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Exploring the role of AI in education

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Abstract

New advancements in machine learning and AI can be used to augment student learning and teacher capabilities. Examples of AI approaches in education include generating personalized student recommendations, autograding essays, and improving educational resources. AI programs intended to improve education can be categorized informally into three groups: Guidance, Learning, and Teacher. These categories are general and not necessarily mutually exclusive, but provide a framework for organization and further development. This paper intends to look at the past approaches of AI to improve education and categorize them to help guide new development of AI applications in education. The potential benefits of AI-powered education is noteworthy as the current economy is based on higher education. AI can be used to speed up labor-intensive tasks and help close the knowledge gap. Additionally, this paper also looks at potential drawbacks, such as ethics concerns of using student data to power AI. By analyzing the past use of AI in education, this paper seeks to provide a grouping framework to improve understanding of the field and facilitate future development.

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Keywords: Guidance, Student, Teacher

Introduction

Artificial Intelligence (AI) is the ability of computer systems to mimic human cognitive functions such as learning and problem-solving (Artificial Intelligence vs. Machine Learning: Microsoft azure, 2020). Similarly, machine learning uses data to help computers learn. Though the terms are closely related, they have different meanings. With the release of accessible AI technology such as ChatGPT, it is increasingly important to consider how AI can affect and improve education. The impacts of AI on education can be loosely categorized into "Guidance," "Teacher," and "Student" to more easily consider their benefits and drawbacks. By categorizing past AI approaches in education, new approaches can be developed with a clearer focus. As AI continues to advance and spread, it is useful to have an organizational structure to make informed decisions about its implementation and implications for the future of education.

1. "Guidance" AI Approaches

"Guidance" AI is used to loosely refer to AI programs that assist students and teachers in making decisions. They provide data-based advice and help to improve access to educational opportunities and help decide which ones to pursue. Though not necessarily in the realm of teaching or learning, they can have powerful effects on improving education. For example, through "guidance" AI, we can analyze data to connect disadvantaged students with educational opportunities to decrease educational disparity. Below are examples of such programs.

1.1. Teacher Recommendation System

AI was used to power a teacher recommendation system for online students and teachers (Chen et al., 2021). In online one-on-one courses, recommendation systems play a key role in properly matching teachers and students. Teachers and students need to be properly matched so that there are less scheduling and social conflicts. Reviews and ratings from former students may be noisy and unreliable, making reviews an ineffective recommendation system. To improve recommendations, the AI analyzed data from the academic histories of teachers and students to predict which teachers and students had good compatibility with each other and used it to recommend certain teachers to certain students. The AI also boosted new teachers in the recommendations systems to help give experience to new teachers. The recommendation system resulted in a decrease in average matching attempts from 7.22 to 3.09 over a five month period. The decline of matching attempts suggests that the new matches were more satisfactory and less students wanted to change teachers.

1.2. Identifying At-Risk Students and Giving Intervention

In a study, AI was used to predict students at risk of failing to provide intervention (Hlosta et al., 2021). The study uses predictive learning analytics (PLA) to predict student outcomes. The predictions are used to identify which students are at risk of failing so that the teacher can reach out and provide intervention. Students who got intervention had higher chances of passing. The study also found that disadvantaged students such as those in poverty or of minority groups benefited more from intervention (Hlosta et al., 2021). Though the study

needs to be replicated at a larger scale, it demonstrates the potential for AI to close educational gaps and promote accessible education.

1.3. Informative Actionable Feedback

AI was also used to help students decide what actions they should take to improve their academics. Researchers developed a machine learning program that used data from the learning management system (LMS) to predict academic performance (Afzaal et al., 2021). Then, the predictions were used to automatically generate actionable feedback a student could follow to improve academic performance, such as learning resources they could review or assignments they should do. This approach generates feedback using a technique called counterfactual explanations which predicts what actions if taken would improve the AI's predictions the most. These actions then become feedback for the students to use. This helps students self-regulate their learning and personalizes it so it's more efficient.

