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Effects of Artificial Intelligence Tools on Classroom Learning Outcomes and AI's Impact on the Future of Education

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Abstract:

Artificial Intelligence (AI) applications in education are predicted to increase internationally at a rate of 45% annually, reaching a value of $5.80 billion by 2025. This paper explores the intellectual and political impacts of integrating AI in classroom learning. It analyzes and discusses past classroom learning outcomes when integrated with AI technologies, as well as how classroom learning has evolved and will continue to evolve. To predict and adapt to the future of technology in education, where AI is deeply embedded into the fabric of our educational institutions, we must study its implications from various perspectives, from the classroom to broader society. This literature review aims to dissect the benefits and past results of AI integration, while also examining its controversies and barriers in wider contexts.

Keywords: Artificial Intelligence; Classroom Learning; Educational Technology.

1. Introduction

Before self-learning artificial intelligence (AI) tools even reached the market, educational technology had been consistently evolving: from orally transmitted knowledge and the invention of the printing press to the World Wide Web and the rise of search engines. Technological advancements in data access and research have historically sparked controversy in the field of education every step of the way. These developments have raised questions about learning enhancements and critical learning for generations.

As of August 2024, the international AI market is approximately valued at $196.63 billion—a $60 billion increase since 2020, with an annual growth rate of 16.4%. This rapid growth in value highlights the accelerating pace of AI advancements. Since the launch of ChatGPT in 2022, featuring GPT-3, a model with 175 billion parameters, it has vastly exceeded the previous Turing-NLG model's 17 billion parameters. In April 2024, the release of Llama 3.1 introduced a model with 405 billion parameters. Just a few months later, xAI's Memphis Supercluster, powered by 100,000 Nvidia H100 GPUs, set another new benchmark in AI capabilities and expansion.

These rapid advancements in AI models indicate the most transformative shift in the current and future landscape of education; consequently, as AI becomes more sophisticated, it raises unprecedented opportunities for learning and automation in education. However, these opportunities also incite critical contro-

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versies and questions about the role of AI in classrooms—how can advanced AI tools support educators without replacing the essential human elements of learning?

1.1 History of Artificial Intelligence Research

The emergence of AI traces back to the mid-20th century: In 1950, Alan Turing published Computer Machinery and Intelligence, proposing the Turing Test as a measure of machine learning versus human intelligence. Consequently, the term "artificial intelligence" was officially coined in 1956, marking the birth of artificial intelligence. Moving forward, between 1957 and 1979, AI research experienced rapid growth but also many setbacks. During the late 1960s, the majority of developmental AI funding was sourced from the Defense Advanced Research Projects Agency (DARPA). However, after the Mansfield Amendment was approved, requiring DARPA to only fund research directed by a specific mission, they withdrew funding for new AI research due to AI's novelty at the time. This led to the first notable "AI winter" in the 1970s, where nearly all AI research paused. (Buchanan, 2020)

Once organizations like DARPA began funding AI research again, new programming languages and algorithms were developed, and AI started to enter mainstream culture. In the 1980s, known as the "AI boom," there was a significant rise in AI advancements due to increased government funding. The 1980s marked the commercial release of XCON, the first-ever expert system, and saw initial advancements in deep learning and expert systems.

These historical developments highlight the rapid and relentless pace at which AI has advanced, leading to the present day, where AI has become an integral part of everyday life. The proliferation of AI tools, such as virtual assistants (Apple Siri, Amazon Alexa, Microsoft Cortana) and search engines (Google, Firefox, Bing), demonstrates AI's growing influence (Harris, 2022). However, it is important to note that while these search engines are advanced, they are not products of machine learning but rather traditional algorithms directing users to a database. The rise of deep learning and big data in recent years has further accelerated AI's capabilities, as seen with OpenAI's development of GPT-3 in 2020 and DALL-E in 2021, which can process and understand images to produce accurate captions.

The integration of AI into every corner of education is inevitable. The rapid development of AI technologies offers both advantages and challenges for teachers and students alike. As AI becomes embedded into resources and systems, understanding its impact on students' learning outcomes becomes crucial. Teachers and students need to recognize and adapt to this transformative element, as the direction of education will undoubtedly be shaped by AI advancements.

