

Reimagining Education with Artificial Intelligence

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Abstract

Artificial intelligence (AI) technologies have been implemented successfully in many industries, from virtual hospital assistants to algorithm-based warehouse processing. And now that Covid-19 has forced students and teachers to transition to online or hybrid learning, these technologies could offer new and exciting possibilities for education as well. By incorporating AI and machine learning tools into online classrooms, educators can address many of the challenges that have emerged with the recent loss of face-to-face instruction, including the struggle for students to self-regulate their learning, the burden of curriculum planning and administrative work for teachers, and the loss of personalized interaction between students and teachers. This chapter will explore some of the AI technologies that have been used in educational contexts and describe applications of AI in other industries that could be adapted to create more personalized, flexible, inclusive, and engaging learning experiences. If the future of education is going to include online learning as a substantial component, then AI could be the key to maintaining high levels of motivation and engagement from students and teachers alike.

Keywords: artificial intelligence, machine learning, higher education, intelligent tutoring system, natural language processing, student engagement, administrative tasks, virtual assistants



1. Introduction

It is estimated that the average American looks at a screen two hours every day around the nation, and this number only increased with the Covid lockdowns (Wong et al., 2021). This increase can be attributed to the shift online of many aspects of our lives, from education to business. And with this shift comes increased data collection capabilities, which has opened the way for artificial intelligence (AI) and machine learning technologies to penetrate our everyday lives. Nick Bostrom, a leading artificial intelligence expert from Oxford University, has said in an interview with CNN that “[a] lot of cutting-edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it is not labeled AI anymore” (CNN 2006). Although many of these applications have integrated AI concepts, the fact often goes unnoticed in day-to-day life.

Because AI is an interdisciplinary field it is not easy to give it a description. Philosophy, mathematics, economics, neuroscience, psychology, linguistics, and biology all have their own definitions and perspectives on AI, but in order to define AI in the field of computer science, it is important to first explain the concept of machine learning (Luckin et al., 2016). Machine learning systems are computer systems that can analyze and learn from previous data and make predictions. For the purposes of this paper, AI will be defined as a field of computer science that specializes in creating computer systems that are designed to interact with the world and can mimic and operate as human beings by utilizing machine learning. Because our lives have started transitioning online, there has been increased spending and investment in the technology sector. Unfortunately, very few of these investments go toward education. As shown in Figure 1, artificial intelligence spending in the education sector is low compared to many other industries. However, with more non-profit artificial intelligence research companies like the OpenAI and The Future Privacy Forum, spending for artificial intelligence in education (AIED) may increase substantially.

