

Artificial Intelligence and Machine Learning Applications in Education

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Abstract

Artificial Intelligence (AI), Data Analytics, and Machine Learning technologies are poised to transform the field of education as we know it. They have already upended industries from retail to manufacturing and now that the coronavirus pandemic has accelerated the shift to online classrooms, with remote teacher-student interaction and remote curriculum test, AI-powered tools are more critical for teachers and students than ever before. AI-powered intelligent tutoring systems, AI chatbots can interact with students to increase engagement of students in studies, and Machine Learning algorithms can analyze student data. Together these provide great opportunities for improving student learning, will help teachers also and will also help in many other aspects of education. This chapter will highlight some of the most interesting real-world applications of AI and Machine Learning and explain the methodology of their implementation, then describe how they can improve student learning and the effectiveness of education systems. This chapter will also discuss the critical challenges that educators and researchers face when applying these technologies in the field of education. Finally, the chapter is concluded with a discussion of the roles AI and Machine Learning can play in post-pandemic education world and of promising technologies that could be significant driving forces for even more AI and Machine Learning applications in education in the future.

Keywords: artificial intelligence, machine learning, data analytics, intelligent tutoring systems, chatbots, learning management systems, algorithms, student modeling, personalized learning, online education, remote learning, technology in education, AI ethics in education



1. Introduction to Artificial Intelligence and Machine Learning

Before the discussion of the applications of AI and Machine Learning in education in details, it is imperative to clearly define and explain what AI and Machine Learning are, highlight the basic concepts and point to the main differences especially since the two terms have been used interchangeably even though they are different concepts.

Artificial Intelligence can be roughly stated as machines trying to understand the behavior patterns of humans and trying to mimic the behaviors such that it can replicate these actions. Artificial Intelligence has come into existence in 1956 with a group of people under John McCarthy and Alan Turing. The concept of AI is to learn from the experience based on a set of internal rules and conditions, which provide responses that are processed using huge amount of data. The purpose of AI is to solve the problems. Artificial intelligence enables computers to think at various stages and is a broad spectrum where it covers Machine Learning and Deep learning. It senses the data, reads, and finds reasons to act as per the situations and adapts to the situation.

Machine Learning came into existence in 1980's where it borrowed the concepts and methods of models that belong to statistics and probability. Machine learning algorithms learn from the data and build models. Model is a system that finds and predicts based on the input parameters given that are used to make decisions and learn from the system. It observes the data and identifies the differences and facilitates its learning. The algorithm trains the model by searching for patterns in the data and then comes up with the result.

Artificial Intelligence (AI), Machine Learning (ML) being used interchangeably in today's computer programming world. These terms overlap and can be easily confused if one doesn't dive deeper into it. Machine learning is the subset of AI, which means all machine learning is counted as AI, but not every AI is machine learning. For example, symbolic logic, expert systems, and knowledge graphs are AI but they are not machine learning. The machine learning algorithms include decision tree, clustering, inductive logic programming, reinforcement learning, etc. The aspect that separates these from being machine learning is they are not dynamic and will not modify itself when exposed to more data. If AI is mimicking human behavior, then Machine Learning is mimicking human learning.

Machine learning is a form of Artificial Intelligence in which algorithms process and interpret data to recognize patterns by comparing the data with preset rules or inputs. The technology depends on earlier data that it uses to identify any new data to classify it or to execute a predetermined output. Thus, it depends on stored instructions in the form of structured or labeled data. In other words, machine learning requires a programmer to define objects or data for it to recognize them and execute the required action. The initial data and commands provide the technology with the ability to compare any new data with it. The initial input of data for future comparison is called training. Machine learning thus requires training for it to recognize similar data in the future to determine what preprogrammed command to execute. The system becomes better with further exposure to data for training and hence improves in its capacity to recognize similar data in the future. The need to define or label data in advance makes machine learning a supervised form of artificial intelligence [25]. There are three main types of machine learning: supervised, unsupervised, and semi-supervised machine learning. A supervised algorithm learns from labeled data and learns how to classify or perform regression on similar data. For this particular algorithm, a specifically labeled training data set

is allotted which is manually allotted. As the algorithm learns from the data, its classification of similar data sets starts to gain more accuracy. On the other hand, an unsupervised machine learning algorithm looks at any given unlabeled data set to find patterns such as clusters. The semi-supervised algorithm is a hybrid of both a supervised and unsupervised algorithm.