1.2 Purpose of this Study

This literature review aims to explore the multifaceted effects of AI tools on learning outcomes, distinguishing between their beneficial and detrimental impacts and considering how AI can be effectively integrated into teaching practices to complement rather than replace human intelligence. Through this focused scope, this review will seek a balanced perspective on the negative effects of AI tools on education and student learning (e.g., literacy, attention span, and information retention) and the positive enhancements AI can bring to classroom learning through new advancements. Moreover, this paper will compare the effects of AI tools on classroom learning with AI's broader educational impact, considering international influences on education and predicting how AI integration will intersect with these factors..

2. Past Integration of AI in Education

AI's real-life applications range from virtual assistants and web browsers to even self-driving cars; however, in the classroom, AI applications must take a different approach to support individual learning. According to multiple studies selected for this literature review, educators have increasingly adopted AI as a teaching tool over the past decade. Between 2017 and 2021, the use of AI in education grew by 47.5% in the U.S. (Thuong T.K. Nguyen, Nguyen, & Tran, 2023).

Focusing on how teachers have been utilizing AI in the past decade, studies show that teachers primarily employ simulation-based instruction and machine learning models to optimize learning outcomes through tools like Cobots, AIWBES (AI Web-Based Education Systems), and LLMs. The specific algorithms implemented include machine learning, data mining, and knowledge models (as shown in the figure below). Machine learning functions by analyzing training data to identify patterns, enabling the model to make educational predictions, such as matching students to universities based on achievements and preferences. By adjusting based on each student's performance, AIWBES assists teachers in tailoring teaching methods to enhance student comprehension. This model is particularly effective in grading student exams with higher accuracy and speed.

In this context, data mining employs machine learning regressions to predict students' future performance based on demographic information and past results. Learning analytics then uses this data to improve educational practices, assisting schools in monitoring and supporting each

student's progress (e.g., identifying potential dropouts). In Figure 1, Nguyen illustrates how these AI functions work alongside teachers in a classroom setting.

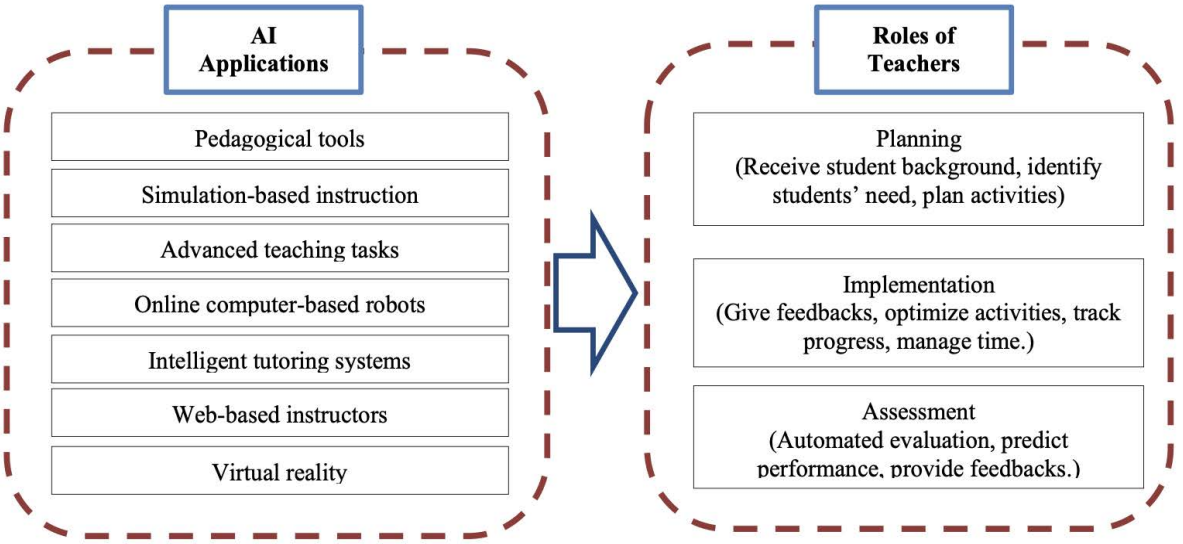

Figure 1: AI applications in supporting teachers.

