

On Applications and Challenges of Artificial Intelligence (AI) in Education

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1. Introduction

The advent of artificial intelligence (AI) has brought about significant transformations across various sectors, including education (Ayeni et al., 2024). This commentary article delves into the multifaceted applications and challenges of AI within the educational landscape, aiming to provide educators, policymakers, and researchers with an overall understanding of AI's potential impacts. By examining the global trends of AI and Taiwan's strategic positioning, this article explores how AI can be harnessed to revolutionize educational practices while addressing the inherent challenges that accompany its integration.

AI has the potential to redefine the educational experience, offering innovative solutions for teaching, learning, and administration. However, the implementation of AI in education is not without its hurdles. Ethical considerations, equity in access, data privacy, and the need for adequate teacher training are critical issues that must be addressed to ensure the successful and responsible deployment of AI technologies. This article will explore these dimensions, providing insights and reflections on how to prepare for the evolving educational landscape shaped by AI.

In this context, understanding the global trajectory of AI and Taiwan's role within this trend is essential. By investigating AI's applications in education and reflecting on the corresponding challenges, we aim to provide a balanced perspective that can guide educational practitioners in making informed decisions. The ultimate goal is to prepare the educational sector for the transformative impact of AI, ensuring that its benefits are maximized while mitigating potential drawbacks.

2. The Global Trend of AI and Taiwan's Position

AI has emerged as a transformative global trend with significant societal impacts (Nemorin et al., 2023; Makridakis, 2017). The rapid proliferation of AI technologies is reshaping markets worldwide, with AI-driven companies dramatically increasing their global market share. Notable examples include Microsoft, the largest investor in

OpenAI, which holds a second position, NVIDIA ranking third, TSMC eighth, and Broadcom twelfth in global market capitalization (CompaniesMarketCap, 2024).

AI's influence extends deeply into daily life, as evidenced by the widespread adoption of ChatGPT (Lo, 2023). Numerous international organizations and countries have developed strategic policies in response to AI's pervasive impact. The United Nations General Assembly (2024) initiated an AI policy focused on sustainable development, while the OECD (2024) updated its principles to promote responsible AI usage. Singapore's AI 2.0 policy (Government of the Republic of Singapore, 2023) is noteworthy for applying AI across various sectors, including medicine (Taeihagh, 2021).

Taiwan has positioned itself strategically within this global trend, recognizing AI's profound implications. Taiwan's international-oriented economic model underscores the importance of AI in its economic development. In 2023, Taiwan's GDP was approximately 755.3 billion USD, with goods exports accounting for 459 billion USD, representing about 60.77% of the GDP (Office of the Accounting & Statistics Bureau, Executive Yuan, 2024). TSMC plays a pivotal role in Taiwan's economy, comprising 31% of the total market share on Taiwan's stock exchange (Taiwan Index Company, 2024).

To maintain and enhance its competitive edge in the high-tech global market, Taiwan is committed to increasing the international competitiveness of its students. The Taiwanese government has established an AI Cabinet at the central government level (Wang, 2024), and the Ministry of Education has announced future curriculum reforms that include AI and digital learning components (TBVS News Staff, 2024). The bilingual policy (National Development Council, 2021) also aims to bolster students' international engagement competencies.

Given these developments, Taiwanese educators must remain cognizant of AI trends and prepare for their implications. AI's integration into various educational facets is growing (Onesi-Ozigagun et al., 2024). While AI offers numerous educational benefits, it is crucial to adopt a critical and reflective approach to its application (Zawacki-Richter, 2019). Such an approach ensures that AI is utilized effectively, minimizing adverse effects and securing the quality of education for all, in alignment with the United Nations' (2015) sustainable development goals.

3. The Potential Applications of AI in Education

(1) Collaborative Teaching Partner

Traditionally, teachers form teams to plan lessons, co-teach, observe, and provide feedback on instruction. However, this approach is limited by time, location, partners, and budget constraints. AI can alleviate these limitations by assisting with lesson planning, generating customized plans, recommending resources and activities, and answering real-time questions. Some successful cases were reported in Kim's (2024) study. For example, Georgia Institute of Technology introduced "Jill Watson," an AI teaching assistant, to its online AI course. Jill answered routine questions and assisted students efficiently, allowing human instructors to focus on complex issues (Goel & Polepeddi, 2018). This innovation led to higher student satisfaction and engagement. On the flip side, some virtual assistants struggled with nuanced questions, leading to student frustration and decreased trust in the technology.

