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Pre-Service Teachers' Awareness and Utilization of AI Tools in Mathematics Education: Evidence from Kwara State, Nigeria

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Abstract
As Artificial Intelligence (AI) reshapes global education, its integration into teacher preparation programs remains limited, especially in resource-constrained settings. This study investigates the awareness and utilization of AI tools in mathematics education among pre-service teachers in Kwara State, Nigeria. Using a mixed-methods design, quantitative data were collected from 50 final-year pre-service teachers using structured questionnaires, while qualitative insights were gathered through interviews with 10 participants. Findings reveal that although 58% of respondents are aware of AI tools, only 10% have ever used them in instructional settings. The study identifies key barriers to adoption: inadequate training (76%), poor infrastructure (70%), and cultural resistance (40%). Chi-square analysis indicates a statistically significant difference between awareness and utilization ($\chi^2 = 26.289$, $p < 0.05$), confirming that awareness alone does not ensure application. The Technological Pedagogical Content Knowledge (TPACK) framework provided a lens for understanding these gaps and the interplay of technology, pedagogy, and content knowledge. This study highlights the need for AI-integrated teacher education curricula, investment in infrastructure, and targeted professional development. The findings contribute to the growing discourse on educational technology in developing contexts and propose strategies to bridge the awareness-utilization gap. Ultimately, the research offers a roadmap for policymakers and educators to improve digital readiness in mathematics education across sub-Saharan Africa.

Keywords: Artificial Intelligence, Mathematics Education, Pre-Service Teachers, TPACK, AI Tools

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Introduction

Artificial Intelligence (AI) has emerged as a transformative force in global education systems, particularly in mathematics instruction. Contemporary research demonstrates that AI-driven tools such as intelligent tutoring systems (e.g., DreamBox), adaptive learning platforms (e.g., Khan Academy), and automated assessment technologies can enhance learning outcomes by 22-35% in developed economies (Patel & Thompson, 2023; Roschelle, 2017). These technologies address persistent pedagogical challenges by enabling personalized instruction, real-time feedback, and data-driven remediation (Hegarty & Narayanan, 2018). However, while OECD countries increasingly integrate AI into teacher education programs (Ng & Lee, 2021), significant adoption gaps persist in resource-constrained contexts; a disparity this study examines in Nigeria's pre-service teacher ecosystem.

In Nigeria, mathematics education faces systemic challenges despite being a compulsory subject. National assessments reveal that 61% of secondary school students perform below proficiency levels (National Bureau of Statistics, 2023), with similar trends observed at tertiary levels (Ogunjimi et al., 2024). While experts identify technology integration as a potential solution (Akanmu & Fajemidagba, 2015), implementation remains inconsistent. Pre-service teachers critical to sustainable educational transformation report minimal utilization of AI tools, with only 12% incorporating them in teaching practicums (Madu & Musa, 2024). This paradox highlights a critical research gap: the disconnection between AI's demonstrated potential and actual classroom application in developing contexts.

Three interrelated barriers explain this implementation gap. First, 78% of Nigerian teacher training institutions lack structured AI literacy programs (Baiyelo, 2017). Second, inadequate technological infrastructure including unreliable electricity and limited internet access constrains tool utilization (Wilson & Murphy, 2024). Third, cultural resistance persists, with 44% of educators perceiving AI as incompatible with localized pedagogical approaches (Green & Li, 2023). These challenges necessitate urgent investigation, particularly given Nigeria's National Policy on Education (2013) mandate to leverage technology for educational equity.

This study employs the Technological Pedagogical Content Knowledge (TPACK) framework to investigate AI adoption among pre-service mathematics teachers in Kwara State. Three research objectives guide the inquiry to:

1. assess the pre-service teachers' awareness of artificial intelligence tools for teaching mathematics.
2. assess the level to which pre-service teachers are utilizing AI tools to teach mathematics.
3. examine how pre-service teachers' see AI's ability to help students learning mathematics.
4. determine the barriers to the use of AI in mathematics instruction.
5. determine the influence of pre-service teachers' awareness and utilization of AI tools in learning mathematics.

The findings will inform Nigeria's emerging educational technology policies while contributing to broader discourse on AI integration in Global South contexts. By bridging the awareness-utilization gap identified in preliminary studies (Fahimirad & Kotamjani, 2018), this research offers practical pathways to enhance mathematics instruction through sustainable technological adoption.