The use of AI in classroom instruction, pedagogical aid, and education administration has considerably benefitted classroom learning outcomes (Chen, Chen, & Lin, 2020). In the past, AI integration has significantly improved accessibility for students with disabilities and provided administration aid to reduce teacher workload. In Figure 2 down below, Chen outlines the specific tasks AI can effectively aid in when trained properly.

	The work AI can do in education
Administration	● Perform the administrative tasks faster that consume much of instructors' time, such as grading exams and providing feedback. ● Identify the learning styles and preferences of each of their students, helping them build personalized learning plan. ● Assist instructors in decision support and data-driven work. ● Give feedback and work with student timely and directly.
Instruction	● Anticipate how well a student exceed expectations in projects and exercises and the odds of dropping out of school. ● Analyze the syllabus and course material to propose customized content. ● Allow instruction beyond the classroom and into the higher-level education, supporting collaboration. ● Tailor teaching method for each student based on their personal data. ● Help instructors create personalized learning plans for each student.
Learning	● Uncover learning shortcomings of student and address them early in education. ● Customize the university course selection for students. ● Predict the career path for each student by gathering studying data ● Detect learning state and apply intelligent adaptive intervention to students.

Figure 2. The work AI can do in education.

In a 2023 experiment with 20 South Korean undergraduate students, the effects of AI collaboration on specifically creative tasks were investigated. [The AI tested was AutoDraw: Machine learning system that provides image suggestions from doodles of user] Results revealed that AI-collaboration improved students' creativity, particularly students who initially exemplified lower drawing skills (Kim & Lee, 2023).

1. Students with positive AI- attitudes: 1.15-point improvement in creativity from AI-collaboration
2. The study's Wilcoxon signed-rank test showed statistically significant improvements in expressivity and public utility
3. Students with the highest level of drawing skills exemplified disappointment with Autodraw's results AI's automation contributes to performance-enhancement, but

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lacks in reflecting individual student's domain-specific skills and agency. [Potential Downside]

