A Concept Paper on Readiness in Artificial Intelligence (AI) Mastery and its Impact on 21st Century Pedagogy among Pre-Service History Teachers

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ABSTRACT

This concept paper investigates the readiness of pre-service History teachers to integrate Artificial Intelligence (AI) into secondary school education, in response to the increasing influence of advanced technologies in contemporary pedagogy. Anchored in Vygotsky's Constructivist Theory and the Technological Pedagogical Content Knowledge (TPACK) framework, the study aims to explore the gap between teachers' awareness of AI and their practical and ethical preparedness to implement AI tools in the 21st century pedagogy classroom. Employing a mixed-methods design, the proposed study will gather quantitative data through structured questionnaires administered to 100 teacher trainees and qualitative insights via in-depth interviews with 20 selected participants. Preliminary observations suggest that while awareness of AI is relatively high among pre-service teachers, there is limited understanding of its pedagogical applications and ethical implications. Key barriers include insufficient training, limited access to digital infrastructure, and lack of institutional support, alongside concerns about data privacy and algorithmic bias. Despite these limitations, pre-service teachers express a strong interest in the potential of AI to enhance differentiated instruction, automate administrative tasks, and improve student engagement. This paper advocates for comprehensive reform in teacher education, emphasizing the integration of experiential AI training, faculty upskilling, equitable technological access, and digital ethics instruction. By addressing these areas, teacher preparation programs can cultivate educators who are not only technologically adept but also ethically informed and pedagogically innovative. The findings from this proposed study aim to contribute to ongoing discourse on equipping future teachers to navigate and lead in AI-augmented educational environments.

Keywords: Artificial Intelligence, Pre-service History Teachers, 21st Pedagogy

INTRODUCTION

History pre-service teachers, are tasked not only with developing foundational literacy and numeracy in young learners but also fostering critical thinking, creativity, and digital literacy. Their role is thus multifaceted which they must be technologically competent, pedagogically innovative, and emotionally attuned to the developmental needs of their students. However, there is mounting evidence that many teacher preparation programs have yet to fully AI competencies within their curricula. Teachers-in-training often receive limited exposure to emerging educational technologies or are offered only theoretical overviews without hands-on experience (Bekdemir, 2024; Roshan et al.,2024). Furthermore, the learning environments of the 21st century are increasingly characterized by personalization, interactivity, and real-time feedback, all of which are made possible through AI and digital platforms. For teachers to remain relevant and effective, they must possess a deep understanding of how to deploy these tools for formative assessment, differentiated instruction, and behavior management. Yet, multiple studies report that pre-service teachers frequently lack confidence in using AI tools due to insufficient training, limited access to technology, and the absence of institutional support structures (Chuyen & Vinh, 2025; Rajapakse et al., 2024). The implications are particularly significant for early childhood education, where digital fluency must be balanced with age-appropriate pedagogy.

Compounding the issue is the ethical dimension of AI use in education. Teachers must be equipped to navigate issues such as data privacy, algorithmic bias, and the socio-emotional impact of AI-mediated learning

environments. AI in education is not merely a tool but it is also a powerful mediator of values, access, and equity. As such, teacher education must incorporate a critical lens through which future educators can interrogate and evaluate the technologies they are expected to use. Ethical readiness must be seen as equally important as technical competency (Abisheva et al., 2024; Yue et al., 2024). Lastly, the global agenda for 21st century education underscores the urgency for systemic reform in teacher education. Governments and educational institutions are under pressure to produce educators who are not only technologically competent but also visionary leaders capable of leveraging technology for inclusive, equitable, and high-quality education. This necessitates a paradigm shift in teacher trainingfrom content delivery to capacity building for innovation, adaptation, and leadership in digital learning contexts (Li & Liang, 2025; Harakchiyska & Vassilev, 2024). This study aims to evaluate the current state of pre-service secondary school teacher in History subject readiness for AI integration in 21st century pedagogy at the Faculty of Education and Sports Studies, University Malaysia Sabah in Education with History programs.

BACKGROUND

Although discussions around the rise of artificial intelligence (AI) have gained global momentum, empirical studies suggest that many teacher training programs are not keeping pace with these technological developments. Across various contexts, pre-service teachers often report a lack of adequate training in how to effectively use AI for pedagogical purposes. The existing literature points to a significant disparity between awareness and actual preparedness. For instance, Wang et al. (2023) demonstrated that while most teachers recognize the educational potential of AI, many lack the cognitive, technical, and ethical readiness required for its meaningful integration (Wang et al., 2023). This readiness gap is also influenced by inconsistent institutional support and limited access to AI-related professional development resources (Roshan et al., 2024).