In the future, AI could observe teaching, discuss it with human teachers, and provide feedback using its ability to process and explain images and videos, as seen with ChatGPT 4o ["o" for "Omni"], released on May 13, 2024. AI's capabilities in generating text, images, videos, and multimedia materials suggest it could eventually simulate instructional methods for various subjects.

(2) Adaptive Assessment

AI, such as ChatGPT, assists teachers in creating testing items to evaluate learning outcomes, significantly reducing workload. While teachers might spend hours creating a test, AI can do it in minutes, freeing teachers to focus on differentiated assessments for diverse needs. An AI-powered learning system can personalize experiences through adaptive assessments, analyzing performance, and suggesting targeted interventions. By maintaining and analyzing learning data, AI can provide real-time analysis, automated grading, identify knowledge gaps and strengths, offer immediate feedback, personalized recommendations, and remedial suggestions, thereby saving time and enhancing assessment quality.

(3) Facilitating Special Education

AI provides tailored support and accommodations for students with diverse special education needs. It can present information in multiple formats (visual, auditory,

kinesthetic) to cater to different learning styles. AI-powered Individualized Education Programs (IEPs) reduce the labor-intensive process for teachers, allowing them to enhance exceptional education quality with saved time and energy. AI offers personalized instruction at a student's pace, providing additional practice or explanations as needed. Assistive technologies, such as text-to-speech and speech-to-text tools, facilitate learning for visually or hearing-impaired students, or those with handwriting difficulties. Automated sign language translation improves communication with nonverbal students, ensuring an inclusive learning environment.

(4) Serve Social-Emotional Needs

AI addresses students' social-emotional needs, fostering a positive learning environment. Tools like ChatGPT 4o, which interact through text, audio, and video, can detect and respond to emotions. AI-powered chatbots provide a safe space for students to express concerns or ask questions anonymously, offering emotional support and comfort. These chatbots monitor emotional status and flag issues for teacher intervention when necessary. Virtual counselors powered by AI can provide guidance, identify mental health concerns, offer coping strategies, monitor behavior, and detect signs of stress, anxiety, or disengagement, ensuring early intervention and support.

(5) Being a Personal Tutor

AI could be a personal tutor, offering individualized support and guidance beyond the classroom. AI tutors are available 24/7 to answer questions, clarify concepts, and provide practice exercises, facilitating continuous learning and understanding. Immediate feedback on assignments and quizzes helps students learn from their mistakes and improve efficiently. Intelligent Tutoring Systems (ITS) enhance the tutoring experience by tracking progress, identifying areas needing help, and simulating one-on-one tutoring. These systems adapt to individual learning styles and paces, providing personalized explanations, guidance, practice exercises, and assessments tailored to each student's needs.

(6) Other Applications

AI enhances administrative efficacy by streamlining tasks such as scheduling, attendance tracking, and grading, allowing educators to focus more on teaching. AI facilitates automatic teaching and learning systems, providing automated lesson plans and grading systems that adapt to student performance. It also plays a crucial role in

language learning and translation, offering real-time translation and personalized tools to help students master new languages. AI creates virtual learning spaces, enabling immersive and interactive online classrooms. For example, DreamBox Learning, an adaptive math platform, has shown remarkable success in personalizing education for K-8 students. By analyzing student interactions, DreamBox adjusts lessons to individual needs, significantly improving math proficiency (Longnecker, 2021). Personalized support systems identify individual needs and provide tailored interventions, ensuring every learner receives the support they require. These diverse applications demonstrate AI's transformative potential in creating more efficient, personalized, and accessible educational environments.

4. The Potential Challenges of AI in Education

Several challenges of AI in education have been discussed, including privacy, ethics, equity, teacher training, and whether AI will replace teachers.