2. The Benefits of AI and Machine Learning in Education

Machine Learning, AI, and Data Analytics have been used to maximize students' learning and success. They have been widely applied to track student performances and extract key insights into how these could be improved. These technologies help institutions gain a holistic perspective about their students. Machine Learning and Data Analytics can help teachers identify the learning behaviors of their students, which can lead to improved understanding and better grades for these students. They also allow institutions to accommodate their students' interests and make informed choices that allow them to excel in campus activities.

Before diving into the specific real-world applications of AI and Machine Learning in education and the methodology of their implementation, it is worth taking a moment to summarize what makes these new technologies attractive to educators and students. In a nutshell, AI and Machine Learning could provide substantial benefits to both students and educators in the following areas:

Personalized Learning

AI and Machine Learning, along with data analytics, have the potential to create personalized learning experiences to deal with different challenges. In the past, teachers have noted that "not every student needs the same homework exercise," but it would be absurd to ask a human instructor to tailor each assignment to the various needs of their different students [2]. Some students might find a particular subject easy while the others might have some doubts or difficulty in that subject. This is why the assignment or homework needs to be personalized for each student but it is difficult to do so each time. However, this level of personalization could easily become possible with AI. This approach if brought to implementation will allow each student to enjoy a curriculum and content uniquely tailored to their needs and could improve the motivation and engagement of students in studies. Additionally, such an approach could help teachers to understand the learning styles of each student and help them accordingly.

Smarter Grading

AI and Machine Learning can help in grading work. They have the potential and capability to help in grading work.

Career Suggestions for High School Students

Another promising application for AI & Machine Learning in the education sector could be providing career suggestions for high school students [7]. Intelligent AI-based recommendation systems could collect information of different parameters related to the students' like their academic records, the standardized scores on tests, career dreams, etc. and offer recommendations based on this data.

Student Engagement in Studies

AI tools that monitor student engagement in studies could be extremely useful. Machine Learning, AI, and data analytics could play an important role in keeping students engaged in studies. At the simplest level, they could be leveraged to detect when a student in a remote session is not attentive and nudge them to remind them to pay attention to what is being taught. At the most complex, researchers are testing AI-based frameworks that can successfully detect boredom and engagement in studies using keystrokes, which would allow online teachers to redirect the student's attention accordingly just like an in-person instructor might do [8].

These are just a few of the potential possibilities and uses of AI technologies in the field of education. By offering more personalized, flexible, inclusive, and engaging learning experiences, these technologies have the potential to make virtual classrooms more meaningful and productive. And the future they represent is not far off; in fact, many such applications for AI are already being tested or put to implementation at initial small scale.

3. Real World Applications of AI and ML in Education

Educational Data Mining

One key area of application for AI and ML is Educational Data Mining (EDM). EDM is the practice of collecting student data and apply data mining to personalize education and generate new insights about learning. The data mining methods include classification, clustering, association analysis, and outlier analysis. The classification is a process of finding a set of models for the sake of predictions. Clustering analyzes data objects and creates meaningful groups called clusters. For example, clustering can be used to identify groups students based on their learning styles or class performances or any other metric so that individualized or small group targeted learning can be applied. The main goal of data mining is to reveal previously unknown, implicit, non-trivial patterns and potentially useful knowledge from data.

EDM methods have been used in the past to determine the effectiveness of various pedagogical approaches by measuring student learning in real-time. Researchers have also been able to use EDM to determine whether a particular student is off-task, bored, or frustrated [9,10]. Such methods have obvious advantages for online learning, as teachers can't monitor the attention and engagement of their students as easily in such environments. But with the help of AI systems that collect and analyze large amounts of student data, teachers could be made aware of when their students' attention was beginning to wane. This kind of real-time data could be a helpful substitute for some of the essential non-verbal cues that teachers have lost access to in the shift away from face-to-face instruction.