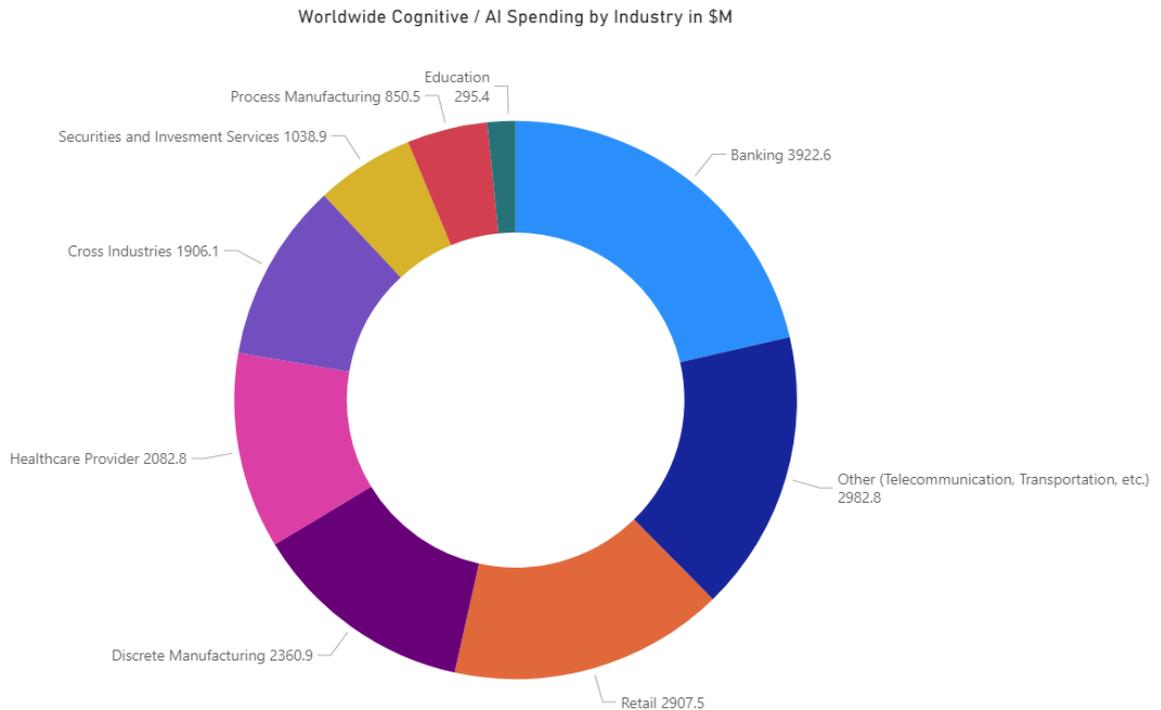


Figure 1. Worldwide Cognitive / AI Spending by industry.

From “Artificial Intelligence Spending Quick Look: U.S. Buying Behavior By Industry, Company Size, and LOB Versus IT” by Soohoo, 2020. Own graph.

1.1 Artificial Intelligence and Machine Learning

Before exploring the concepts and the opportunities that AI offers in the education sector, it is important to thoroughly understand the subsections of both artificial intelligence and machine learning. Artificial intelligence can be classified into three subsections: weak, general, and strong AI. Weak artificial intelligence is usually interchangeable with narrow AI because they imply limited capabilities. A weak AI can only perform the tasks that are given to it and cannot overarch to other actions. General artificial intelligence is an AI that can perform any given intellectual task with the performance and efficiency of humans. Strong artificial intelligence is an intelligence system that can surpass any human intelligence and it can perform any human task better than any human. Weak and narrow AI is the most common AI in today’s world. Some examples of narrow AI are recommendation algorithms on e-commerce websites, self-driving cars, and speech recognition. Constructing any general or super AI would require a huge operation, a prohibitive budget, and significant human power.

There are three types of algorithms that are most common when creating a machine learning system: supervised, unsupervised, and semi-supervised. A supervised algorithm learns from labeled data and is generally used to classify incoming data. The data set that trains this sort of algorithm needs to be manually labeled for the machine learning algorithm to learn. An unsupervised algorithm can look at any given unlabeled data and perform regressions, perhaps to make future predictions. A semi-supervised algorithm can complete the functions of both

supervised and unsupervised algorithms, meaning it uses a small amount of labeled data and a large amount of unlabeled data.

1.2 Benefits of Artificial Intelligence

For students, the transition to an online learning environment brought with it both benefits and drawbacks. It has been especially difficult for educational institutions to transition and meet the needs of their students. Nevertheless, online education delivered a more personalized learning experience for many students with more relaxed deadlines, giving the students the freedom of trial and error without receiving any judgment, and students were able to search and learn the concepts they needed on the spot. By analyzing student data, many schools were able to analyze student progress and even identify knowledge gaps among different groups of students. This transition also enabled companies that were developing artificial intelligence-powered learning platforms to find the marketplace and the consumers that they needed. Online education providers can create and sustain machine learning algorithms that conduct data analysis because it is becoming increasingly easier and cheaper to do so. The improvements that artificial intelligence has provided in our daily lives are immense, and this article only plans to scratch the surface of the benefits that this technological revolution can offer to education through personalized content, automated administrative tasks, and student interaction. These are the areas where artificial intelligence can provide help in education and where current developments are underway (Lynch, 2020).

2. Using Artificial Intelligence to Personalize Education

Perhaps the most important contribution artificial intelligence can make to education is personalization. Using artificial intelligence, student knowledge can be modeled and accounted for when teaching. This makes learning much more efficient and adaptive, as it helps teach students only what they need by recognizing knowledge gaps and understanding their grasp on the subject. Each student's learning preferences are different: some prefer to learn through visuals, some through audio, some through repetition. By customizing the content of every student's curriculum, each student's learning could be optimized to help them in areas where they need it the most. This can eliminate the need for a universal curriculum and students who excel in certain areas can move through these topics faster than their peers. Each student can move at their own pace, making the learning process much more efficient. In these ways, artificial intelligence can fundamentally transform how teaching is done, allowing for a much more adaptable and personalized educational environment. As the Organization for Economic Co-operation and Development (OECD) states, "education needs to start adapting to increasing individualism in societies, and artificial intelligence can help do this" (Lynch, 2020).

