Exploring Teacher Trainees' Perspectives on Integrating Artificial Intelligence (AI) Into Primary School Science Education: A Case Study

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.90300120

Received: 01 March 2025; Accepted: 05 March 2025; Published: 03 April 2025

ABSTRACT

The integration of Artificial Intelligence (AI) in education has become a significant area of research due to its potential to transform teaching and learning (T&L) processes. However, little is known about the perspectives of teacher trainees regarding AI integration in primary school science education. This study addresses this gap by exploring the attitudes, beliefs and concerns of teacher trainees toward AI implementation. The primary objective is to identify the possibility, challenges and effectiveness of AI in primary school science teaching. This study is grounded in the Technology Acceptance Model (TAM), which assess users' acceptance of new technologies. A qualitative case study design is employed using structured interviews with four purposively selected teacher trainees. The collected data undergo thematic analysis to uncover patterns and themes related to AI integration. The findings provided that AI has the potential to transform science teaching by offering personalised learning experiences and making abstract concepts more accessible through visualisations and simulations. However, significant challenges remain including inadequate teacher training and unequal access to AI tools especially in rural areas. The study concludes that while AI presents great opportunities for enhancing primary science education, address barriers like training and access is critical for its successful integration.

Keywords: AI integration, STEM education, Technology Acceptance Model (TAM)

INTRODUCTION

In today's global economy, driven by rapid technological advancements, the need for a skilled and adaptable workforce is crucial. Education plays a key role in preparing students for an increasingly complex and interconnected world (Razak, 2023). In Malaysia, as in many countries, the education system faces the challenge of equipping students with essential skills for the future. Technological innovation like artificial intelligence (AI), automation and data analytics are transforming industries and reshaping job markets (Javaid et al., 2022). As a result, demand for individuals skilled in Science, Technology, Engineering and Mathematics (STEM) is growing along with the need for critical thinking, creativity and adaptability (Li, 2022; Poláková et al., 2023).

The integration of Artificial Intelligence (AI) in education has gained attention for its ability to enhance T&L through personalised experiences and data-driven insights (Ng et al., 2023). AI technologies including intelligent tutoring system, adaptive learning platforms and educational data mining create individualised and efficient learning environment that enable teacher tailor instruction for diverse student need (Bhutoria, 2022; Kamalov et al., 2023). In primary school science, AI-driven tools like virtual labs, simulations and augmented

reality applications allow students to explore scientific phenomena immersively to improve understanding and curiosity (Dagmar Mercedes Heeg & Avraamidou, 2023). AI also enhances cognitive and affective outcomes, motivation and computational thinking with tools such as intelligent tutoring systems and automated grading increasing learning efficiency and accessibility (Rizvi et al., 2023; Rania Abdalla Abdulmunem, 2023).

However, successful AI implementation requires professional development and institutional support (Akhmadieva et al., 2023). Teachers must receive training on AI applications and have access to resources that support their use of AI tools. Without such support, misconceptions about AI and a lack of preparedness could hinder the effective integration of these technologies into science teaching (Kim & Kim, 2022). Hence, this research attempts to explore teacher trainees' perspectives and to achieve the following objectives: i) to explore the possibility of implement AI in teaching and learning (T&L) process of primary science education and its effectiveness. ii) to explore the benefits and limitations, challenges and opportunity in implementing AI in T&L process.

Research Questions

The overall and specific research questions addressed in this study are: What are the science teacher trainees' perspectives towards integration of AI in primary school science education?

1. How did AI possible to implement in T&L process of primary school science and its effectiveness?

2. What did the teacher trainees' view toward the benefits and limitations, challenges and opportunities in implementing AI in science T&L process.

