HIGH SCHOOL EDITION
Journal of Student Research
Volume 13 Issue 4 (2024)

Educational Interventions and Future Trends of AI/ML – Game-Based Learning, Cognition, Special Ed

Shayan Farooq

British International School Al Khobar, Saudi Arabia

ABSTRACT

The fields of Machine Learning and Artificial Intelligence (ML/AI) have seen unprecedented growth in recent years, and this rapid expansion of technology has provided ample opportunities to reform and revolutionize a myriad of fields. This paper will specifically entail the discussions of the reforms and revolutions caused by ML and AI in education, primarily by reviewing existing literature on the matter. Notably, the other focus of this research publication will be centralized upon current platforms and systems that take advantage of these developments. The impact of AI is refined by accompaniment with technologies like Natural Language Processing (NLP), which allows for increased approachability for students, and this is capitalized on by state-of-the-art digital learning platforms. This research publication will look into the new development of cognitive sciences that is an interdisciplinary combination of AI, psychology and education, effectiveness of applying AI interventions for special ed students, limitations associated with neuroimaging and education, alongside future predictions of policies and historical advancement that will bolster the educational progress of youth.

Introduction

The development of AI in the context of education has been researched upon for the past 20 years, where researchers have witnessed the prominence of creating new modules of game-based learning, and educational enrichment programs that bolster the educational progress of young scholars and adults. Historically, from the 1960s to the 1990s, researchers witnessed the implementation of reasoning that can simulate human intelligence, supported by projects and workshops at Dartmouth college, that contributed to the birth of computer science in the 1940s. (Williamson et al., 2020) Specifically, researchers have witnessed how the development of AI-based tools for classrooms have led to significant advancement in the space of cognitive science, in witnessing how both learning analytics and educational data could be used both within classrooms and outside of classrooms to lead to many intelligent tutoring systems. (Williamson et al., 2020) With cognitive science gaining traction over the past few decades, researchers are able to see the interdisciplinary combination of cognition, technology and education to highlight new interventions like the intelligent tutoring systems that can drastically improve the speed and quality of students' learning. Then, in the early 2010's to mid 2020's, researchers saw a paradigm shift in the way educational technology has created certain platforms and big data in educational mining, that has led to significant innovative products released in the business world and market.

Comprehensive Analysis of AI, ML, NLP in Educational Interventions

Researchers have been exemplifying the advancements made in Artificial Intelligence that have bolstered the academic readiness of young scholars at the K-12 level by identifying three central purposes of AI: "technical concepts, ethical implications, and career futures." (Zhang et al., 2023) Intrinsically, researchers are looking at the impact of

accessible platforms such as Code.org, ReadyAI's AI-in-a-box as well as AI4Kids in exploring how AI is making education more enriching and immersive for young students. (Zhang et al., 2023)

Precisely, through the implementation of AI, personalized learning is a module that is made possible in accommodating the specific needs of each student. For instance, now with the implementation of AI, students are able to facilitate different learning resources, gain guidance on different areas of improvement that they can focus on, as well as adjust their learning levels to their own needs and requirements. To back this with prominent statistics and research, Carnegie Learning's AI-powered mathematics software was proven to be effective in improving students' performance in mathematics by up to 30%, in addition to Duolingo's AI-based language learning platform being effective in creating a personalized learning experience for students to receive tailored support on their comprehension and understanding of foreign languages – syntax, grammar, diction, and other forms. (Harry et al., 2023) In addition to this, recent advancements in AI have highlighted the effectiveness of adaptive learning technologies in ensuring an experience that engages students with large amounts of data and provide insights into specific students' performance, which can then be extracted by teachers to derive meaningful insights. (Harry et al., 2023)

Interdisciplinary Areas of AI and Neuroscience to Bolster Personalized Learning and Cognitive Development

As demand for research expands, artificial intelligence has recently emerged as an revolutionary approach to many fields, including cognitive science and neuroscience. It has opened up new ideas for understanding the complexities of the human mind and has revolutionized the way researchers approach interventions in these disciplines. AI has had profound contact within the fields of cognitive science and neuroscience, highlighting the advancements and interventions that have been made possible by this technology. (Murphy, 2019) Cognitive science and neuroscience seek to unravel the mysteries of the human brain and cognition. With the introduction of AI, researchers have gained access to powerful tools and techniques that can enhance their understanding and accelerate progress in these areas. Machine learning algorithms, in particular, have proven to be immensely valuable in understanding complex brain processes and patterns of human cognition.