2.1 Intelligent Tutoring Systems

One of the primary ways artificial intelligence helps personalize education is through Intelligent Tutoring Systems (ITS). These ITSs help guide students through concepts with step-by-step personalized tutorials. The ITS finds the best way to teach the student using its own knowledge on the subject and pedagogy along with its conception of the student's understanding. Then the ITS responds to how the student performs and gives guidance when it finds it appropriate to do so. The ITS must strike a balance between giving away the answer

to everything and not giving enough help when it is needed, and these systems typically draw from one of the following models in order to make such decisions: the domain model, the pedagogical model, and the learner model. A typical ITS architecture can be found in Figure 2.

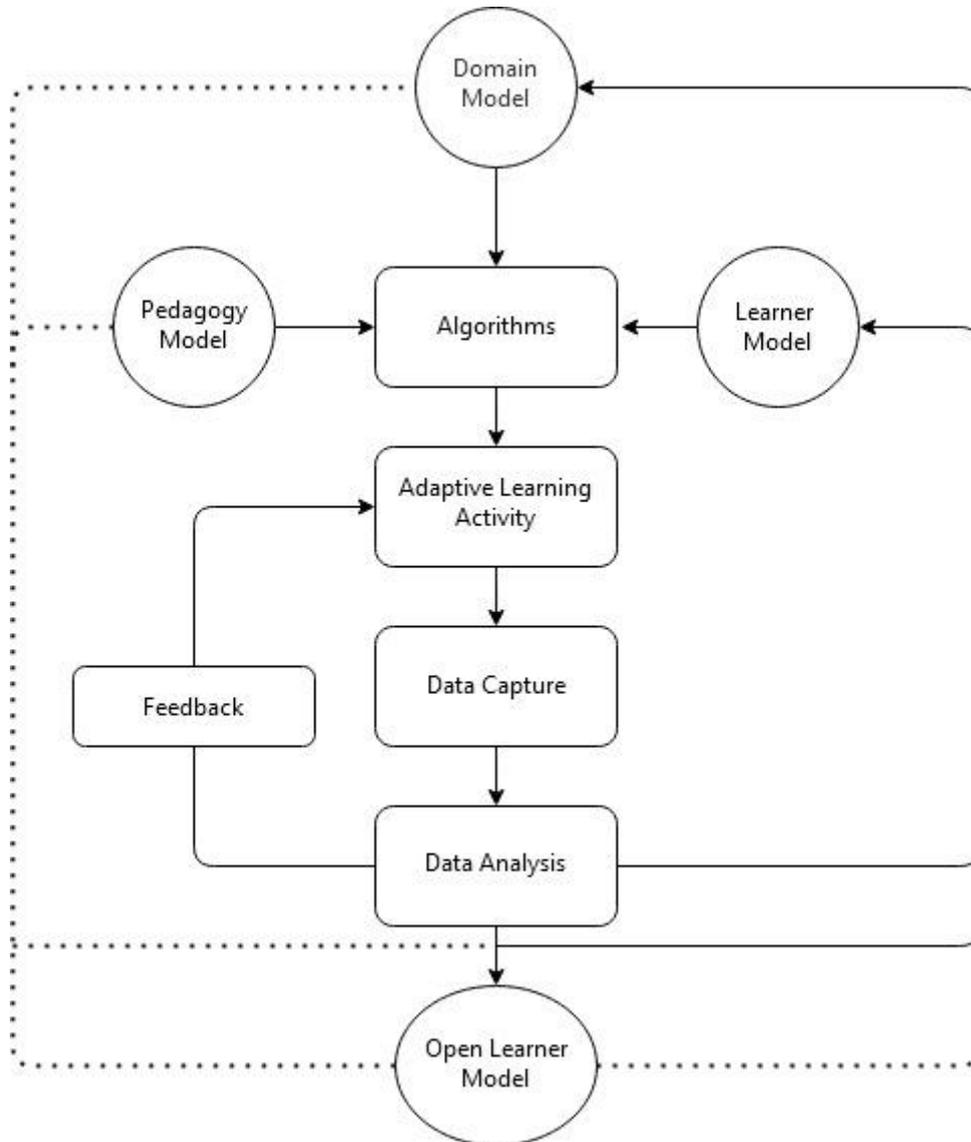


Figure 2. The architecture of a typical Intelligent Tutoring System (ITS)

From “Intelligence Unleashed: An Argument for AI in Education” by Luckin et al., 2016. Own diagram.