METHODOLOGY

This study used a qualitative case study design that employing interviews to explore science teacher trainees' perspectives on AI integration in primary school science education to enable rich, in-depth insights into their experiences, attitudes and contextual understanding. This study used purposive sampling which is a non-probability technique to select four teacher trainees meeting specific criteria. Participants were currently enrolled in teacher training programs which experienced or on-going practicum in primary science teaching and familiar with AI technologies. Their identities remained confidential and represented by alphabets RP (Research participants). Structured interviews with open-ended questions were conducted via Google Meet to explore teacher trainee's perceptions of AI integration. Responses were recorded and the interview protocol covered key themes such as effectiveness, benefits, drawbacks, challenges and opportunities. The research procedure began by defining the study focus, objectives and questions. By using purposive sampling, participants experienced in AI technologies and primary science teaching were recruited. Structured virtual interviews were conducted, recorded with consent and transcribed verbatim. Thematic analysis was applied to identify key patterns and themes addressing the research questions on AI integration. Interview transcripts were analysed using thematic analysis to identify key patterns, themes and categorized related to AI integration perceptions, benefits and limitations, challenges and opportunities. Themes were aligned with research questions and connections were described. Results were analysed and discussed to address research questions and achieve objectives.

FINDINGS

Interview had been carried out with the four RP to explore their perceptions on possibilities, effectiveness, benefits and limitations, challenges and opportunities to implement AI in primary school science T&L. The findings were organized according to suitable themes according to research questions in order to achieve the research objectives.

Table 1 Themes, sub-themes and summary of the findings

Themes	Sub-themes	Summary
Effectiveness	1. Enhanced understanding and participation	A simplifies and visualizes abstract science concepts such as energy and the solar system through immersive simulations and 3D models.
Benefits	1. Personalised learning	AI enables personalized learning by tailoring lesson plans, instruction and teaching aids to meet individual student needs to enhance engagement and accommodating varying learning abilities.
	2. Interactive learning	AI enhances interactive learning by providing engaging simulations that make complex concepts more accessible and enjoyable.
	3. Assessment of students	AI streamlines student assessment by providing immediate feedback that analyse performance and offering detailed insights for both students and teachers.
Limitations	1. Overreliance	Overreliance on AI may hinder students' critical thinking and problem-solving skills.
	2. Limit hands-on experiences	AI may limit hands-on learning experiences particularly in topics requiring physical experimentation.
Challenges	1. Lack of training	Lack of training hinders teachers' ability to effectively use and integrate AI tools in teaching and learning.
	2. Unequal of access	Unequal access to technology especially in rural areas limits AI integration in schools.
Opportunities	1. Build skills	AI helps build essential skills, foster creativity, imagination and engagement for students' future success.
	2. Time saving	AI saves time by automating record-keeping and lesson preparation that allow teachers to focus more on instruction.

DISCUSSION

Research question (i): How did AI possible to implement in T&L process of primary school science and its effectiveness?

The effectiveness of AI in primary school science teaching is tied to its ability to enhance both understanding and participation (Zhang et al., 2024). According Kumar et al. (2023), Muhamad Fazil Ahmad and Rohila (2019), AI tools such as VR and AR help make abstract concepts like solar system and energy become more accessible and engaging through interactive simulations and models as noted by the participants. This approach aligns with constructivist theory which emphasises active learning through hands-on experiences (Marougkas et al., 2023; Jaziar Radianti et al., 2019).

In accordance with Câmara Olim et al. (2024) AI-driven tools create immersive environments that deepen understanding and boost engagement by allowing students to explore scientific phenomena interactively. Moreover, Zhao (2022) and Adesina Isaac Okunade (2024) had mentioned that AI personalises learning by adapting content to individual learning styles and paces can further enhance participation and comprehension. This tailored approach that highlighted by RP 3 makes learning more interactive and responsive to students' needs that facilitate meaningful engagement with challenging content.

RP 3:

"*Science teachers can adapt AI with personalized learning experience to match students learning ability to help them understand the concept better. AI is an interactive simulation that create fun learning and engaging learning environment*."