(1) Privacy

Integrating AI in education brings significant privacy concerns that must be addressed to ensure the safety and security of students' personal information. One of the primary issues is data privacy and data security. AI systems often collect and analyze vast amounts of student data, including personal information, academic performance, learning tendencies, and preferences. This extensive data collection raises the risk of sensitive information being misused, either through unauthorized access, unprofessional employees, cyber-attacks, or unethical use by third parties. The potential for data breaches and the exploitation of personal information can undermine trust in educational institutions and AI technologies. Protecting student data privacy is paramount. Implementing data anonymization techniques ensures that personal information is removed before analysis (Martinez & Herrera, 2023). To mitigate these risks, robust solutions are essential. Strong data encryption, secure authentication processes, and regular security audits can help protect data from unauthorized access and cyber threats. Additionally, developing clear policies and regulations regarding data usage and ensuring transparency in how student data is collected, stored, and used can help build trust and safeguard privacy. Educators and institutions must also prioritize teaching students about digital literacy and privacy, empowering them to understand and protect their own data. By addressing these privacy concerns proactively, the educational sector can harness the benefits of AI while maintaining the highest data security and privacy standards.

(2) Ethics

The ethical concerns surrounding AI in education encompass a range of issues that must be carefully managed to balance innovation with integrity. One of the primary ethical considerations is the potential for over-reliance on technology, which can undermine critical thinking skills and reduce human agency in the learning process. The ethical landscape of AI in education is further complicated by the issue of data bias. Algorithmic bias can lead to unfair outcomes, perpetuating existing inequalities and disadvantaging certain groups of students. This bias can manifest in various ways, from the misinterpretation of data patterns to the reinforcement of stereotypes, ultimately affecting students' educational experiences and opportunities.

Moreover, the growing digital dependence facilitated by AI technologies raises concerns about the potential erosion of essential interpersonal skills and the holistic development of students. While AI can offer personalized learning experiences, excessive reliance on these systems may diminish the role of human educators, leading to a less human-based interactive and emotionally engaging learning environment. Academic integrity is another critical concern, as AI-driven tools could inadvertently facilitate cheating or plagiarism if not adequately monitored. Ensuring that AI systems are designed to uphold academic honesty and prevent misuse is essential.

Addressing these ethical challenges requires a multifaceted approach. Ensuring the explainability of AI decisions can help educators and students understand how outcomes are derived, fostering transparency and trust in AI systems. Maintaining human oversight is also crucial; humans should hold the final decision-making authority to ensure that AI complements rather than replaces human judgment. The educational sector can leverage AI's benefits while safeguarding against its potential ethical pitfalls by fostering an ethical framework that prioritizes fairness, transparency, and human involvement.

(3) Equity

Equity concerns in AI education are crucial, especially in guaranteeing that every student has equal access to AI technologies, irrespective of their socio-economic status or geographic location (Roshanaei, Olivares, & Lopez, 2023). At an individual level, while essential AI tools might be freely available and uniformly accessible, advanced AI applications often come at a cost, creating a digital divide between students who can afford these tools and those who cannot. This disparity is further pronounced at the

district level, where schools in affluent metropolitan areas can invest in state-of-the-art AI technologies, while those in poorer, remote counties struggle with limited resources and outdated infrastructure. This inequity in access not only affects the quality of education but also widens the achievement gap, as students in underfunded counties miss out on the personalized learning and advanced educational opportunities that AI can provide. Addressing these equity concerns requires targeted solutions, such as government-funded programs to subsidize AI technology for disadvantaged schools, and initiatives to improve digital infrastructure in remote areas. Additionally, fostering partnerships between the public and private sectors can help bridge the gap, ensuring that all students, irrespective of their background, can benefit from the advancements in AI education. By prioritizing equitable access to AI technologies, we can create a more inclusive educational landscape that offers equal opportunities for all learners.