Student models created through EDM could also lead to more personalized e-learning. Even a university with over 100,000 students could use these student models—updated continuously via AI technologies—to create customized programs for each individual learner. Every student learns in different ways, and the topics they excel at are also different. Instead of having a universal curriculum for all students to follow, customizing the content of every student's classes could optimize teaching to help students only where required. This will benefit the students by making sure they learn as per the requirement and without wasting

time on already understood subjects. Of course, this is only one dimension that courses can be customized with, and a wide assortment of adjustments can be made by AI algorithms to personalize the contents of a class for each student.

Intelligent Tutoring Systems (ITS)

Intelligent Tutoring Systems (ITS) use AI to simulate one-on-one human tutoring by providing both extensive knowledge of their subjects and the ability to respond to instantaneous changes in students' behavior and motivation. Intelligent Tutoring Systems could be helpful for teachers and students. Learners at times do not try to completely absorb the knowledge being given by human tutors or miss out certain curriculum concepts so in such cases the Intelligent Tutoring Systems could help. Primarily, ITSs are viewed as AI technology that work best to supplement and help teachers and not replace them [1].

Thanks to AI and Machine Learning, it is possible to identify the unique needs of each student and take or propose relevant action in real-time to address these needs without disrupting the education process. If mode of learning becomes more digital, they could become essential parts of the online classrooms of the future.

AI Chatbots

AI chatbot can be adopted in the field of education. Chatbots are typically used to interact with students and answer common questions. Students can get answers to their common questions from chatbots at any time.

One additional benefit of having chatbots available 24/7 for all kinds of questions is the vast amount of data that would be collected about the concerns and interests of students. This data could be used as input for further data analytics and Machine Learning to extract insightful and actionable knowledge that could help to develop solutions to students' problems and innovative new services to address the interests of students at large.

The University of Murcia in Spain is among the universities to use AI chatbots to interact with students and answer their questions. In just its first year of piloting, the chatbots were able to answer close to 40,000 questions, with an impressive 91% accuracy [19]. In addition to this success, officials also reported that the chatbot increased student motivation and interest.

Staffordshire University in the UK also rolled out chatbots to answer students' questions 24/7. They found one side benefit of such AI-based chatbots is that they allow professors more time to focus on instruction, high-quality teaching material development, and research [19].

Personalized Learning Systems

AI is also transforming students' learning through its implementation in Personalized Learning Systems (PLS). A PLS aims to deliver personalized learning unique to student needs that are identified by analyzing data generated during student interaction with learning resources. Such an AI-enabled PLS can not only process vast amounts of data but it can also scale up easily. A PLS could potentially scale to applications with tens of millions of students, identifying issues from data and generating customized recommendations for each student that is specific to their needs.

4. Using AI & Machine Learning for Efficient School Operations and Automation

Managing and proper allocation of resources is the crucial factor in the education system, where data is the key to efficiency. For example, effective use of data mining on school data can provide insight into the enrollment numbers of different class sections.

Automation is one the simplest application of AI and often provides the most immediate benefit. By automating tasks such as grading, digital asset categorization or timetable scheduling, educator's time will be saved and they utilize this time in other work like interacting with students for clearing their doubts in concepts of curriculum, etc. Entrusting a set of routine tasks to AI can help teachers make room for something more important [29]. Another example of using AI and ML for efficient school operations is to automate data collection and apply data analysis to identify emerging trends especially in higher education. By identifying trends, schools can develop relevant new classes that will be useful for students, like by tracking popular industry certifications courses, education classes and programs for such certifications can be started and teaching strategies can be customized as per the requirement.

Challenges

AI and Machine Learning applications in education are expanding rapidly but this rapid expansion of the technology does not come without challenges and concerns.

Data Privacy, Security, and Ethics

In order to benefit fully from AI, Machine Learning, and Data Analytics, data must be readily available, and many proponents of AI technology simply assume that it will be. In order to make decisions about learning and give feedback customized and tailored to the individual needs of each student, the students' curriculum data would need to be made available to programmers, data analysts, and data scientists but this raises important questions about privacy and data ownership. Hence, utmost care would be required to be taken to ensure data privacy and security is maintained and data ownership issues do not arise and the data ownership remains with the respective students whom the data belongs to. It is important that AI companies use data transparently and ethically. Student curriculum data privacy and protection measures need to be considered and implemented in any data warehousing and data lake solutions that enable data analytics.

