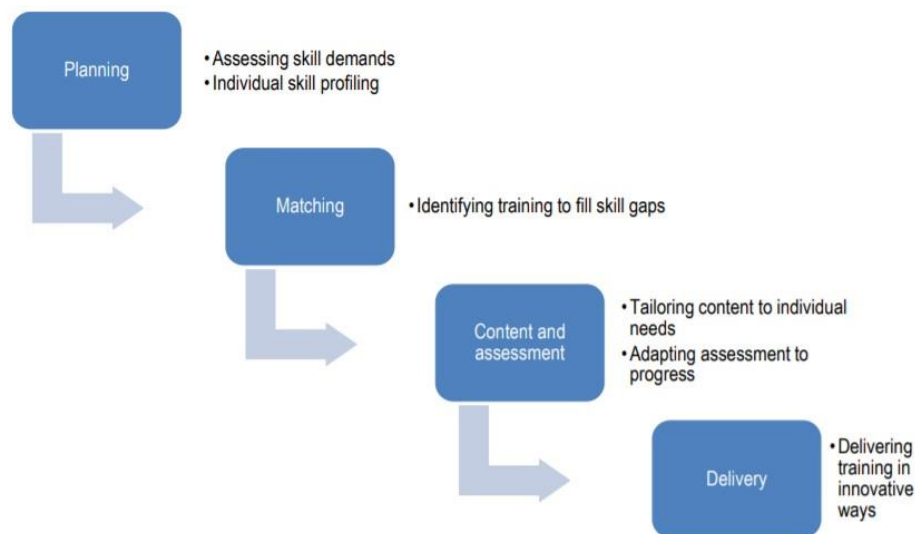
## 1.3 Intelligent Tutoring Systems

Intelligent Tutoring Systems are another form in which AI can be implemented in education. A teacher can only do so much and has many students to focus on in helping catch up. In addition, students learn in many forms and in different ways. Teachers often use a singular strategy when teaching students how to solve certain problems, however, as stated before, students learn in many ways (Artificial Intelligence and Adult Learning, 2020). These kinds of issues can be solved with Intelligent Tutoring Systems. An Intelligent Tutoring System (ITS) is a type of modern AI tool that provides students with adaptive tutorials to guide them through their course content. By analyzing and responding to trends in each student’s performance, the ITS can simulate the experience of one-on-one tutoring (Bisen, Nalcaci, et al, 2021). As Southern Oregon University points out, the primary purpose of an ITS is to “go beyond simply identifying whether a response is correct or incorrect. Rather, the goal is to learn and recognize why a particular response is incorrect and provide guidance as to how to arrive at the correct response” (Artificial Intelligence and Adult Learning, 2020). With their implementation in classrooms, students will ultimately be able to learn why their approach went wrong and be guided to fix those mistakes. This technology is envisioned to work with the teacher rather than be completely apart from them. According to Carnegie Mellon University, teachers would be able to input “their own preferences on how addition is taught, or which form of notation to use in chemistry” as well as enabling them “to create the homework assignments they prefer for the AI author” (Spice, 2020). Ultimately, bringing this technology into the classroom will create a more efficient environment for the teacher and the student by getting rid of redundant tasks and allowing for personalized teaching.

## 1.4 Adult Learning Systems

Another successful method for implementing AI is within an Adult Learning System (ALS). According to the Organization for Economic Co-operation and Development, “the way we work is changing rapidly, and yet only four in ten adults across the OECD participate in education and training in any given year, and these numbers are even lower for vulnerable groups on the labour market” (Verhagen, 2021). ALSs help prepare individuals for this

changing workforce with personalized training. Even in an environment centered around vocational learning, the implementation of AI is highly beneficial as it can personalize education which saves time and money for all of those involved (Verhagen, 2021). In an interview by the European commission with Dr. Topi Litmanen, Chief Educational Scientist of education start-up Claned, he states that in adult learning “[y]ou need to personalize the delivery, which is exactly what AI can achieve” (Artificial Intelligence and Adult Learning, 2020). The current method of implementing AI in ALS involves the steps of planning, matching, content and assessment, and delivery, as seen in Figure 1. This is pivotal as it exhibits that a similar process can be carried out in a multitude of environments, emphasizing just how broad of a reach AI can have when used correctly.