2. "Student" AI Approaches

"Student" educational AI refers to the combination of AI technologies and educational principles to improve education quality, such as by making learning more engaging or functioning as a more accessible and personalized teacher. Examples of "learning AI" may include intelligent tutoring systems, game-based learning, or learning analytics. They focus on the student-side of education and aim to help students understand, retain, and use the knowledge they are presented with. For AI to be most effective at improving learning, it is important to follow educational principles of learning and associated research. The following paragraphs are examples of "Student" educational AI.

2.1. ALEKS Progress Checks

ALEKS is an online educational program, specializing in teaching STEM. It teaches its students "topics" and later assigns progress checks to test for learning. Progress checks are important because they check if a student has retained what they learned. However, according to student feedback, users of ALEKS preferred learning new material over progress checks (Adams et al., 2021). Moreover, researchers noticed students experienced "assessment fatigue" and were less likely to answer a question later on a progress check (Adams et al., 2021). To improve the progress checks, researchers used AI to predict which topics were likely to be forgotten and should be included on the progress check. They then used these predictions to optimize which topics the progress checks decide to test for in order to improve learning gain. They defined learning gain as topics that were remembered in the progress check. They analyzed two groups of around 150,000 students in 2019 before the new progress check and in 2020 after the new progress check and found a 9% learning gain increase from 2019 to 2020, which may be especially significant due to the COVID-19 pandemic (Adams et al., 2021).

2.2. Game-Based Learning

According to the Entertainment Software Association, 65% of Americans, or 212.6 million, play at least 1 hour of video games a week (Pierre-Louis, 2023). Using the widespread appeal of video games, educators can combine game-elements and education to create a more

interactive and engaging learning experience. Educational games use elements like badges, points, plotline, quests, and more to guide students through learning activities, give immediate feedback, or simplify learning content to manageable tasks (Kirchner-Krath et al., 2021). For example, educational games may use elements such as a plotline, in-game rewards, or appealing aesthetics to increase student engagement and interest in learning. AI could add new capabilities to such games by powering interactions with human-like NPCs (non-player characters), adapt gameplay based on the student, and collect data for learning analytics. One game includes Crystal Island, a microbiology game-based learning environment where learners have to diagnose a disease infecting people on an island. The plot of the story is able to adapt to the student in response to plot goals and the student's current interactions and progression in the game (Rowe et al., 2009). For example, based on the information the student has received, such as clues or character dialogue, the AI can predict the student's goals and adapt the plot if needed (Dever et al., 2021). This means students can self regulate their learning with accessible adaptive support when needed (Goslen et al., 2022).

3. "Teacher" AI Approaches

"Teacher" AI refers to AI technologies that help the teacher teach. In this case, AI functions as a complementary tool to the teacher through functions such as increasing time spent on teaching by outsourcing redundant tasks or expanding the methods a teacher could use to teach more flexibly. Examples may include automatic grading or the use of new teaching methods made possible through AI. Below are some example approaches.

3.1. Essay Autograder

Automated essay scorers use AI techniques to score essays. To do this, they use machine learning and natural language processing to score essays without human intervention. AI models recognize patterns from previous human-scored essays to determine which essays are higher quality. Though an AI model can't truly understand why an essay is good or bad, and may miss nuances and context, they can use statistical patterns observed in previous high-scoring essays to predict the correct scores. Additionally, essay autograders can be further improved such as by using item response theory to average multiple automatic essay scorers (Aomi et al., 2021). By using an essay autograder, teachers can reduce the time needed for manual grading and spend more time on interacting with students. Furthermore, future essay scorers could expand their capabilities and learn to provide personalized feedback to make essay writing and free response less labor-intensive to grade.

3.2. Inq-Blotter Teacher Dashboard

Inq-ITS uses AI to analyze student responses and engagement in an online lab. It monitors the students' progress as they complete the lab in real-time and predicts when they need help (Dickler et al., 2021). If a student is stuck on a problem or concept, the AI can detect it and alert the teacher to offer their assistance. This technology helps teachers more effectively identify and teach struggling students, which helps ensure the entire classroom progresses without leaving some students behind.