Fortunately, researchers have been experimenting with new solutions, paving the way for heightening accuracy of clinical AND diagnosis through the implementation of deep learning AI. Deep learning AI models are "multilayered artificial/convolutional neural networks, allowing us to directly process images" (Castiglioni et al., 2021). Using these deep learning AI models, it may be possible to find amyloid plaques in retinal images, a key diagnostic criterion for AD as these plaques are commonly found in patients with AD and cause problems with the functionality of the brain. These plaques are formed as strings of amino acids called amyloid-β (Aβ). When such plaques form protein pieces called amyloid-β (Aβ) clump together, they become biomarkers that could be used to detect various forms of neurological diseases. In this case, amyloid plaques that are present in the retina can be used to identify early signs of AD through the presence of amyloid-β. Identifying the relationship between the presence of amyloid β and concurrent AD is vital for this reason, as determining an accurate correlation between the presence of amyloid plaques and the successful detection of Alzheimer's will inevitably lead to a higher accuracy in clinical AD diagnosis.

Interventions of AI on Special Ed Students (Learning Disabilities)

With various metrics being introduced in day-to-day life, including AI, machine learning and technological advancements, students with disabilities are able to receive proper guidance from AI applications and machine learning to bridge educational disparities. (Garg et al., 2020) In terms of specific applications, AI has aided special-needs students by implementing modules with assistive technology and robotics by utilizing Siri in mobile devices as well as sources from Google's Alexa, to ensure that assistive technologies can be used by those with impairments. (Garg et al., 2020) In terms of other adaptations and installations, Microsoft Translator has also served as an AI assistive device that can

help deaf learners and those with hearing impairments by providing an interactive hearing experience with the guidance of proper sound protections and warnings. Recent educational progression in terms of providing pedagogical institutional support needs to be in line with proper policies that ensure proper accessibility in AI tools for special-needs students. Specifically, with the implementation of research and development followed by policies governed by healthcare institutions as well as mental health institutions, new products must be patented to ensure that they meet the requirements of new industrial requirements. (Garg et al., 2020)

Ethical Discussions and Considerations for Integrating Machine Learning, AI and Neuroimaging for Cognitive Diseases

When reviewing these results entailing the interdisciplinary areas of AI and education, it is prominent to identify that there are limitations associated with diversifying these subset of results. For instance, one weakness is associated with the idea that some findings are outdated from 2019, as evident from Murphy's studies. (Murphy, 2019) When reviewing the applications of AI, due to the fact that technology continues to progress in society, it is essential to consider that these applications can be utilized for all consumer groups – including different generations, wealth groups or income statuses, as well as those with both impairments and disabilities, and those with none. In addition to this, there are ethical limitations associated with testing AI on marginalized students, especially those that are disabled. For instance, when applying assistive technology on special-needs students, there needs to be proper informed consent, appropriate disclosures, as well as proper transparency. Hence, researchers in the future years need to ensure that these ethical limitations are considered, before testing on special-needs, or cognitively-impaired research groups.

Applications of AI in Game-Based Learning

Artificial Intelligence has had a significant impact on the domain of game-based learning (GBL). With children interacting with video games from early ages, gaming is becoming a growingly common activity, to the point of normalization amongst the younger generations (Dyulicheva et al., 2021). One of the primary methods of integrating AI into GBL is by using games to source player data. (Pérez et al., 2023) An example of using games to source data can be seen in Google's "Quick, Draw!" game, which uses players' drawn responses to prompts to improve its own model. Google Creative Lab also used this technology to develop AutoDraw as a drawing tool.