The domain model contains the knowledge about the subject being taught. For example, if a mathematics lesson on fractions is being taught, the domain model might include knowledge about the addition and multiplication of fractions. The pedagogical model, on the other hand, represents the most effective approaches to teaching. This model might optimize the best time

to help the student with a hint or to review a certain topic. The learner (or student) model considers what the student understands as well as some of their behavioral qualities. This model will track how well a student performs and what concepts the student might not understand along with their emotional state and previous achievements and difficulties (Holmes et al., 2019). There is also an interface component, which is the medium through which the student interacts with the ITS. When used with neural networks (self-training algorithms), these models can constantly improve, learning from each interaction with every student that uses them and finding the best teaching methods to use in specific instances. This way, the ITS can learn to recognize patterns that might have been impossible for humans to find, leading to a much more effective model for teaching.

These models not only help create adaptive learning environments, but they also provide further insight into the mechanics of learning. By personalizing education, educators can learn more about how students learn and the steps they take during this process (Luckin et al., 2016). For example, these adaptive learning systems could help educators find common misconceptions students have while studying mathematics and help them address these discrepancies.

By modeling learners' cognitive and emotional states, an ITS can adapt its feedback type to maximize a positive affective state, which has been proven to increase learning performance (Grawemeyer et al., 2015). In this way the ITS can learn more about what type of feedback might be most effective in specific circumstances, further individualizing the learning experience. ITSs can also use more meta-cognitive frameworks to approach learning, which helps improve student motivation and willingness to learn (Du Boulay et al., 2007). For instance, the use of narrative framing while teaching could be one approach that boosts student motivation (Luckin et al., 2016). Some ITSs might even take the approach of the Socratic method, having the learner engage in dialogue where they repeatedly ask questions to increase their understanding of the subject, leaving the learning more in the hands of the student than the tutor.

ITSs have the possibility to transform learning and increase the opportunity for more individualized teaching. Education can shift towards a more tutor-based approach, where students rely more on their ITS. One-on-one human tutoring is perhaps the most effective teaching method; however, it is impossible for every student to get this treatment in traditional learning contexts. ITS can bridge this gap and help provide feasible and affordable intelligent tutors for every student. An alternative to ITS, called exploratory learning environments (ELE), can help learners by giving them a much more hands-on approach to learning, leaving the students to learn on their own and guiding the students when needed (Holmes et al., 2018). The student is exposed to and experiences the concept rather than simply being told about it. Because of this, ELE tend to be more unstructured and up to the learners, giving up some control in exchange for a more self-sufficient learning experience for the student. This way a much more student-based approach to learning can be achieved.

In practice, ITSs have been very successful at increasing both student performance and motivation. For example, the Andes Physics Tutoring System is an ITS that helps guide students through their physics homework. As the student solves each problem, the ITS gives feedback, significantly improving student learning (VanLehn et al., 2005). If an ITS that solely helps with homework can increase student performance significantly, it is reasonable to

think that a more sophisticated ITS at the center of an entire course would be even more effective. ITSs might not only help increase student performance, but also reduce learning time, giving students more time to focus on other activities. Another example of a successful ITS is Carnegie Learning's Cognitive Tutor, a mathematics course with textbook resources and an automated cognitive tutor. This ITS focuses on real-world problem solving with mathematics primarily for students aged 13 to 17. Cognitive Tutor has been shown to improve average student performance by about 50% to 60% (Holmes et al., 2018).

2.2 Educational Data Mining

AIED has also helped many schools through educational data mining (EDM). By analyzing data about students and their behavior, data analysts can predict their likelihood of dropping out, among other important factors (Luckin et al., 2016). This type of data mining can also help educators gauge their teaching abilities and test out different teaching methods, since they can analyze the effect these different styles of teaching have on the performance of the students. EDM could also help replace tests and exams as the primary way to assess student knowledge by helping educators track student performance while taking many more factors into consideration (Hill et al., 2014). Through EDM, educators can better understand how a student answers a question and why a student gave a particular answer, rather than whether they got the question right or wrong. This way, students can be assessed as they learn, rather than having to interrupt their education for assessments to take place. These learning analytics can also provide further insights into when students need assistance throughout their education, and reveal more about their successes and challenges, along with their motivation throughout their learning process (Luckin et al., 2016). All these things that the use of EDM unlocks can help not only personalize learning but also provide a better and more motivational environment for students to learn in.