Need for Initial Time and Effort Investment

One major goal of Machine Learning is to automate simple tasks that would require a large time investment from educators. These technologies promise to allow instructors more time to focus on valuable person-to-person teaching or doubt clearing of curriculum concepts but there is some concern that these using these technologies based systems would require some sort of training and methods to be learnt in order to handle things efficiently in cases of some technical errors or issues. Asking teachers to acquire the training of efficiently handling and utilizing different technologies based systems like big data and analytics based systems, AI-ML based systems, etc. may initially during the training period cut into the very time that the AI-technologies were intended to save. All of this could mean the need for higher initial costs,

and high initial investments by educators to learn and adapt to these new applications. This has been one major point of concern.

Loss of Soft Skills

Many of the above uses of AI are attempts to replicate the benefits of in-class learning in an online environment. In times like the present, when in-class learning is no longer an option due to precautions regarding pandemic, this becomes an essential function for AI. But this doesn't mean that AI can or should fully replace in-person learning. Much of what is learned in a classroom is not the course content itself but the attendant "soft skills" that students gain from the social experience of the classroom. These soft skills are an essential part of learning, and no matter how sophisticated our gadgets become, all of us still have a fundamental need to be part of meaningful classroom communities. The classroom community is what makes learning fun, and it creates a peer-to-peer accountability mechanism that encourages skills such as time-management and group cooperation. The future of AI-based educational technologies will need to be aware of this need and strike a balance between the value of personalized teaching and the need for cohesion and classroom community.

Lack of Human Interaction & Role Models

There is plenty of evidence to suggest that students learn well with genuine teacher interactions. For that reason, the idea of introducing automation into education has raised some concerns. And indeed, the rapid shift to online instruction has made the importance of real student-teacher interaction even more clear. But AI doesn't have to be a threat to student-teacher interactions or try to mimic and replace them. Yes, AI can be great for creating personalized learning customized for each student and providing immediate feedback, but it will be important to find the right balance of AI use in the classroom. Teachers will always play a crucial role in our society, as one must never underestimate the value of human interaction and critical thinking in the field of education [24]. As the applications of these technologies in the field of education increases and even becomes the norm, the optimum results will still be the product of a balanced combination of human strengths and AI capabilities. Although it is clear that AI and Machine Learning algorithms can help to guide decisions significantly, there will always be a need for human interaction, especially for younger students. Educators, school administrators, and policymakers should never lose sight of the importance of the human element that is critical for human development, soft skills, and much more and not allow educational activities to be performed solely by robots and algorithms.

5. Education in a Post-Pandemic World

In 2020, the COVID-19 pandemic transformed the way the K-12 and higher education is carried out. Schools and colleges were shut down for months, and the ones that opened after many months at different places where the pandemic condition improved, saw a reduced number of students, with many parents opting to continue their children's education in online mode only instead of sending them to school. Most teachers are still working remotely, and parents—who are often working remotely themselves—are being asked to help their kids with schoolwork more than ever. Some online education or hybrid online and face-to-face programs already existed, but they had not been implemented at a very large scale unlike in

pandemic times where entire curriculum is being taught online using Learning Managing Systems (LMS) and video conferencing options but even existing LMS platforms could continue to improve through the use of artificial intelligence that merges content with evaluation and allows educators to efficiently monitor and track the students' progress. There have been significant developments and breakthroughs in the world of AI and Machine Learning over the last couple of decades, and these technologies give educators the ability to extract key insights about individual students, identify bottlenecks, diagnose issues that prevent student learning, and develop customized learning materials using the vast amount of data being collected through their LMS. Now that the pandemic has made such learning platforms a necessity rather than a luxury, the possibilities for data analysis and algorithmic innovation is unlimited. A well-configured LMS enriched with AI and Machine Learning capabilities will enhance personalize learning, provide immediate feedback, and customize the online learning experience especially in the world of post-pandemic education.