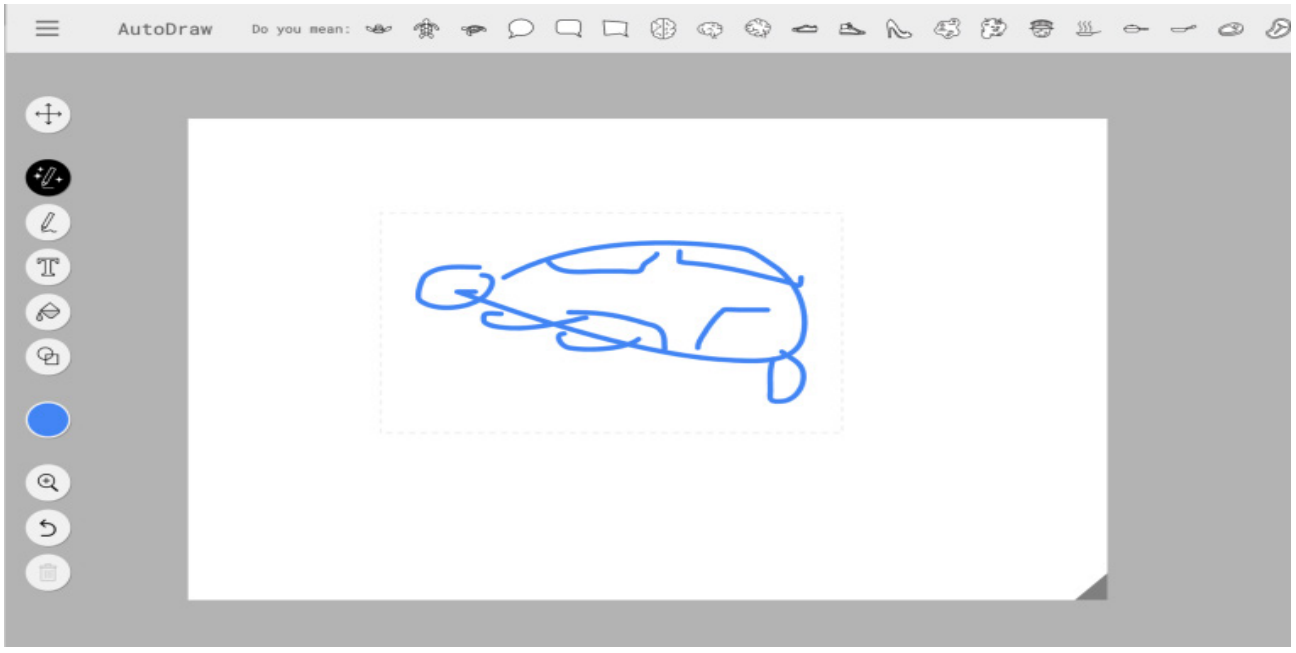

Figure 3. Original drawing inputted into Autodraw by author.

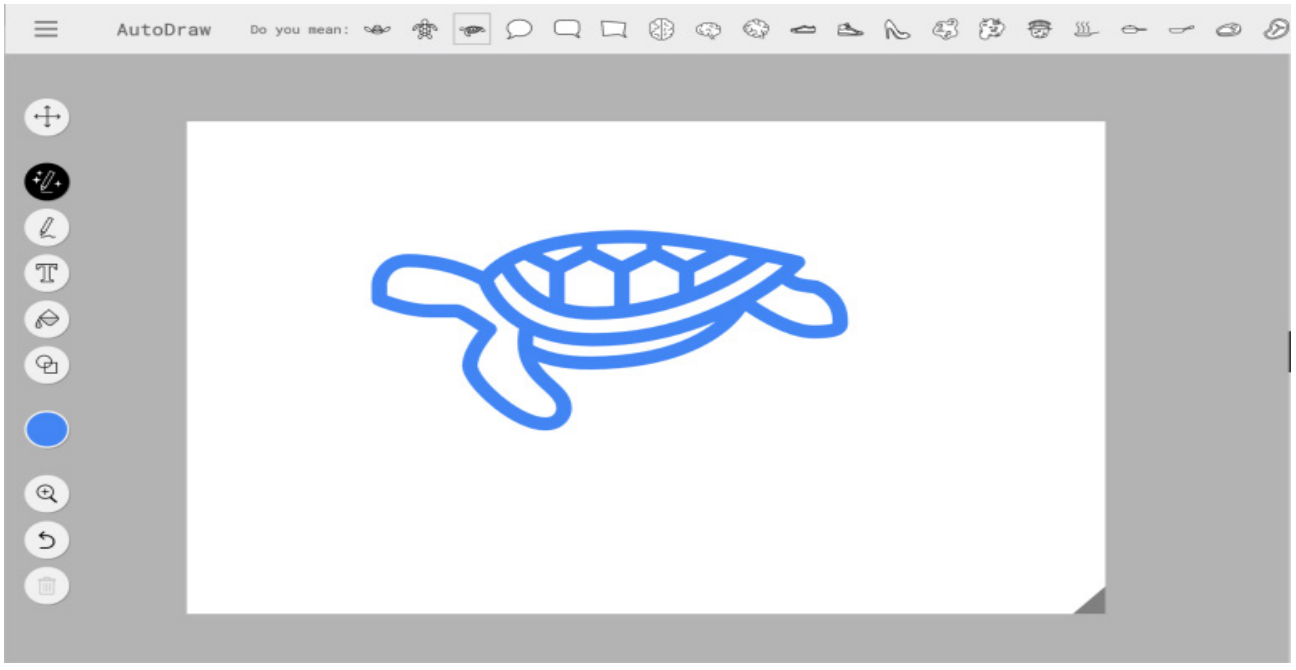

Figure 4. Immediate output from Autodraw enhancing input.

74 graduate students compared AI-generated [LLM] feedback using ChatGPT to human feedback in an argumentative essay activity (Seyyed Kazem Banihashem et al., 2024).