3. Using Artificial Intelligence in Administrative Tasks

The implementation of artificial intelligence in administrative tasks can help educational institutions save great amounts of money. As technology progresses, the implementation of technologies like artificial intelligence becomes cheaper and cheaper. Therefore, it becomes inefficient to pay administrators to do jobs that can be automated by artificial intelligence. Although automation is a concern for many, ultimately, it would have a positive effect for educational institutions, as artificial intelligence can do many of the repetitive administrative tasks required of both teachers and administrators. Because of this, the implementation of artificial intelligence in administrative tasks would ease the workload of teachers and administrators and make it easier for them to focus on what is important. This would also mean that the implementation of artificial intelligence in this area would not be a threat to student-teacher interactions which is an essential aspect of learning. In fact, by easing the workload of teachers and administrators, it could, instead of replacing them, make their roles more student centric.

3.1 Artificial Intelligence for Grading

One of those repetitive administrative tasks, perhaps the most prevalent for teachers, is grading. Grading takes up a great deal of teachers' time. But imagine if teachers did not have to spend hours grading assignments and could instead spend more time interacting with their

students. Moreover, grading by artificial intelligence may actually be more reliable in some cases, as teachers are often subject to unintentional biases. (Murphy, 2019) There could be many benefits to using artificial intelligence instead of teachers to grade assignments, and in fact, many artificial intelligence grading tools already exist for teachers to use. Gradescope, for example, is an online grading tool for higher education that uses artificial intelligence (UMass Lowell, n.d.). With tools like these, the possibility for biased grading can be greatly reduced. Artificial intelligence could also be used to detect plagiarism and cheating, which would provide more appropriate grading, since these cases can be difficult for teachers to detect. Several workshops at the International Conference on Machine Learning investigated the use of artificial intelligence-powered grading systems that could grade computer assignments at a large scale to decrease the workload of higher education teachers and to reduce the need for teaching assistants (True Interaction, n.d.). Although it is unlikely that artificial intelligence will become a replacement for educators anytime soon, the implementation of artificial intelligence does seem to be a promising way to relieve educators from a variety of their administrative burdens.

The first commercial automated essay scoring systems, Intellimetric and e-rater, were commercially available by the early 1990s (Bisen et al., 2021). Intellimetric has many applications in the industry, and many companies and organizations still use it for tasks like screening job applicants and certification testing. These early scoring systems were utilized by educational institutions too. More recently, organizations like EdX and Coursera that provide extensive open online courses for immense amounts of students have also implemented automated essay scoring systems to their courses to grade student writing. Current automated essay scoring systems can not only give an overall holistic writing quality score for student writing, but they can also give feedback, guidance, and even model writing samples to assist students with improving their writing. Some of these current systems are Turnitin's Revision Assistant, Pearson's Write to Learn, the CopyLeaks AI Grader, Grammarly, the Educational Testing Service's Criterion Online Writing Evaluation Service, and Chegg's Writelab. Each of these systems offers a variety of different types of feedback to students (Murphy, 2019). Unfortunately, there have been cases where automated essay scoring systems have produced higher scores than what should have been produced. However, humans are more prone to mistakes than automated essay scoring systems, so it is still a viable option even though they still are not efficient enough to replace good writing teachers who spend their time while grading. Nevertheless, as these technologies advance, they could match or even surpass good writing teachers in efficiency.

3.2 Natural Language Processing

Natural language processing, a field of artificial intelligence, is what makes automated essay scoring systems possible. This field analyzes written language by implementing artificial intelligence techniques like machine learning. If natural language processing continues to become more sophisticated, teachers could conceivably be replaced by artificial teachers. Currently, natural language processing plays a huge role in many different industries. For example, it is used in the medical industry to gain insights into medical records and other text data. Because of natural language processing, a team of researchers in Taiwan were able to help determine which stroke patients needed intravenous thrombolysis (Thomas, 2020). Natural language processing is also used in the pharmaceutical industry, where it can help researchers analyze data from all the stages in the drug development process in more efficient

and useful ways than before. In addition, natural language processing has been used in the interpretation of clinical trials as well. The financial industry also utilizes natural language processing. Financial institutions have to deal with lengthy legal documents daily, and they can use natural language processing to extract the necessary information from those documents and organize the documents according to certain requirements. Furthermore, natural language processing is used similarly in the insurance industry, in which insurance companies also need to deal with large numbers of lengthy documents.