The widespread exposure of games motivates the usage of games as a teaching medium in the form of GBL. GBL represents a combination of two main methods of incorporating games in education: i) Development of games designed with teaching as a primary objective, and ii) Gamification of tasks where appropriate. The first method includes games known as serious games, which are not focused on entertainment at all, but rather knowledge acquisition (Dyulicheva et al., 2021). Examples of serious games include Foldit, a puzzle game to teach the concept of protein folding, as well as REACtion S.G., a single player simulation to experience the jobs of social workers. Foldit is especially interesting in this regard as it combines GBL to research as well; researchers can examine the best performing structures made by students to identify potential real world uses. Applications of gamification include the House Points system used by some schools, which involves designating each student a house (commonly a color) and then rewarding efforts with points that are aggregated by house to declare a winner. This creates a cooperative but also competitive environment which has proven to be effective for student motivation.

Policies and R&D (Research and Development) That Support AI's Influence on Education

Despite the rapid turnover in advancements in AI-powered solutions, researchers argue that there must be the construction of appropriate policies that highlight equal accessibility to AI. For instance, policies in healthcare, education and other industries must ensure that every individual, in both financially-disadvantaged and wealthy groups must have access to AI technologies. For instance, UNESCO has been playing a central role in developing policies that address complex challenges, as evident in the discussions hosted on AI and sustainable development at Mobile Learning Week, as well as the UN's flagship event on Information and Communication Technology in education. (Miao et al., 2021) In addition to that, UNESCO highlighted the importance of reaching proper education by 2030, by hiring at least 68.8 million more teachers to ensure equitable access to AI technologies, which would support the SDG4 policy governed by the world in UNESCO, in reaching 'inclusive and equitable education and promote lifelong opportunities for all'. (Miao et al., 2021) In addition to this, researchers must consider policies that also consider the ethical limitations of educational tools, such as highlighting the issue surrounding plagiarism and bias mitigation, in ensuring that there is no gap between education and ethics in creating appropriate technological integration.

Future Predictions and Trends on the Interdisciplinary Intersections of AI and Education

Artificial Intelligence in Education (AIED) has already been transforming the education landscape. Notable impacts include the increasingly rapid transition of education from being "problem-solving knowledge transfer" to a "creative convergence" (Paek et al., 2021). This refers to the declining emphasis of teaching specific, technical problem-solving techniques, which is a direct consequence of Artificial Intelligence being able to apply such techniques far more efficiently than humans, rendering their teaching growingly impractical. Pattern recognition is a fundamental feature of Artificial Intelligence, so it can employ conventional, known problem-solving methods consistently, which reserves the development of new techniques as a task for humans. This is an increasingly creative process, and this practice being generalized across different disciplines can be thought of as a "convergence"; in several fields, progress relies on creative, novel approaches, so creativity is what needs to be taught.

As this trend continues, researchers argue, a 'liberal arts' education, as in encompassing multiple different disciplines in addition to a central focus, is becoming more valuable, as it is said to precisely encourage softer skills like creativity (Lewis, 2018). Another influence that is being brought by AIED is the personalization of education, as identified by a group of researchers. (Paek et al., 2021) They note that in the industrialization era, education was collective and rigid, but is becoming increasingly personal in the AI era. Techniques like Computer-assisted language learning (CALL) and devices such as chatbots all contribute to this customization of education for each individual (Chen et al., 2020). AIED also aids with tailored pacing: via the use of dynamic and adaptive content, educators no longer need to ensure that each member of a cohort remains in sync, and efforts are diverged from content delivery. Instead, attention can be focused on content development, resulting in the process becoming less protracted and more efficient. Thus, the continued development of AIED could also culminate with more bespoke knowledge delivery.