1. Results: Peer feedback focused on identifying and criticizing flaws in the essays,
2. ChatGPT provided more descriptive and structural feedback.
3. Both AI and human feedback improves essay writing through accurate feedback.
4. Quality of AI feedback was comparable to peer feedback: Integrating AI in grading can effectively alleviate heavy workload. [Positive Effect]

Examples	Feedback Source	
	ChatGPT-generated feedback	Peer-generated feedback
Example #1	*The essay presents multiple arguments against PIF sterilization, such as the possibility of recontamination during production and preparation, the presence of beneficial components that may be lost with sterilization, and the risk being relevant only to a small group of infants. However, some of these arguments lack detailed elaboration and specific evidence.*	*Since I think your position is missing in the introduction section, I think the response to counter arguments is also somewhat missing. Personally, I would suggest that you could first add your position, which would also make the response to counter arguments easier.*
Example #2	*The essay nicely argues that consumers are ultimately responsible for the safe consumption of food. It highlights that even with regulations in place, consumers need to make informed decisions about handling and preparing food to minimize foodborne illness risks. To strengthen this argument, the essay could provide real-life examples or case studies where lack of consumer responsibility led to foodborne illnesses, highlighting the need for awareness and adherence to safe food practices.*	*I feel that your position is missing, I didn't see your clear stand in the introduction section, perhaps you could add some simple sentences to show where you stand.*
Example #3	*The body of the essay presents multiple reasons why PIF should be sterile, such as the risk of harmful bacteria like Cronobacter sakazakii, the extended shelf life, and the risks of temperature abuse and improper cleaning. Each reason is supported with relevant citations, which adds credibility to the argument. However, the essay lacks a counterargument section that addresses the opposing perspective. To create a more comprehensive and persuasive essay, it's essential to acknowledge the counterarguments and refute them with evidence.*	*The responses are explained. However, no justification is presented against the counter argument of the European Commission. The mention of GMOs does not explain why the argument of the European Commission would be invalid.*

Affective | Cognitive- Descriptive | Cognitive-Identification | Cognitive-Justification | Constructive

Figure 5. List of peer-generated and ChatGPT-generated feedback examples.

An experiment conducted with elementary school students: Measured physical, social-emotional, and intellectual outcomes from a robot-building activity guided by AI(Sdenka Zobeida Salas-Pilco, 2020). [System used: LEGO WeDo paired with XO laptops for programming]

1. Results: Improved students' learning across all three domains [Positive Effect]

2. Intellectual: Improved problem-solving skills as students learned programming concepts → Significant enhancement in creativity and innovation when developing solutions → A deepened understanding of robotics through trial-and-error process

3. Social-emotional: Increased self-confidence in STEM-interested students → Stronger collaboration and teamwork among groups → Enhanced social responsibility.

4. Physical: Students' fine motor skills improved as they continued to manipulate small robotic pieces → Improved hand-eye coordination assembly → Greater fluency in using software, increasing technology literacy.

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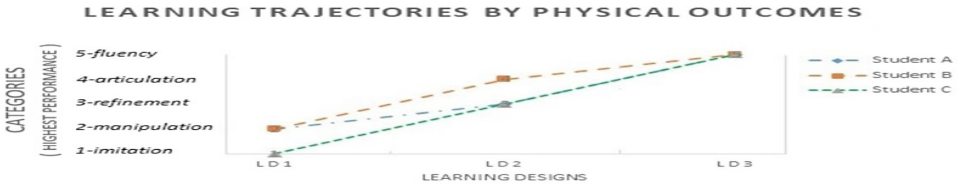

Figure 1: Students' learning trajectories by physical outcomes in each learning design

Figure 2: Students' learning trajectories by social-emotional outcomes in each learning design