4. How Grouping is Helpful

Categorizing AI approaches in education can help boost safe and effective development. The groups "Student," "Teacher," and "Guidance" were suggested in the context of AI in education. "Student" refers to approaches that help learning, "Teacher" refers to approaches that help the teacher teach, and "Guidance" refers to approaches that help manage academics. These groups can provide a framework for understanding how AI approaches can be used in education, which can facilitate improvements of AI in education.

4.1. Generalization

Firstly, grouping the uses of AI in education allows generalizations to be applied to groups of AI approaches. For example, "Student" and "Teaching" AI approaches are both directly a part of education, which means AI approaches to improving student learning or expanding a teacher's capabilities should be grounded in cognitive science or educational research. "Guidance" AI is more related to management and can involve functions like adaptive scheduling or study recommendations, meaning insights from management research may be more useful. These generalizations may allow knowledge transfer from different fields to occur more easily. Since AI in education is multidisciplinary by nature, grouping AI approaches can help different fields collaborate.

4.2. Targeted Development

Grouping the uses of AI in education can also promote targeted development. Using groups identifies common goals and challenges within each category, meaning it is easier to anticipate problems and develop solutions. For example, an personalized AI tutor could provide quick and accessible responses, but may prevent the student from thinking independently. Additionally, it is easier to find past approaches similar to new AI approaches by looking within a category, which can help provide inspiration and insight to development. There are other possible methods of categorization, but the central idea is that AI in education is inherently multidisciplinary, so an organizational structure is essential to foster collaboration and development between AI and education.

5. Drawbacks of AI Implementing AI in Education

Though AI has a large potential to improve education, there are still many limitations and drawbacks that weaken its ability to safely and effectively benefit education. Its limitations include factors like cost, privacy, ethics, lack of explainability, or reliance on accurate data. These limitations can make AI be too costly for its benefit or potentially harmful by invading privacy, which can reduce the feasibility of implementing AI or make it unsafe or unwanted to do so.

5.1. Lack of Human Interaction

If AI replaces functions typically done by humans, such as teaching and grading, we may lose the benefits of human interaction. Though AI is capable of personalizing feedback and education, it can't completely replicate the relationship between teachers and students. In many cases, AI may not be as flexible as teachers in personalizing feedback and adapting

their teaching methods. Teachers have access to more information and can observe body language and facial expressions to understand if their explanations were effective. Teachers can also fulfill emotional and social needs of students by providing encouragement or creating a friendly learning environment. Additionally, acquiring knowledge for the class is only a part of education. Educators also foster morals, ethics, conscientiousness, and resourcefulness in students (Ghafar, 2022). These important aspects of education can't be fully replicated by AI. Human teachers have the ability to promote critical thinking, facilitate discussions, and promote values beyond academics.

5.2. Privacy, Data Security, and Ethics Considerations

When AI is used in educational settings, there are potential concerns of misuse of data. Since AI is a new and rapidly growing field, there is not much history or precedent in regulating the field. The first comprehensive set of AI regulations was the European Union's AI Act in 2023 (EU AI Act: first regulation on artificial intelligence, 2023). Many people may be against the collection or sale of their data and may not support the addition of AI, so experts need to be hired to develop proper guidelines to protect users of AI, resulting in additional costs. According to Salary.com, the median entry-level cybersecurity analyst makes is 77,592 dollars (Entry Level Cyber Security Analyst Salary in Houston, Texas | Salary.com., 2019).

5.3. Reliance on Accurate Data

AI relies on data, so the amount and quality of data the AI has access impacts its effectiveness. When there is not enough data or certain data values are overrepresented, AI can spread and empower harmful biases. For example, an automatic essay checker may give lower scores to unorthodox essay styles even if they were effective because there is not enough data. Systems need to be developed to monitor possible biases or faulty outputs from AI (Khan et al., 2023). This means the data students learn may be biased and incorrect and further spread those biases.