6. The future of AI & Machine Learning in Education

As discussed so far, AI & Machine Learning has very impressive and promising applications in education but as AI technology is continuing to advance, its future applications could surpass even the most optimistic possibilities stated in this chapter. However, there are different challenges with applications of AI and ML in education sector as well which were also discussed in the chapter. The challenges need to be dealt with and optimum solutions should be brought out. In the next section, a few promising applications of AI & ML and other technologies that have direct implications to using AI& ML in education are highlighted.

Internet of Things (IoT) in Education

The Internet of Things have great potential to be used in education. When IoT coupled with Machine Learning and AI, IoT can be very helpful in education.

Virtual Reality (VR), Augmented Reality (AR) Technologies in Education

VR and AR devices have been widely used in mostly gaming and entertainment sectors but these technologies have potential and scope to be used in education sector as well. If these technologies are used along with AI and Machine Learning in education sector, it could turn out to be very useful for the education sector.

7. Conclusion

Artificial Intelligence (AI) and Machine Learning technologies are poised to transform the traditional education. With the technological advancements, COVID-19 pandemic, the need and preference of online/remote education, ever changing tide of how to carry on during pandemic, AI-powered tools have become critical for teachers and students than ever before. AI-powered systems provide students the best opportunities to showcase their abilities by maximizing the limits of their strengths and weaknesses and motivating them to continue their pursuit of knowledge and education. On the other side of the spectrum, teachers are benefitting by being provided with a highly intelligent tool that analyzes and helps them learn about their students curriculum related strengths and weakness and the most effective

methods for teaching them specifically to combat with the obstacles of online teaching in the classrooms of today. It is difficult for the teachers to specifically personalize learning for each student as per the requirement and understand all the habits and learning pattern of all the students in the classroom. An AI system powered with latest machine Learning algorithms can help in personalizing learning and analyzing the learning patterns of the students and give suggestions accordingly. AI can analyze and compile the multiple aspects of a student's strengths, weaknesses and learning habits, and can personalize and present the curriculum concepts to students.

Automating grading though AI, can be really helpful for the teachers and can save their time. AI-based recommendation systems can also be utilized to help provide customized career suggestions for students based on test scores, academic records, and overall career aspirations.

In this chapter major AI & Machine Learning applications in education were presented.

AI stands poised to be a transformational force in education. Like any other technology, the design, implementation should carefully be planned, and the human teaching students pattern should be continued and AI and ML should be included only to help the students and teachers. With non-stopping nature of advancement in AI and Machine Learning, the possibilities are endless, and it will take time to implement these technologies into education ecosystem delicately, efficiently and successfully. All the factors need to be carefully assessed before implementing these technologies so that solutions for issues that are present or can arise in the education world can be found using AI tools to help create a better education system for all.

References

- [1] Southgate, E., Blackmore, K., Pieschl, S., Grimes, S., McGuire, J., & Smithers, K. (2019) Artificial Intelligence and Emerging Technologies in Schools, *A Research report Commissioned by the Australian Government Department of Education*
- [2] Hutson, Matthew (2021). Who needs a teacher? Artificial intelligence designs lesson plans for itself. *Science Magazine*.
- [3] Wang, H. C., Chang, C. Y., & Li, T. Y. (2008) Assessing creative problem-solving with automated text grading. *Computers & Education*, 51(4), 1450–1466.
- [4] Abbott, R. G. (2006) Automated expert modeling for automated student evaluation. *International Conference on Intelligent Tutoring Systems* Springer, Berlin, Heidelberg, pp. 1–10.
- [5] Kucak, D., Juricic, V. and Dambic, G. (2018) Machine Learning in Education—A Survey of Current Research Trends. *Proceedings of the 29th DAAAM International Symposium*, B. Katalinic (Ed.), DAAAM International, Vienna, Austria, pp.0406–0410.
- [6] Alice Liu, Back to the Future Classroom: VR/AR/AI Transformation, <https://www.eqoptech.org/publications/2020/8/22/back-to-the-future-classroom-vr-ar-ai-transformation>
- [7] Gorad, N., Zalte, I., Nandi, A., & Nayak, D. (2017) Career counselling using data mining. *International Journal of Innovative Research in Computer and Communication Engineering*.
- [8] Bixler, R. and D’Mello, S.K. (2013) Detecting boredom and engagement during writing with keystroke analysis, task appraisals, and stable traits. *Proceedings of the 2013 International Conference on Intelligent User Interfaces*, p. 225.
- [9] D’Mello, S.K., Craig, S.D., Witherspoon, A.W., McDaniel, B.T. and Graesser, A.C. (2008) Automatic detection of learner’s affect from conversational cues. *User Modeling and User-Adapted Interaction*, 18, 45–80.
- [10] Baker, R.S.J.D. (2007) Modeling and Understanding Students’ Off-Task Behavior in Intelligent Tutoring Systems. *Proceedings of the ACM CHI 2007: Computer-Human Interaction Conference*, 1059-1068
- [11] Dekker, G., Pechenizkiy, M. and Vleeshouwers, J. (2009) Predicting Students Drop Out: A Case Study. *Proceedings of the International Conference on Educational Data Mining*, Barnes, T., Desmarais, M., Romero, C., and Ventura, S. (eds.), Cordoba, Spain, 41-50.
- [12] Romero, C., Ventura, S., Espejo, P.G. and Hervás, C. (2008) Data Mining Algorithms to Classify Students. *Proceedings of the 1st International Conference on Educational Data Mining*, 8-17.
- [13] Superby, J.F., Vandamme, J.P. and Meskens, N. (2006) Determination of factors influencing the achievement of the first-year university students using data mining methods. *Proceedings of the Workshop on Educational Data Mining at the 8th International Conference on Intelligent Tutoring Systems*, 37-44.