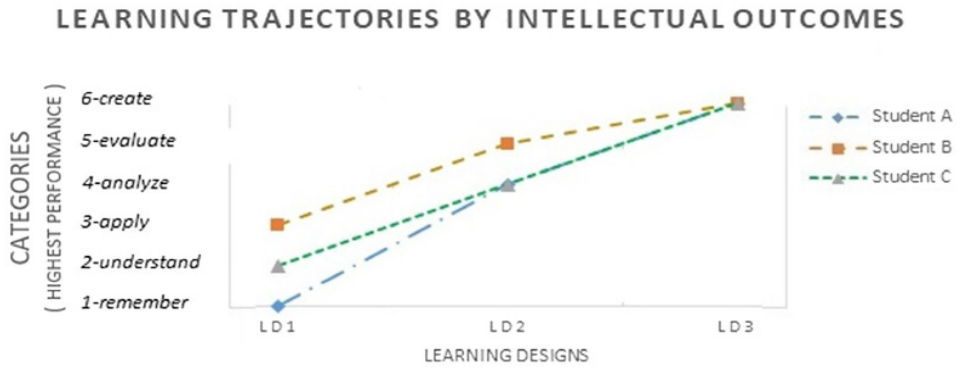

Figure 3: Students' learning trajectories by intellectual outcomes in each learning design

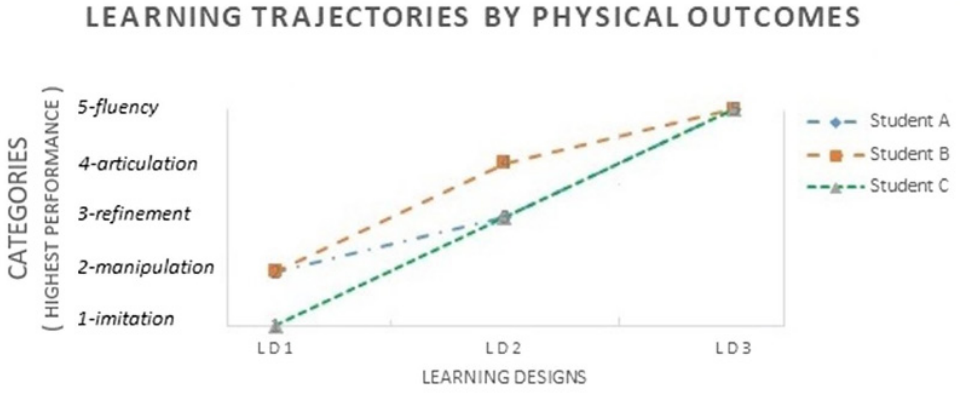

Figure 6. Students' learning trajectories in all three domains.

Lynn and Emanuel review tested the effectiveness of how recommender systems aid students with course selection [Hybrid recommender systems combining content-based and collaborative filtering methods] (Lynn & Emanuel, 2021).

1. Hybrid recommender systems provided highly personalized course recommendations.

2. The system significantly improved the course selection process by gauging a student's academic backgrounds, skill performance, and career goals. [Positive Effect].

3. System still faced limitations in gauging complexities of students' personal interests and long-term objectives: Less engagement from a larger demographic of students [Potential Downside]

In this context [a rather narrow scope], "effectiveness" is measured by how algorithms deliver relevant content following an institution's curriculum while catering to a student's specific needs. Simultaneously, students have

evaluated their retention of the new system and their comfortability with AI adaptation. From the accumulation of data and net positive effects this study has gathered, sensible AI integration has increased teachers' job effectiveness, efficiency, and caliber. Trained-AI integration in education enhances intellectual outcomes in classrooms.

3. Discussion: Artificial Intelligence Impact from a Larger Scope

AI's real-life applications range from virtual assistants and web browsers to even self-driving cars; however, in classrooms, AI must adapt to support individual learning. According to multiple studies referenced in this literature review, educators have been adopting AI in various ways as a teaching tool over the past decade. Between 2017 and 2021, the use of AI in education grew by 47.5% in the U.S. (Thuong T.K. Nguyen, Nguyen, & Tran, 2023).

AI systems, when trained on incomplete data, can perpetuate existing biases within students' learning environments. Additionally, relying heavily on AI-generated content can compromise critical thinking skills, potentially hindering students' ability to think independently. Furthermore, while AI-based systems can combat cheating and plagiarism by analyzing writing styles for similarities across submitted files, ethical concerns persist around balancing academic integrity with individual learning needs (Inna Nomerovska, 2023).