One major issue contributing to this readiness gap is the inadequacy of current teacher education curricula. In many institutions, the focus remains on traditional content delivery, with insufficient emphasis on technology enhanced pedagogies or interdisciplinary competencies such as AI ethics, digital citizenship, and data literacy. Research by Yue et al. (2024) and Chuyen and Vinh (2025) has highlighted how most pre-service teachers show strong content knowledge but lack the technological and pedagogical dimensions outlined in the Technological Pedagogical Content Knowledge (TPACK) model (Yue et al., 2024; Chuyen & Vinh, 2025). Without structured modules that include hands-on experience with AI tools, such as chatbots, adaptive learning platforms, or analytics dashboards, the trainee teachers remain underprepared for digital classrooms.

Another critical barrier to readiness is digital inequality. Access to AI tools, fast internet, and supportive infrastructure varies widely between institutions, especially between urban and rural regions. For example, Purnama et al. (2025) found that urban teachers in North Bali were far more ready to integrate AI due to better access to technological infrastructure and training compared to their rural counterparts (Purnama et al., 2025). Similarly, Rajapakse et al. (2024) observed that teachers in Sri Lanka lacked self-efficacy and content mastery in AI due to gaps in training and technological access (Rajapakse et al., 2024). These disparities call for a national and institutional strategy that ensures equitable distribution of resources, professional development, and support systems across all teacher education institutions.

Mindset and self-efficacy also play a crucial role in shaping pre-service teachers' readiness. Several studies have shown that digital confidence correlates positively with a willingness to integrate AI in the classroom. Teachers with a growth mindset are more likely to explore emerging technologies despite institutional or technical constraints (Li & Liang, 2025). However, anxiety related to AI misuse, data privacy, and fear of technology replacing traditional teaching roles also contributes to resistance (Ayanwale et al., 2022). Ghiasvand et al. (2024) emphasized the role of national culture and systemic support in shaping AI readiness, showing that factors like economic development and societal values can influence teacher attitudes significantly (Ghiasvand et al., 2024).

These challenges must be understood in the broader context of 21st century education, which envisions a learner centric, adaptive, and inclusive education system powered by smart technologies. Teachers are no longer mere content deliverers but facilitators, designers, and co-learners in a dynamic digital ecosystem. The successful implementation of this vision depends on a radical shift in how teacher training programs are

structured, assessed, and supported. As highlighted by Bekdemir (2024), the transformation toward AI integrated pedagogy cannot be achieved through fragmented reforms or one-off workshops because it requires a holistic, multi-level strategy that includes collaboration between academia, industry, and policymakers to create sustained impact.

Research Objectives

This study aims to:

1. To examine the level of readiness to use Artificial Intelligence among pre-service teachers in the History Education Program.

2. To assess the level of mastery of 21st-century pedagogy among pre-service teachers in the History Education Program.

3. To investigate the relationship between the readiness to use Artificial Intelligence and the mastery of 21st-century pedagog among pre-service teachers in the History Education Program.

4. To identify the issues, challenges, and problems in using Artificial Intelligence within 21st-century pedagogy among pre-service teachers in the History Education Program.

THEORETICAL FRAMEWORK AND RESEARCH DESIGN

This study is anchored in two key theoretical models that underpin modern educational technology integration: Vygotsky's Constructivist Theory and the Technological Pedagogical Content Knowledge (TPACK) framework. These theories offer a dual lens which are psychosocial and structural for understanding how AI and can be incorporated meaningfully into teacher education. Vygotsky's theory emphasizes the social construction of knowledge, where learning is mediated through tools and social interaction. In contemporary classrooms, artificial intelligence serves as a sophisticated mediating tool, capable of adapting instruction, offering scaffolding, and simulating teacher and student interactions (Chounta et al., 2021). The notion that cognitive development occurs in the "Zone of Proximal Development" (ZPD) directly aligns with AI's ability to provide tailored support based on learner needs, thereby expanding learning capacity.

In this context, AI functions not merely as a content delivery mechanism, but as an intelligent scaffold that enhances learner engagement, motivation, and autonomy. For example, adaptive learning platforms can dynamically adjust content difficulty, while conversational agents can guide learners through inquiry based tasks. These technologies reflect Vygotsky's principles of mediated learning, with the AI acting as a "more capable other" that supports learners within their ZPD. However, such integration necessitates that teachers understand both the affordances and limitations of AI tools, requiring a theoretical grounding that combines pedagogy, technology, and content knowledge. Here, the TPACK framework becomes particularly relevant as a comprehensive guide for developing these competencies (Yue et al., 2024).