5.4. Lack of Explainability

AI suffers from lack of explainability. Though developers know the data they input and the conclusions the AI reaches, they don't exactly know how it reaches those conclusions due to the complexity of the algorithms. AI has been referred to as a black-box, where we have little understanding on how the AI performs its functions (Chowdhury et al., 2012). This can make AI hard to manage, for example if it is promoting biases that need to be corrected. It is harder to correct AI if developers don't know what went wrong. AI also becomes less effective if it can't be explained. In the context of education, if a student asks an AI how it solved a math problem, it might not be able to explain it properly and the student would know the answer but not the explanation.

5.5. Lack of Contextual Understanding

AI's contextual understanding may be limited compared to a human. AI can find patterns in data but it doesn't understand why that pattern occurred, which limits its ability to draw accurate conclusions in new contexts (Hoffman, 2023). Also, AI training tends to be for a specific task and context, which may prevent it from effectively being applied to new context. For example, much of learning occurs in the context of previously learned topics. Teachers

build upon their previous lessons, but AI may find it difficult to personalize learning with the quality of a human teacher.

5.6. Cost

AI can be expensive because it requires significant computational resources and time, which can limit schools from using it. AI requires a costly computer investment and high quality computer systems to run their programs. Additionally, personnel need to be hired to maintain and improve the AI infrastructure. Latitude CEO Nick Walton, who made the game AI Dungeon, remarked that they paid about as much for AI and humans (Vanian, 2023). Investing in AI education will require a big budget that many schools may not have or are unwilling to invest in the new technology.

5.7. Loss of Soft Skills

By relying on AI, both teachers and students may lose their soft skills, which are generally skills that can be used across many different contexts. Soft skills include time management, leadership, creativity, and more. While AI can attempt to teach such skills or facilitate their development, many soft skills develop only in the context of human interaction, which is difficult for AI to imitate. It is generally accepted that soft skills cannot be learned passively (Caeiro-Rodriguez et al.). Therefore, it can be said that human teaching is a more effective method of teaching such skills than AI, since the teacher and student are physically interacting. Additionally, many soft skills are generally useful in the context of human relationships, so it would be difficult for an AI to simulate the growth of soft skills like socialization and cooperation.

6. Implementation & Accommodation

Though AI is expensive and has some limitations, its rapid development and growing range of applications make it widely used across many sectors. AI has its limits, but based on the trend of its advancement, these limits may be removed in the next decades. Since AI has the potential to transform many tasks, many fields have already started to use AI and education will likely follow. Major problems of AI in education include ethics, effectiveness, cost, and a need to be human-centered. Key objectives for implementing AI in education are making it safe and effective, which include measures like ethical guidelines, developing new technologies based on educational research, and training to handle AI. Below are some factors educators need to consider when implementing AI.

6.1. Privacy, Data Security, and Ethical guidelines

AI uses large amounts of data, which may be collected from students and teachers. To prevent misuse of data, regulations need to be put on what data AI can collect and whether users should be informed that their data is being used. Since users of educational AI will include students, who are too young to comprehend how their data is being used, regulations may need to be stricter to prevent misuse of data. Regulations on AI could be modeled after other ethics guidelines like the EU AI Act (EU AI Act: first regulation on artificial intelligence, 2023). Most existing AI guidelines have emphasized principles such as transparency, justice and fairness, non-malfeasance, responsibility, and privacy (Jobin et al., 2019). These

principles can guide the development of schools' AI regulations and students, parents, and teachers can sign forms acknowledging how AI will be used.

6.2 Educational Principles & Direction

AI in education will need to be based on educational principles from teachers and education research studies to ensure they are effective in improving education. Oftentimes, partnerships between AI and humans fail due to lack of human-centered design (Holstein et al., 2019). For example, if the teacher isn't able to usefully interpret what the AI is telling them, then the AI is ineffective. Even if AI is introduced into education systems, it doesn't necessarily mean education will inevitably improve, so it's important to develop AI to complement people's abilities. To promote human-AI synergy, AI developers need to involve direct practitioners like teachers and focus on combining strengths of humans and AI (Holstein et al., 2019)

Additionally, education powered by AI should prioritize learning skills that are still needed in the future. Some fear robots and AI will replace many jobs. To remain relevant, future workers need to be innovative and creative (Rampersad, 2020). As AI becomes more developed, it will get better at the tasks it can mimic from humans, so tasks it can't mimic yet like creativity and critical thinking will rise in importance. "Though most people are aware of the value of critical thinking, it lacks emphasis in curricula" (Spector et al., 2019). Educators need to focus on teaching students the skills that won't become obsolete as AI advances and takes more jobs, meaning skills like critical thinking and creativity are especially important to teach.