First developed in the 1950s, natural language processing algorithms are used in text-to-speech applications, language translation applications, and even in virtual speech assistants like Apple's Siri. On the other hand, the algorithms of automated essay scoring systems extract parts of a text and learn the patterns between the parts and different writing levels with natural language processing (Murphy, 2019). Different automated essay scoring systems have different input features based on their goals for providing feedback and scoring (Automated Essay Scoring, 2003). These different input features range from linguistic and nonlinguistic surface features like grammatical errors and the number of words to sentence-level and essay-level qualities like the use of passive voice and style respectively. Additionally, while some automated essay scoring systems provide scores holistically, others give scores and feedback based on individual aspects of the text instead. In most cases, training these automated essay scoring systems can require hundreds or even thousands of essays and many hours of labor by expert graders to analyze and grade essays. However, in the end, the time that these systems can save for teachers greatly exceeds the effort put into making them.

3.3 Scheduling

Scheduling is another repetitive administrative task that must be done every year and that could easily be facilitated by AI technology (Bisen et al., 2021). Creating schedules for students is very tedious and, in many cases, very difficult. Especially in smaller schools, finding a way to give every student their preferred classes can be an impossible task. In bigger schools, even though giving students their preferred classes may be less of a problem, the higher abundance of students also creates challenges. There is simply a larger number of schedules to make and giving students their preferred teachers can be a problem as well. But with artificial intelligence, this process could be greatly streamlined and made more satisfactory for everyone. Artificial intelligence can analyze more possibilities for schedules to make sure that more teachers and students are satisfied with their schedules. Many such implementations of artificial intelligence already exist in the industry. For example, ServiceMax, a Field Service Management company, implements artificial intelligence scheduling software to automate their scheduling processes (ServiceMax, n.d.) Moreover, through the use of algorithms that analyze student behavior and student backgrounds, artificial intelligence could be used to match students and teachers based on the data from those algorithms. This could help improve the bonds between students and teachers by creating points of interest or matching personalities. Also, the implementation of artificial intelligence in scheduling can save school administrators a lot of hassle, giving them more time to help their students.

3.4 Virtual Assistants

Artificial intelligence could also help answer non-course-related questions that would normally be directed to administrators. These questions could be about things such as school

events, administration, college application process, and graduation. In addition, artificial intelligence could be used to answer students' course related questions that would normally be directed to teachers. Most large banking companies already implement artificial intelligence in similar ways. For example, HSBC implements an online virtual assistant that is able to answer common queries from customers such as questions about their account details or balance (Thomas, 2020). The implementation of virtual assistants or chatbots like these helps those companies save money by decreasing the need for call centers. Additionally, many companies that have online retail stores have chatbots on their websites too. If educational institutions were to implement virtual assistants or chatbots in similar ways, they too could save money by decreasing the need for large amounts of counselors. They could at least save the counselors' time, allowing them to focus on other important tasks.

One educational organization, The Common App, recently implemented an artificial intelligence chatbot named Oli to help students throughout the college admissions process. This chatbot was introduced due to the decrease in applications in Fall 2020, a time at which Covid-19 was prevalent. This way, they were able to bring college advising to students' homes at a time where it would have been very difficult to do so. Other educational organizations have implemented chatbots too.

Schoolinks, a college and career readiness platform, also implements artificial intelligence in a variety of ways. Its implementation can ease the work for counselors. First of all, they too implement a chatbot to help students with their college applications or career search. Additionally, Schoolinks has career assessments that implement machine learning algorithms (Schoolinks, n.d.). These algorithms help students find careers that fit their personality and courses that fit their interests through the use of artificial intelligence. Schoolinks also uses artificial intelligence to assist students with their college search. By analyzing data about a student's personality obtained through simple tests, Schoolinks can recommend colleges that fit not only the students' merit, but also their personal characteristics. Furthermore, Schoolinks' use of artificial intelligence can benefit students by also providing personalized internship and volunteering opportunities. This platform can benefit school administrators as well by saving them time and bringing them new insights regarding their students.