The TPACK model, introduced by Mishra and Koehler, builds upon Shulman's concept of Pedagogical Content Knowledge by incorporating technological knowledge (TK) as an essential domain. In today's AI driven educational context, effective teaching depends on the ability to synthesize TK with pedagogical knowledge (PK) and content knowledge (CK). Teachers must not only know what to teach (CK) and how to teach it (PK), but also how technology, particularly AI, can transform both. Several studies have applied the TPACK model to evaluate teacher readiness for AI integration, often revealing deficiencies in the TK domain despite strong PK and CK foundations (Li & Liang, 2025); (Kim & Kwon, 2023). These findings underscore the need for explicit and ongoing development of technological fluency in teacher training.

To operationalize these frameworks, this study proposes a conceptual model that links AI readiness with multiple intersecting variables, including institutional support, ethical awareness, and perceived pedagogical relevance. The model assumes that AI readiness is multidimensional by comprising cognitive understanding,

practical ability, ethical sensitivity, and visionary thinking that echoing recent empirical models proposed by Wang et al. (2023) and Alshorman (2024) (Wang et al., 2023); (Alshorman, 2024). The conceptual model in this study hypothesizes that higher levels of AI readiness among pre-service teachers are positively associated with a willingness to integrate AI into teaching practice, mediated by institutional and instructional support.

This framework also acknowledges the influence of affective and contextual variables. Teachers' emotional responses to AI that ranging from enthusiasm to anxiety can significantly affect their willingness to engage with these technologies (Ayanwale et al., 2023). Similarly, the presence or absence of facilitating conditions, such as professional development opportunities and access to AI tools, can either enhance or inhibit technology integration. By aligning the theoretical underpinnings of Vygotsky and TPACK with these empirical findings, the study offers a nuanced lens through which to assess pre-service teacher readiness in the 21st century pedagogy era. This model serves as both a diagnostic tool and a roadmap for designing responsive, future focused teacher education programs.

LITERATURE REVIEW

The integration of artificial intelligence (AI) into education has opened new frontiers for personalized learning, real time feedback, and adaptive instruction. Several studies have shown that AI supported pedagogical models can enhance learner outcomes, particularly in fostering critical thinking, problem solving, and metacognitive skills. Mission et al. (2024) found that AI powered tools such as intelligent tutoring systems and learning analytics dashboards help differentiate instruction and offer personalized learning trajectories (Mission et al., 2024). Similarly, Arvin et al. (2023) highlighted how teachers using AI-based tools observed enhanced student engagement and learning outcomes, particularly when the tools were integrated into formative assessment practices (Arvin et al., 2023). However, both studies caution that without teacher readiness and training, these benefits are difficult to realize.

21st century pedagogy has been proposed as a strategic response to the demands of technologies in education, aiming to align educational content and delivery with technological advancements. This curriculum model emphasizes experiential learning, interdisciplinary knowledge, and the integration of AI, IoT, and big data analytics. Pujilestari (2024) argues that while 21st century pedagogy offers immense potential, its success hinges on the structural preparedness of institutions and the capacity of educators to adapt teaching approaches accordingly (Pujilestari, 2024). Additional research by Johari et al. (2019) and Bekdemir (2024) highlights the need to embed digital competencies, ethical reasoning, and problem-based learning into teacher education to meet the pedagogical goals of 21st centrury pedagogy (Johari et al., 2019; Bekdemir, 2024).

Studies have emphasized simulation based learning and AI integrated practicum modules, which allow pre-service teachers to develop practical experience with technology in controlled, reflective settings (Harakchiyska & Vassilev, 2024). However, implementation remains inconsistent across institutions, often limited by resource availability, lack of faculty training, or outdated curricula. The use of digital tools in classroom teaching has been widely studied. Nguyen et al. (2023) examined AI supported language learning platforms and found they not only improved learner autonomy and language proficiency but also encouraged more reflective teaching practices (Nguyen et al., 2023).

A recurring theme in the literature is the ethical dimension of AI in education. Teachers express concern over student data privacy, algorithmic bias, surveillance risks, and the potential dehumanization of the learning experience. Abisheva et al. (2024) explored ethical competence development in Kazakhstan and proposed a six-dimensional framework for integrating ethics into AI training for EFL teachers (Abisheva et al., 2024). Similarly, Chounta et al. (2021) emphasized the importance of incorporating Fairness, Accountability, Transparency, and Ethics (FATE) principles in AI supported education environments in Estonia (Chounta et al., 2021). These studies suggest that ethical readiness is just as important as technological or pedagogical competence, and that ethical reflection must be embedded into all stages of teacher training and not treated as an afterthought.