- [14] Arnold, Kimberly & Pistilli, Matthew (2012) Course signals at Purdue: Using learning analytics to increase student success. *ACM International Conference Proceeding Series*. 10.1145/2330601.2330666.
- [16] Graesser, A. C., Li, H., & Forsyth, C. (2014). Learning by communicating in natural language with conversational agents. *Current Directions in Psychological Science*, 23(5), 374-380. doi:10.1177/0963721414540680
- [17] Kulik, J.A. and Fletcher, J.D. (2016) Effectiveness of intelligent tutoring systems: a meta-analytic review. *Review of Educational Research*, 86(1), 42-78.
- [18] US Department of Education (2011) Winning the education future: the role of ARPA-ED.
- [19] McNeal, Marguerite (2016) A Siri for Higher Ed Aims to Boost Student Engagement. EdSurge-Digital Learner in Higher ED.
- [20] Hao, Karen (2019) China has started a grand experiment in AI education. It could reshape how the world learns. MIT Technology Review.
- [21] Settles, Burr & Meeder, Brendan. (2016). A Trainable Spaced Repetition Model for Language Learning. 1848-1858. 10.18653/v1/P16-1174.
- [22] Bisen, I., Arslan, E., Yildirim, K., Yildirim, Y., "Artificial Intelligence and Machine Learning in Higher Education," Machine Learning Approaches for Improvising Modern Learning Systems edited by Gulzar, IGI Global, May, 2021.
- [23] Klein, Alyson (2019) Can artificial intelligence predict student engagement? Researchers investigate. Education Week.
- [24] Rouhiainen, Lasse (2019) How AI and data could personalize higher education. Harvard Business Review.
- [25] Kersting K. (2018). Machine learning and Artificial Intelligence: Two fellow travelers on the quest for intelligent behavior in machines. *Frontiers in Big Data*, 1(6). doi: 10.3389/fdata.2018.00006
- [26] Radu, Iulian. (2014). Augmented reality in education: A meta-review and cross-media analysis. *Personal and Ubiquitous Computing*. 18. 1533-1543. 10.1007/s00779-013-0747-y.
- [27] Fletcher, J. D. (2011) DARPA Education Dominance Program: April 2010 and November 2010 Digital Tutor Assessments. 31.
- [28] Guo, J., Bai, L., Yu, Z., Zhao, Z., & Wan, B. (2021). An AI-Application-Oriented In-Class Teaching Evaluation Model by Using Statistical Modeling and Ensemble Learning. *Sensors (Basel, Switzerland)*, 21(1), 241.
- [29] Doug Bonderud (2019), Artificial Intelligence, Authentic Impact: How Educational AI is Making the Grade. Ed Tech Magazine.