(4) Teacher Training

Integrating AI in education brings significant concerns regarding teachers' training and professional development. As AI continues to disrupt and evolve the educational landscape, constant change becomes the norm, requiring teachers to update their skills and adapt to new technologies continuously. Traditional teacher training programs may not adequately prepare educators for the rapid advancements in AI, necessitating the development of specialized professional development mechanisms focusing on AI literacy and application. Teachers need robust support systems that equip them with the technical skills to use AI tools effectively and provide ongoing guidance on integrating these tools into their teaching practices. This includes training on flexibly adjusting their utilization of AI to enhance learning experiences without developing an over-reliance that could lead to their roles being diminished or replaced. Solutions to these challenges include creating dynamic professional development programs that are responsive to technological changes, fostering a culture of continuous learning, and ensuring that teachers have access to resources and mentorship. By prioritizing comprehensive training and support, we can empower teachers to leverage AI to complement and enhance their instructional capabilities, ultimately benefiting students and maintaining the vital human element in education.

(5) Will AI Replace Teachers?

A prevailing concern among educators is whether AI will eventually replace teachers, especially with the advent of generative AI tools that can assist with listening, speaking, reading, and writing tasks. Personal AI tutors and automatic learning systems

are becoming increasingly sophisticated, capable of providing individualized support and managing various aspects of the learning process. This technological advancement raises anxiety about the potential redundancy of the human teacher's role in education. However, the key to addressing this worry lies in building trust and understanding that AI is designed to be a supplement, not a replacement for teachers. AI can handle repetitive tasks, offer personalized assistance, and manage administrative duties, thereby allowing teachers to focus more on critical thinking, emotional support, and personalized instruction that AI cannot replicate. Educators should be trained to use AI flexibly, enhancing their teaching methods while retaining control over the learning environment. By viewing AI as a powerful tool that supports and extends their capabilities, teachers can embrace technological advancements without fear of being replaced, ensuring a harmonious integration of human and AI in the classroom.

5. Reflection: Making Ready for the Impact of AI in Education

The world is changing rapidly, driven by the relentless advancement of AI technologies. The potential opportunities presented by AI in education are vast, offering the promise of personalized learning, enhanced administrative efficiency, and improved support for diverse educational needs. However, these benefits come with significant impacts and challenges that cannot be ignored. As AI continues to reshape the educational landscape, it is imperative for educators, institutions, and policymakers to prepare for its effects proactively.

Continuous learning and adaptation are essential to stay ahead in an AI-driven world. Educators must commit to ongoing professional development to understand and effectively integrate AI tools into their teaching and administrative practices. This preparation involves acquiring technical skills and fostering a critical understanding of AI's capabilities and limitations. Preparing students for an AI-driven world means equipping them with the skills to navigate and leverage these technologies while maintaining a solid foundation in critical thinking and ethical reasoning.

Moreover, the development and deployment of AI in education must be guided by ethical principles. The role of educators is crucial in ensuring that AI is used responsibly and equitably. Addressing privacy concerns, mitigating algorithmic bias, and ensuring equitable access to AI resources are fundamental to maintaining trust and fairness in educational environments. By prioritizing ethical AI development, educators can help create an inclusive and just educational landscape that benefits all students, as the Sustainable Development Goals (SDGs) expect.

To maximize the benefits of AI while mitigating potential drawbacks, several key actions should be taken. First, establishing and adhering to robust ethical frameworks is essential to guide the use of AI in education. These frameworks should emphasize transparency, accountability, and fairness to ensure AI systems are designed and implemented in ways that respect students' rights and promote equity.

Second, collaboration between educators, technologists, policymakers, and communities is vital. Such partnerships can foster the development of AI tools that are educationally sound, culturally relevant, and aligned with the needs and values of diverse student populations.

Third, implementing continuous evaluation and feedback mechanisms allows for the ongoing assessment of AI's impact on education. This approach helps identify unintended consequences, areas for improvement, and opportunities for innovation, ensuring that AI applications remain effective and beneficial.

Fourth, ensuring that AI technologies are designed inclusively and accessible to all students, including those with disabilities and from marginalized backgrounds, is critical. This approach helps bridge the digital divide and promotes equal opportunities for all learners.

In conclusion, integrating AI in education holds tremendous promise, but it also poses substantial challenges. By embracing continuous learning, preparing students for the future, and upholding ethical standards, the educational sector can harness the power of AI while safeguarding the integrity and quality of education. The journey toward an AI-enhanced educational future demands vigilance, adaptability, and a steadfast commitment to equity and ethics. Ensuring that its benefits are maximized while mitigating potential drawbacks requires a concerted effort from all stakeholders in the educational ecosystem.

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