METHODOLOGY

This study will adopts a mixed-methods exploratory design, combining both quantitative and qualitative data collection to provide a comprehensive understanding of pre-service teachers' readiness for AI integration in the context of 21st century pedagogy. The rationale for this design is rooted in the need to capture not only the breadth of participants' knowledge and attitudes but also the depth of their lived experiences. Quantitative data was collected via structured questionnaires distributed to a purposive sample of 100 students from Education with History Programme in Faculty of Education and Sports Studies, university Malaysia Sabah.

Qualitative data was obtained through semi-structured interviews conducted with a subset of 20 participants from the initial survey pool. These interviews were designed to delve deeper into participants' reflections on their coursework, practicum experiences, and perceived barriers to AI integration. The themes were cross validated with quantitative findings to identify convergences and divergences, thus increasing the reliability of the overall analysis. This triangulated approach allows the study to construct a more nuanced portrayal of the institutional and personal factors affecting AI readiness. To ensure data validity and reliability, Cronbach's alpha was used to assess internal consistency, yielding a value of 0.85, which indicates high reliability. The credibility of qualitative data was reinforced through member checking, peer debriefing, and methodological triangulation. This comprehensive design ensures that the findings are not only statistically robust but also contextually rich and grounded in real world teaching experiences.

EXPECTED FINDINGS

It is anticipated that the study will reveal a general awareness of artificial intelligence (AI) concepts among pre-service teachers, primarily developed through academic exposure and digital media. However, their understanding is expected to be superficial, with AI often associated with digital assistants or smart technologies rather than seen as pedagogical tools. This indicates a potential gap between surface-level awareness and deeper conceptual or practical knowledge of AI in teaching and learning. In terms of digital competency, it is expected that pre-service teachers may perceive themselves as having limited ability to effectively utilize AI based tools in an educational context.

While there may be a strong interest and willingness to explore technologies such as adaptive learning systems, automated assessment tools, and intelligent tutoring platforms, actual usage is likely to be constrained by limited institutional support, lack of structured training, and insufficient access to technological infrastructure. Despite these challenges, the study is likely to find that participants recognize the transformative potential of AI in supporting 21st-century pedagogy. Opportunities such as personalized learning, administrative efficiency, and enhanced student engagement are expected to be highlighted. Nevertheless, ethical concerns, particularly those related to data privacy, equity, and the over reliance on automation, are also expected to emerge as critical considerations. These findings will underscore the importance of integrating both technical skills and digital ethics into teacher education programs to ensure balanced and responsible AI adoption in future classrooms.

IMPLICATIONS AND CONTRIBUTIONS

The findings call for immediate pedagogical reforms in teacher education programs to align with the competencies required for Education 4.0. AI and 21st century must become core components of teacher training curricula, with a focus on experiential learning. Universities should implement lab based practicums that allow pre-service teachers to design, deploy, and evaluate AI driven lesson plans. This not only improves technological fluency but also fosters pedagogical innovation and reflective practice. In parallel, institutional support systems must be strengthened. Faculty development initiatives should be implemented to upskill lecturers in AI enhanced pedagogy. This includes regular workshops, collaborative learning communities, and access to digital teaching labs. Equitable access to technological resources is essential to ensure no pre-service teacher is disadvantaged due to infrastructural limitations. Institutions must also adopt strategic partnerships with EdTech providers to stay abreast of rapidly evolving AI tools and platforms. At the policy level, the study offers valuable insights for shaping national teacher competency frameworks and digital education policies. Policymakers should mandate the integration of AI readiness indicators into teacher

accreditation standards. Additionally, ethical use of AI must be codified in national education guidelines to prevent misuse and promote responsible innovation. By embedding these changes across curriculum, training, and policy, Malaysia can cultivate a new generation of educators capable of thriving in and shaping the digital education landscape.

CONCLUSIONS

This study provides a comprehensive analysis of pre-service teachers' readiness for AI integration within the 21st century pedagogy. While awareness is relatively high, practical application and ethical literacy remain underdeveloped due to limitations in curriculum design, institutional support, and digital infrastructure. The dual application of Vygotsky's Constructivist Theory and the TPACK framework offers a robust lens for interpreting these findings and framing actionable recommendations. By triangulating quantitative and qualitative data, the study will identify critical leverage points for reform, including hands-on practicum experiences, faculty training, and digital ethics education. These interventions are essential for transforming pre-service teachers into digitally competent and ethically grounded educators. Importantly, the enthusiasm demonstrated by students suggests a strong foundation upon which to build transformative change. In conclusion, the transition to AI enhanced education is not solely a technological challenge but a pedagogical and ethical one. Through systemic reforms in teacher education, faculty development, and national policy, Malaysia can prepare a future ready teaching workforce that not only adapts to but leads in the age of Education that based on technologies.

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