6.3. Digital Literacy

AI can be a powerful tool, but it needs to be used properly. Holstein et al. notes some human-AI partnerships fail because humans aren't able to use the AI due to the person not having necessary knowledge or the AI not being developed properly (2019). Since AI in education is new and unfamiliar, both teachers and students will need training and experience to use it effectively. Without training, teachers and students may waste valuable time trying to adapt to the technology. Educational AI is meant to facilitate education, so it would be ironic if teachers and students spent more time figuring out how to use the technology than learning or teaching. Additionally, AI may become a core component of future industries or workplaces, so training on how to use AI is a skill that has applications beyond school.

6.4. Transparency & Explainability

To effectively manage and use AI, it needs to be transparent and explainable so that people can understand how it works, but a major limitation of AI is its lack of explainability. "They [AI] are often regarded as black boxes that merely attempt to map a relationship between output and input variables based on a data training set" (Chowdhury, 2012). This means AI can generate outputs such as the solution to a math problem or essay improvements, but the user may not know how the AI reached those conclusions. This can be troublesome because humans and AI have to work together. Users who use AI need the reasoning behind AI recommendations or else there will be a lack of trust and synergy. For example, if a student asked an AI to solve a problem but the AI is unable to explain how it solved it, the student wouldn't be able to learn the steps to reach the solution or trust it. Additionally, if the AI gave

a wrong or problematic response, developers would be unable to easily fix it. For example, if the AI misunderstood the input or generated a bias, it would be difficult to figure out what caused them without explainability. To mitigate problems caused by lack of explainability, developers can use explainable AI methods like LIME or Anchors (Holzinger et al., 2022), which help provide insight to AI logic. By adopting such techniques, AI systems can be more transparent, providing users insight into AI's decision-making process to foster collaboration between humans and AI.

6.5. Infrastructure and Cost

Since AI is a relatively new development, many school systems aren't ready to incorporate AI. There is a lack of ethical guidelines, technological resources, experience, and money to fully support the use of AI in education. To fix these problems, an organization or a branch of a school's executive system could be formed for managing AI to develop the proper infrastructure. This organization could determine ethical guidelines, purchase the software and hardware to use AI, and develop the training people will need to learn how to utilize AI. Basically, this organization would help make the addition of AI to education smooth, safe, and clear. Members would be people who are knowledgeable in the use of AI and management or can learn. Furthermore, partnerships could be created between schools, technology companies, and universities to promote the use of AI. Companies and universities could use schools to test or use AI while schools benefit off of experience and opportunities with AI. These partnerships allow students to be exposed to AI technology and allow the school to use AI at a lower cost, while universities or companies can benefit from recruiting future students and testing technologies.

Conclusion

In the context of AI's rapid development, it is crucial to examine the applications and regulations of AI in education. Though at the moment, AI has yet to become commonplace in the education sector, there is a possibility for AI to become a core component of education in the coming decades due to the rapid pace of its advancement. Correspondingly, we need to examine how AI can be safely and effectively implemented. AI applications in education can be grouped as "Student," "Guidance," and "Teacher" to clearly define their purposes. Grouping them in this way makes it easier to develop new applications for education because there is an organizational framework that helps developers understand this field. Principles from past approaches can be used to avoid reinventing the wheel and accelerate progress. Despite the potential of AI, there are constraints that need to be addressed such as ethics concerns, technical limitations, or cost. Through categorizing AI applications in education and understanding the drawbacks of AI, we can develop safe and effective AI-powered solutions to the education sector.

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