Ethics, Discussion and Limitations

Despite these significant advancement in technology, researchers have also witnessed some ethical limitations of AI platforms, such as the limitations surrounding facial recognition softwares. For instance, with the advancement of these tools that are being implemented by industry, government and even academic institutions, some biases that may fall by algorithms in terms of admitting and recruiting particular students for admission, or making certain tools more

accessible to certain ethnic groups over others could hinder the development of fair AI tools. (Borenstein et al., 2020) Thus, the issue lies now in ensuring that these algorithms do not lead to certain fallible human designs and errors, and ensuring that every group of consumers in the education space has access to platforms that help students with their educational progression. In addition to this, it is prominent to note that there are also ethical limitations associated with diversifying these subset of findings, as some of the sources are limited to research studies within the United States, which could make applications in the educational space for consumers outside of the US more difficult. In addition to this, the research behind AI and education is also limited to those that either belong to middle-class consumers or consumers in the higher wealth group, due to those belonging to lower-income communities lacking access to technology.

Conclusion

In conclusion, Artificial Intelligence and Machine Learning has been seen to have significant advancement, from witnessing the applications for special ed students, to how their findings have garnered the pathway for educational institutions to implement game-based learning. Specifically, with the introduction of new policies and R&D, coupled by the ethical limitations of AI and educational modules, in the upcoming years, it is discussed by researchers that these tools must carefully bridge ethical, racial and financial barriers by considering Diversity, Equity, and Inclusion. In highlighting the cognitive theories behind AI and education, researchers in the future can predict greater success with these tools, by ensuring that they adhere to proper industry standards across various settings. At the same time, researchers must consider making novel forms of AI and ML tools that can make educational tools more accessible to not solely classroom settings, but also in the settings of financial and fintech industries, alongside electrical engineering where these tools can be further digressed through the introduction of new prototypes.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

References

Borenstein, Jason, and Ayanna Howard. "Emerging challenges in AI and the need for AI ethics education." *AI and Ethics* 1 (2021): 61-65.
Castiglioni, Isabella, et al. "AI applications to medical images: From machine learning to deep learning." *Physica medica* 83 (2021): 9-24.
Chen, Lijia, Pingping Chen, and Zhijian Lin. "Artificial intelligence in education: A review." *Ieee Access* 8 (2020): 75264-75278.
Dyulicheva, Yulia Yu, and Anastasia O. Glazieva. "Game based learning with artificial intelligence and immersive technologies: An overview." *CS&SE@ SW* (2021): 146-159.
Garg, Shalini, and Shipra Sharma. "Impact of artificial intelligence in special need education to promote inclusive pedagogy." International Journal of Information and Education Technology 10.7 (2020): 523-527.
Harry, Alexandara, and Sayudin Sayudin. "Role of AI in Education." *Interdiciplinary Journal and Hummanity (INJURITY)* 2.3 (2023): 260-268.
Lewis, Pericles. "Globalizing the liberal arts: Twenty-first-century education." *Higher education in the era of the fourth industrial revolution* (2018): 15-38.
Miao, Fengchun, et al. *AI and education: A guidance for policymakers*. Unesco Publishing, 2021.
Murphy, Charlotte, et al. "Modes of operation: A topographic neural gradient supporting stimulus dependent and independent cognition." NeuroImage 186 (2019): 487-496.

Paek, Seungsu, and Namhyoung Kim. "Analysis of worldwide research trends on the impact of artificial intelligence in education." *Sustainability* 13.14 (2021): 7941.
Pérez, Jaime, Mario Castro, and Gregorio López. "Serious games and ai: Challenges and opportunities for computational social science." IEEE Access 11 (2023): 62051-62061.
Williamson, Ben, and Rebecca Eynon. "Historical threads, missing links, and future directions in AI in education." *Learning, Media and Technology* 45.3 (2020): 223-235.
Zhang, Helen, et al. "Integrating ethics and career futures with technical learning to promote AI literacy for middle school students: An exploratory study." *International Journal of Artificial Intelligence in Education* 33.2 (2023): 290-324.