Research question (ii): What did the teacher trainees' view toward the benefits and limitations, challenges and opportunities in implementing AI in science T&L process.

The integration of AI in primary science teaching brings several advantages. In agreement with Rizvi (2023) and Frank (2024), AI facilitates personalised learning by tailoring lesson plans and content to students' needs to create a more inclusive and effective educational experience. Teacher trainees highlighted AI's role in generating adaptive lesson ideas that allow educators to provide varied support for students with different abilities (Igbokwe, 2023; Jin et al., 2023). Furthermore, AI-driven tools like VR and AR enhance interactive learning that transform abstract science concepts into engaging, visual experiences that foster student participation and comprehension (Barnett-Itzhaki et al., 2023).

RP 1:

"*I think it is useful and beneficial in mainly two ways. First, it provides a personalized learning to students make sure they have the support they need in understanding a topic. Second, it provides a better quality of assessment with analysis which not only saves teachers' time in marking and analysis but also helps teacher to identify which section of a topic is comparatively weaker among a class of students.*"

Despite these benefits, teacher trainees expressed concerns about AI's potential overreliance which could diminish students' critical thinking and problem-solving skills if they become too dependent on technology for answer (Selwyn, 2024). Science education benefits from students actively engaging in inquiry, questioning and problem-solving skills that may be compromised with excessive AI use (Rizvi, 2023). In addition, as specified by Meyer et al. (2019), AI's limitations in hands-on learning were noted. While simulations provide visual understanding, yet they cannot fully replace the sensory experiences of real-world experiments that essential in science education.

RP 4:

"*However, overreliance on AI might limit student's hands-on learning experiences and hence hinders student's development of critical thinking."*

The key challenges to effective AI implementation include the lack of training among teachers and unequal access to technology (Velander et al., 2023). Teacher trainees emphasised the need for professional development to help educators understand and use AI tools effectively (Joseph et al., 2021; Won, 2022). Besides, according to Mhlanga (2024), unequal access to AI technology was raised as a barrier particularly in under-resourced and rural school that lack infrastructure. This digital divide could limit AI's transformative potential to only well-resourced schools and hinder equitable access to quality education and reinforcing educational disparities.

RP 3:

"Not all schools have equal access to technology and tools, especially in rural area. Next, science teachers need training to use AI tool effectively and integrate it to T&L."

In terms of opportunities, Walter (2024) agree with AI supports skill-building in problem-solving, digital literacy and creativity that prepare students for technology-driven future. AI also presents a significant time-saving benefits by automating routine tasks like grading and lesson planning to allow teachers to focus on individualised instruction and engagement (Firuz Kamalov et al., 2023). By integrating AI thoughtfully, educators can create more efficient, skill-enhancing learning environments that benefits both teachers and students.

RP 1:

"It helps to build skills which is required for students' future life. It exposes students with ways to use AI and build interest towards AI of students through the exposure. This also increase AI literacy of students."

RP 2:

"Additionally, AI can assist teachers by automating routine tasks, such as grading and lesson planning, freeing up more time for them to focus on individualized instruction and student support."

CONCLUSIONS

The study reveals that while science teacher trainees are generally optimistic about the potential of AI in primary school science education, there are significant challenges that need to be addressed. These include training gaps, resource constraints and concerns about balancing AI with traditional teaching methods. Addressing these challenges will require coordinated efforts from educational institutions, policymakers and teacher training programs. Ultimately, AI has the potential to make science education more engaging and effective but its success will depend on the preparedness and perceptions of future educators. By uncovering the opportunities and barriers perceived by future educators, this study contributes valuable insights that can inform policy and training programs to ensure that AI tools are used effectively and responsibly in education. The implications suggest that for AI to transform teaching practices meaningfully, targeted teacher training, investment in infrastructure and a thoughtful integration strategy are essential. This research underscores the importance of preparing teacher trainees to navigate and utilise AI effectively so that contribute to a more adaptive and student-centered educational landscape.

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