**Figure 1 (Verhagen, 2021)**

## **2. Drawbacks of using AI & Machine Learning**

Although AI and machine learning are meant to be near perfect when doing their designated tasks, there are some things that can still be improved. As with most new technologies, the integration of AI’s potential into educational institutions has been less than perfect. Some early concerns have involved issues of data privacy and ethics, how to assure that both students and teachers are properly prepared for the implementation of AI and machine learning, and the biggest hurdle of all, the monetary cost of it all. Thankfully, we already have some real-world examples of these drawbacks that suggest how future applications of AI and machine learning in education might be improved.

### **2.1 Data Privacy, Security, and Ethics**

A drawback to AI & machine learning that we can’t ignore is the collection of data. Though data collection can bring many benefits, many people are justifiably concerned that their data could be stolen and sold to other companies via these technologies. This may make students hesitant to embrace AI & machine learning in their lessons. Schools are going to have to invest resources into protecting this data not only to keep companies from getting a hold of

this data and using it for their advantage, but also to create the perception that AI is safe to use. This could be accomplished by hiring experts to fortify this data, but this increases the cost of AI and could make it prohibitive. These experts work in cybersecurity and according to WGU have a base median salary of \$103,000 per year (Cybersecurity Salary: Where Can You Go? (2021 Update), 2021). Schools will have to protect this data well if they want students to accept AI & machine learning implemented which means that they are going to have to hire somebody for cybersecurity.

## 2.2 Loss of Soft Skills

Another big fear when it comes to implementing AI into the classroom is the potential loss/inability to teach soft skills. Much of what is learned in a classroom is not the course content itself but the attendant social and interpersonal “soft” skills that students gain from the social experience of the classroom and that are so important in the workplace (Yildirim & Celepcikay, 2021). Skills such as communication, creativity, teamwork, and inclusivity are often not directly part of the course content, but they are still essential goals for teachers and a crucial part of the learning experience. Although it is perfectly reasonable to be hesitant to add AI into workspaces because of the fear of losing soft skills, ultimately, the simplest solution to this is to not completely replace everything with AI so that people still get to interact with each other and develop their soft skills properly. The classroom community is, after all, an important accountability mechanism that encourages skills such as time-management and group cooperation (Yildirim & Celepcikay, 2021). In order to protect the social space of the classroom in which essential soft skills can be acquired, AI-based educational technologies will need to strike a balance between the value of personalized teaching and the need for cohesion and classroom community.

## 2.3 Barriers to Introduction of AI & Machine Learning

According to researchers at MIT, there are four main barriers that prohibit the widespread adoption of AI: missing and disparate data, complexity challenges, time and energy limitations, and a skills gap (Fu, 2018). Data is being collected every day, so the amount of data available is not the issue. However, the integration of this data is very difficult due to the variety of available storage formats.

When looking at the complexity challenges, making AI “smarter” poses a challenge to humans. Deep learning involves creating complex “hierarchical representations” from simple inputs. The information starts simple, but the AI combines that information with something much more complex and it creates a loop in which it ultimately becomes smarter. This complexity leads to harder “optimization algorithms” (Fu, 2018). “It becomes so hard that data scientists can’t explain how they work. AI can provide the answer but is not able to provide the way it obtained that answer” (Fu, 2018).

When people think of AI, it is often software that comes to mind, yet they forget that for the software to work, vast amounts of data must be processed and stored in a physical state. AI requires the redesigning of “hardware to support AI, particularly for embedded applications like mobile technologies and drones” (Fu, 2018). In addition, the issues of both physical and digital storage are also of great importance.

One of the biggest issues is the amount of talent available. This technology is slowly starting to be integrated in many businesses and not many people have the skills to understand

and work with AI. Some businesses are taking initiatives to provide training and development to allow them to have people who understand it. Overall, it is a very time and resource consuming endeavor to overcome.