Overall, incorporating AI raises significant ethical concerns about privacy, integrity, and the authenticity of human interactions. For example, in a longitudinal study on student accommodations, researchers in 1993 sparked debates over using calculators and spell-check programs for students with disabilities, a practice initially restricted to specific groups (Stefan and Kerr, 2017). These conversations also touch on the issue of equitable access to AI and advanced technologies in education across diverse demographics, potentially reinforcing existing systemic inequalities.

Despite bans on tools like ChatGPT in schools and colleges, experts increasingly recognize the benefits of using AI in education when implemented thoughtfully. Advanced chatbots, for example, can enhance classroom interactivity, support media literacy, create personalized lesson plans, and streamline administrative tasks. Educational technology companies are integrating AI into their platforms, making it crucial for schools to ensure AI use complements rather than replaces human intelligence.

A primary concern regarding official AI integration in classrooms is the potential impact on human interaction and social skills. This concern is valid, considering the documented negative effects of increased technology use on intellectual and social development, as seen during the COVID-19 pandemic. According to Rogers, school closures during the pandemic led to decreased peer interaction and increased isolation, affecting students' emotional development, attention spans, and academic performance. Symptoms of ADHD in children, including inattention, hyperactivity, and impulsivity, peaked during this period, exacerbated by the lack of structured school environments and prolonged technology exposure (Rogers & MacLean, 2023).

Roger's meta-analysis linked increased technology exposure to declining cognitive ability and academic performance, suggesting that remote learning contributed to lower student grades (Vijayan, 2021).

The most significant barrier to AI integration in education is the lack of consensus on AI literacy and the political debates surrounding its adoption. The disparity between public and private educational institutions in the U.S. widens this divide, as public schools, often located in lower-income areas, lack resources and political support to implement AI literacy programs. In contrast, private institutions can more easily adopt AI technologies, exacerbating educational inequality.

Cascal-Otero argues that integrating AI into the national curriculum requires a more collaborative approach, as current implementations are scattered and unstandardized globally. This inconsistency increases educational inequalities, especially in countries like China and the United States, where initiatives like AI4Future integrate AI into secondary education but with varied resource availability and training support (Casal-Otero et al., 2023; Walter, 2024).

Additionally, a lack of AI literacy, particularly among older generations, has fueled distrust in AI applications. Vaccari notes that older users are more likely to be suspicious of AI and are more vulnerable to deepfakes, with 33.2% of older respondents expressing uncertainty about their ability to detect these manipulations (Mustak, Salminen, Mäntymäki, Rahman, & Dwivedi, 2023). This distrust, held by many who wield influence in our political landscape, presents tangible challenges for integrating AI into educational settings (Vaccari & Chadwick, 2020).

Another public concern with AI integration centers on its impact on future careers. While AI has significantly benefited STEM fields, there is worry about its potential to displace workers in art-related industries. In the film industry, for example, AI's ability to generate scripts, special effects, and CGI has raised alarms about job security, as reflected in the 2023 Writers Guild of America strike. Cetinic reports that 42% of American workers fear AI replacement (Cetinic & She, 2022).

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The broader labor market also faces potential disruptions from AI. A report by Carl Benedikt Frey and Michael Osborne found that 47% of U.S. jobs are at high risk of automation, with arts and media careers particularly vulnerable (Cheng, 2024). Lastly, AI's role in the arts raises ethical questions about the value of human creativity. Although AI-generated art often appears indistinguishable from human-made pieces, many argue that AI lacks the inherent creativity and cultural context that enriches artistic works, leaving artists at risk of job displacement.

4. Conclusion

The integration of AI in education brings vast potential for enhancing intellectual outcomes and reshaping traditional curricula. At its current development pace, AI could be a transformative tool in education, but its rapid evolution risks widening existing socioeconomic disparities, especially in access to AI-driven educational tools. This disparity complicates the goal of building an equitable education system.

While AI promises greater efficiency in classrooms, educators face the challenge of balancing its benefits with the ethical concerns surrounding its use. Striking a balance between leveraging AI's capabilities and preserving the critical human elements of teaching will be essential to shaping the future of education responsibly.

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