These virtual assistants could be developed to where they can answer not-so-basic questions that would normally be directed to administrators or even teachers (Bisen et al., 2021). This would allow teachers to focus on their curriculum and teaching and alleviate the stress that comes with having to explain everything about the subject. It would also help make sure all student's questions are answered and teachers/administrators would become the "last resort" for asking questions. This concept would work very well with the previous concept of personalizing education and learning for each student as well. While students work at their own pace, they could ask their questions to a virtual assistant instead of compressing learning into an hour-long class where they have more limited time to think of and ask the questions that they have. On a classroom level, a sufficiently advanced virtual assistant could be a place where students could ask the due date of an assignment, the submission process of a test, details of their next homework, and any other questions about the class itself.

3.5 Tests and Exams

Another important administrative area where artificial intelligence can be of assistance is in the creation of tests and exams (Bisen et al., 2021). This could be as basic as choosing the

difficulty of the next question depending on correct question streaks and the performance of the student or perhaps using a question bank to randomly select the questions in a test to prevent students from cheating. AI systems could make testing more effective and decrease the likelihood of cheating. Artificial intelligence could also be used to detect the similarities between students' exams by looking at variables such as time, word usage, submission date, and so on, to identify the students that may be cheating. By enabling teachers to make more effective tests and to identify inappropriate student behavior, the use of artificial intelligence in this area could greatly improve testing and examinations.

Pymetrics is a platform that implements artificial intelligence to benefit companies from all types of industries. Pymetrics helps companies with things like choosing the fit candidates for a job and matching members into productive groups. Pymetrics assesses a company's job applicants as well as that same company's top performers. Then it analyzes both of their behavior to find which applicants match. Further, by analyzing current employees, Pymetrics can also help restructure a company in a way that the company would work more efficiently and maximize employee potential. These applications of AI could be useful in a classroom as well. Not only could a platform like Pymetrics be used while hiring teachers and administrators for an educational institution, but the form of artificial intelligence used by Pymetrics could be used to make group-work more productive and organize students with complementary skills into classrooms together.

4. Using Artificial Intelligence in Student Engagement and Interaction

For the last two decades, online education has been gaining popularity. But since its inception in the late 1990s, online education has also raised concerns as to how a remote learning system can keep students attentive and focused (O'Brien, 2002; Tinto, 2006; Truluck, 2007). With the Covid-19 pandemic and lockdowns, many educational institutions had to rely upon online programs to continue teaching their students (Kose et al., 2021). It is already difficult to keep students focused in-person, so how can you expect teachers to keep their students focused in online environments? This is another area where artificial intelligence could prove to be incredibly useful.

When it comes to evaluating student participation, involvement, engagement, and overall success in online education, AI provides teachers with multiple options. Recently the School of Computer Engineering and Science at Shanghai University published a research article talking about how they were able to collect data from a Virtual Learning Environment (VLE), an e-learning system, and used machine learning algorithms to measure student engagement and performance (Hussain et al., 2018). This study analyzed the number of clicks on the webpages of the course such as the forums, the glossary, any subpages, the homepage, and course content and conducted multiple experiments using these algorithms. This experiment was able to find that there was correlation between the students' assessment scores and the students that the study found most engaging according to their clicks (Hussain et al. 2018). Therefore, this study was able to show that artificial intelligence could be used to determine which students are engaged in an online environment. This would give teachers valuable information, as it is often difficult for them to know which of their student are most engaged in an online environment. With the help of this AI, teachers could better reach out to the students in class who need more attention and guidance than their peers.

5. Conclusion

Online education is gaining more and more prominence due to the recent shifts in education brought about by Covid-19. With this in mind, artificial intelligence can play a huge role in this advancement in education. While there are some established uses of artificial intelligence in education today, most applications are experimental, and artificial intelligence uses in other industries are starting to cross over as well. Natural language processing, for example, has been used in many industries for a variety of reasons. Now, natural language processing is being used in the education industry with the introduction of chatbots and automatic essay scoring systems. One of the foremost advantages artificial intelligence can bring to education is personalization with the use of programs like Intelligent Tutoring Systems (ITS). Education data mining (EDM) can also help assess student knowledge in a much more meaningful way. This personalization can bring about a more individualized learning experience for each and every student, increasing both their performance and motivation. AI can also help deal with administrative burdens that teachers and administrators have to go through like grading and scheduling. Finally, artificial intelligence provides an opportunity for increasing the engagement of students, developing self-regulatory skills, and increasing interaction between students, their peers, and their teachers. With all of these benefits in mind, the implication of the introduction of artificial intelligence to education is massive and has the possibility to transform the industry.

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