## **2.4 Continually Shifting Requirements to Become an Educator**

Another negative consequence of integrating AI & machine learning into education is that it could require additional new training for teachers. Without this training, teachers would not be able to use AI & machine learning to its full extent. Additionally, adding more requirements for teachers could place undue burdens on an already exhausted group. New training could cost a lot more resources and time from teachers that could be spent learning other skills that could help students. If teachers can look around this, however, they can use these tools and make them work in favor of them as mentioned in section one.

## **2.5 Potential Sabotage**

One promising chatbox that utilized AI technology was Microsoft Tay, released in 2016. According to the IEEE Spectrum, the purpose of Tay was to serve as an “experiment in ‘conversational understanding’” (Schwartz, 2021,). However, less than twenty-four hours after its release, Tay was taken offline due to “racist, sexist, and anti-Semitic language” (Wolf et al., 2017). The Tay experiment demonstrates the risk of communication-based technologies that use AI to learn from broad data sets. Something similar happened to Google Photos, which in 2015 became infamous for using racist language in its photo labelling (Dougherty, 2015). It is important to analyze the connection between the two cases due to its demonstration that AI technologies which communicate with the public generally have major flaws that can be exploited due to their nature (Wolf et al., 2017). This could have disastrous effects for students in a learning environment. If certain individuals with malicious intent try to feed the chatbox harmful information, then it could have unpleasant interactions with other students, potentially heavily harming their psychological state.

## **3. How AI & Machine Learning Have Been Implemented**

In recent years, AI & Machine Learning have made a significant impact on many aspects of our world, particularly the education sector. Several new websites have arisen which utilize these technologies to personalize a student’s learning, such as Aleks, Noredink, and SchoolLinks. Similarly, countries like China have seen great success when increasing their use of these technologies. Other applications involve using AI to maintain the integrity of the learning environment by flagging suspicious users in online classrooms. Overall, several past implementations of these mechanics have had a bountiful number of positive impacts resulting in an increased quality of learning.

### **3.1 Aleks**

Aleks is a website that helps students learn over 50 subjects related to math or science by using artificial intelligence to select and sequence appropriately challenging assignments for the students. Before starting with a topic, students are given a quick lesson, which Aleks AI uses to detect where the student may be struggling. If the lesson is proving too difficult, the AI can redirect students to something more appropriate to their level of understanding. Once a student has mastered the topic, the AI will move on to a different topic and automatically

incorporate the new information into a periodic assessment. This means that the program won't give students a topic that is too difficult for them to understand. By giving the students topics that they are ready to learn, they help increase "confidence and learning momentum" (Take a Tour - Introduction, n.d.).

### **3.2 NoRedInk**

NoRedInk is a popular website used by schools to help students get a better grasp on grammar. Whenever a teacher assigns a certain topic on NoRedInk, students always have the option to either go slowly by reading the lessons and taking the assessments one at a time or, if they are confident on their skills, they can skip the lessons and their respective assessments and take the final assessment to save time. When it comes to the lesson assessments, NoRedInk uses "[adaptive] technology... to adjust questions based on what students get right or wrong..." (About Our Product, n.d.). What NoRedInk calls "adaptive technology" is just another name for artificial intelligence. The AI that they use helps students genuinely understand grammar rules by not wasting their time on what they already know and focusing instead on where they need the most practice. If a student grows frustrated and gets stuck on a certain lesson, NoRedInk can inform teachers who can provide more assistance and alternate explanations to the student. NoRedInk is not supposed to replace teachers, it is a service that helps teachers find the strengths and weaknesses of their students so that they don't waste time going over things that their students are already confident on.

### **3.3 SchoolLinks**

A pivotal moment in each student's career is the college admissions process. As such, various groups are constantly searching for ways to innovate this sector. One company, SchoolLinks, has designed a College & Career Readiness software that has AI capabilities, including both a planned algorithm and a decision tree (SchoolLinks, Inc., n.d.). Based on this user input, SchoolLinks software is able to recommend colleges that it has determined would be a good match for each unique student, financial aid opportunities that could better serve them, and even possible jobs they could be well-suited for. So far, the technology has been a success. The Katy Independent School District, Naperville Community Unit School District 203, Dallas Independent School District, Norman Public Schools, and many others have incorporated it into their student resources (Industry Partners & Community Building, n.d.). Based on its continued use since 2015 when it was first founded, this appears to be a highly successful instance of AI powered software benefiting the education sector.

### **3.4 China**

One of the biggest implementations of AI in education comes from China. According to CEMAS, Centre for Euro-Mediterranean and African Studies, AI has become widespread due to the massive economic opportunities that it can provide (Islam, n.d.). A project undertaken by PricewaterhouseCoopers estimated that AI technologies would "increase global GDP by \$15.7 trillion, a full 14%, by 2030," including \$7 trillion dollars in China alone (Islam, n.d.). This is because China "has set a national goal of investing \$150 billion in AI" (Islam, n.d.). Of this investment, a major portion goes into education as the creation of "educational tools that require basic automation technology...and through the introduction of adaptive learning systems" (Liu & Carter, 2020). One example of such tools is VIPKid, which pairs students with teachers in accordance to the student's learning skills and knowledge (Liu & Carter, 2020). Another example is 17 Education & Technology, or 17zuoye, which uses AI

technology to grade homework and tests (Liu & Carter, 2020). One of the most relevant examples is Squirrel AI. During the COVID-19 pandemic many classes went online, and students found this transition to remote learning difficult. Squirrel AI “combines physical and digital schooling...through a combination of a human coach and virtual AI tutors” and it creates a “personalized lesson plan tailored to learning needs and gaps in their knowledge” (Liu & Carter, 2020). By transforming the current field delivery models of education, China’s investments in AI technology ultimately put them on track to have one of the biggest economies in the future.

### **3.5 Twitch.tv**

AI could also be used to keep online classrooms safe whenever learning must happen remotely. During virtual learning, there were several instances of people intentionally disrupting or trolling online classrooms. These strangers would get an invite from somebody in the classroom and join the virtual meeting by changing their name to a student’s name to gain access. Once they got admitted, not only could they become disruptive, they would also get the student, whose name they used, in trouble. Nothing could really be done about this other than kicking and muting the person who disrupted the class; however, AI has been used by other online video platforms to solve similar problems. Twitch.tv is not part of the education sector, but they provide an excellent example of using machine learning to keep their environment safe. According to the BBC, “the new suspicious-user detection system is ‘powered by machine learning’ and uses ‘a number of account signals’ to detect ban evaders, Twitch said” (Twitch Unleashes AI Tool to Spot Banned Users, 2021). Once these people were detected, they would immediately be notified to the streamer or moderators. We can compare this to virtual learning and implement this to virtual learning to keep our classroom environment secure.

## **4. How to Ease Implementation of AI & Machine Learning in the Learning Sector**

By observing some early trends in the increased use of AI & Machine learning in the learning sector, we are able to observe in order to attain a better understanding of how to more effectively implement these technologies in the future. To make this analysis, it’s imperative to first understand what specific ways in which the pandemic aided the growth of these technologies. Adequate funding is also crucial for these technologies to be effectively used in the education sector. Due to various sectors vying for funding, there hasn’t been a sufficient allocation of resources for these technologies; however, if the trend of increased funding continues as seen in countries such as China, the impacts of this technology would be much more potent. Lastly, it is crucial that the use of these innovations augments the role of teachers rather than serving as an alternative to them.

### **4.1 How the Pandemic Has Allowed AI & Machine Learning to Flourish**

The increasing presence of AI & machine learning technologies in education has come into “sharper focus during the current pandemic, which has accelerated the shift to remote learning” (Encryption for SIP/H.323 – Zoom Support, 2021). Remote learning has given AI and machine learning more opportunities to be used and as a result, put both their potential and pitfalls more clearly on display. During the pandemic, teachers had a hard time reaching out to their students and providing them with effective learning resources. Some were able to



turn to AI and machine learning for help. AI tools have proven to be useful for measuring student engagement and learning, especially in the online environments that are so difficult for teachers to manage (Yildirim et al., 2021). Because learning had to shift online during the pandemic, our increasing reliance on technology, particularly in the field of education, has only accelerated. This has resulted in a large and growing amount of personal data that has the potential to be valuable for learning.

This transition to online learning has also underscored the need for data security, especially when dealing with information as sensitive as student learning. There has been “a growth in public concern at the ways that personal data is used, and misused. This is reflected in legislation over many jurisdictions, notable the EU for broad uses of personal data and, FERPA in the case of education” (Roll et al., 2021). Data protection became a new priority for many apps and websites during the pandemic. For example, Zoom made sure to have their zoom sessions encrypted to help ease the public's concern on “shared content” within the zoom meeting.

#### **4.2 Re-allocation of Resources**

During both in-person and virtual learning, it is crucial to ensure that teachers can spend the majority of their time helping students learn instead of managing tedious tasks. However, when looking at a breakdown of the time that teachers spend on tasks it becomes clear that much of their time is not being used adequately. In a study based in the US, UK, Canada, and Singapore, researchers found that during a 50-hour work week, teachers spent on average only 49% of their time interacting with the students (Bryant et al., 2020). The researchers then went on to conclude that AI could be used to help reduce the number of redundant tasks educators must perform, freeing up their time and, in the process, potentially allowing for greater personalization in learning. This is corroborated by a report from the International Finance Corporation which states that “AI can improve online tutoring, help teachers automate routine tasks such as grading, and fill gaps in their curricula, and can give students immediate feedback to help them better understand concepts at their own pace and with a greater degree of individualization.” Machine learning is similarly useful and can be fruitful in personalizing learning. In 2017 about 5% of China’s AI investments were in education, and this percentage is trending upwards (Mou, n.d.). If China were to continue this initiative, then the quality of its education would similarly increase. This success of this trend could be followed by other countries which would overall lead to a much more effective use of AI and machine learning in the education sector.

#### **4.3 Ensure it Heightens the Abilities of Teachers Instead of Replacing Them**

Some people fear that AI will someday become so smart that it will be able to replace human workers, even teachers. However, the Institute of Education Sciences reassures us that this is highly unlikely. Adaptive learning programs, which are basically a subset of AI, “do not understand the wide range of the all-important pedagogical contexts” (Kolchenko, 2018). In other words, they do not understand how to solve the issues of students who have not had a good learning experience. This issue is beyond the understanding of AI, since it has no way of registering or understanding complex body language. Although AI works as an adaptive learning program, teachers already are one. Teachers introduce new ways of learning and students adapt to it. Furthermore, teachers understand the “non-verbal clues in the classroom, such as facial expressions, posture, movement, immediate reactions, and interactions” that

allow the teacher to adjust their teaching methods that will benefit the entire class (Kolchenko, 2018). In the end, AI and machine learning systems are going to have a hard time understanding issues beyond algorithmic ones (Kolchenko, 2018). Instead of fearing of this technology taking over, educators should embrace it to make small tasks more efficient such as grading and creating questions for tests.

## **Conclusion**

As a result of the sudden shifts in education brought about by the pandemic, AI & machine learning have gained a much larger hold on the education sector. The benefits of these technologies can be seen in the implementation of Exploratory Learning Environments, Educational Data Mining, Intelligent Tutoring Systems, and Adult Learning Systems. But as these technologies continue to develop, the potential drawbacks become clearer as well, such as the safety issues that come with collecting a vast amount of user data, loss of soft skills, barriers to implementation, shifting factors within this sector. Some of these criticisms have been on dramatic display in failures such as Microsoft Tay. But there are many more instances in which AI technology has been utilized effectively, such as Aleks, Noredink, SchoolLinks, Twitch.tv, and even countries such as China which have recently been increasing their investments in this industry.

As we near a point where the disruptions of COVID-19 in education will either become standard practice or be left behind in a return to normalcy, it is worth taking time to reflect on both the limitations and opportunities of virtual learning, including the possibility that it creates for implementing AI technology in the classroom. Using this technology properly has the potential to further revolutionize the learning industry around the globe.

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