Statement of Problem

Artificial intelligence is an imitation of human cognitive process with the assistance of machines. AI system has the ability to make informed judgments and decisions by responding to patterns in data (Sarmah, 2019). AI is the way the human brain thinks, learns, defines and

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functions as it tries to solve problems related to human understanding computer operations such as thinking, learning, and problem solving (Chatterjee, 2020). Creating an effective AI framework requires creating a category or criteria for a specific filed that brings about deep learning and reinforcement learning (Chatterjee, 2020). Therefore, AI is a way of thinking about the mind of a person who has a computer, a robot, or a product, hence, it is the way human brain thinks, learns, defines, and functions as it tries to solve problems. AI in education has the ability to completely transform conventional teaching methods. There is still a shortage of comprehensive investigation on pre-service teachers' understanding and usage of AI in teaching and learning process. Teaching techniques can be improved with the efficient leverage of technology such as AI learning tools. According to research, instructors' reluctance to adopt AI tools stems from a combination of resistance to change, limited infrastructure, and subpar training programs (Baiyelo, 2017). Considering how much AI is being utilized in education, it's critical to assess how ready pre-service teachers are to inculcate AI-based pedagogy. As a result, this research offers valuable insights into pre-service teachers' awareness and utilization of AI tools into mathematics education.

Research Questions

This research tried to answer the following questions

1. What is the level of awareness of pre-service teachers in Kwara State on AI tools in mathematics education?
2. What is the level of utilization of AI tools on teaching mathematics among pre-service teachers in Kwara State?
3. How do pre-service teachers felt about AI's ability to learn mathematics?
4. What barriers do pre-service teachers face when attempting to include AI tools into mathematics instruction?
5. How might pre-service teachers enhance the use of AI in mathematics education?

Research Hypothesis

H_{01}: There is no significant difference between pre-service teachers' awareness and utilization of AI tools in learning mathematics.

Research Significance

The significance of this research stems from the mathematics teacher, preservice teachers, decision makers and researchers. The research is considered as a way to showcase the importance of AI tools in developing mathematics teachers in the light of technical progress. Also, the preservice teachers could be well equipped and knowledgeable of technology tools such as AI for improving students understanding in mathematics and the research may contribute to shedding light on how AI is used in learning mathematics. It may assist those in charge of professional development programs for teachers in identifying the topics related to AI that preservice mathematics teachers might need. The result of this research may help the management of higher institution in planning mathematics teacher on application of AI in learning mathematics.

The Transformative Potential of AI in Mathematics Education

Recent advancements in artificial intelligence have revolutionized pedagogical approaches to mathematics instruction globally. A growing body of research demonstrates that AI-powered educational technologies can significantly enhance learning outcomes through personalized instruction and adaptive learning pathways. Intelligent Tutoring Systems (ITS) such as Carnegie Learning's MATHia platform employ sophisticated machine learning algorithms to analyze student performance data in real-time, enabling the delivery of customized problem sets and targeted feedback (Pane et al., 2022). Meta-analyses of 42 controlled studies reveal

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that mathematics students using ITS show average learning gains of 0.56 standard deviations compared to traditional instruction, with particularly strong effects in algebraic reasoning and geometric proof construction (Kulik & Fletcher, 2022).

The implementation of adaptive learning platforms like ALEKS (Assessment and Learning in Knowledge Spaces) has demonstrated even more dramatic improvements in developing countries. A three-year longitudinal study in Kenya showed 32% greater competency mastery among secondary students using ALEKS compared to control groups, with the most significant benefits observed among female students and those from low-income backgrounds (Mbugua et al., 2023). These systems utilize knowledge space theory to dynamically map individual learning trajectories, allowing students to progress at optimal paces while ensuring foundational concept mastery (Doignon & Falmagne, 2022).

Teacher Preparedness and AI Literacy in Developing Contexts

The successful integration of AI tools in mathematics education fundamentally depends on teacher competence and confidence in utilizing these technologies. Research consistently demonstrates that teacher training programs in sub-Saharan Africa lag significantly behind global standards in technological preparation. A comprehensive audit of 37 Nigerian teacher training institutions revealed that only 8% offered dedicated courses on educational technology integration, with fewer than 3% covering AI-specific applications (Adewale & Ogunbase, 2023). This training deficit creates a paradoxical situation where teachers recognize AI's theoretical benefits but lack practical implementation skills.

The Technological Pedagogical Content Knowledge (TPACK) framework provides a valuable lens for analyzing these preparedness gaps. Recent applications of TPACK in Ghana and South Africa highlight three critical competency areas where pre-service teachers require development: (1) technological knowledge of AI system operations, (2) pedagogical strategies for AI-enhanced instruction, and (3) content-specific applications for mathematics teaching (Bosch et al., 2022). Qualitative interviews with Nigerian mathematics educators reveal particular challenges in aligning AI tools with national curriculum requirements, with many reporting that existing platforms emphasize Western mathematical contexts over locally relevant applications (Olanrewaju et al., 2023).

Systemic Barriers to AI Adoption in Nigerian Education

The implementation of AI technologies in Nigerian mathematics classrooms faces multilayered structural challenges that extend beyond teacher training limitations. Infrastructure deficiencies represent perhaps the most fundamental barrier, with only 28% of public schools having reliable internet access and 19% possessing adequate computer laboratories (National Bureau of Statistics, 2023). Even in better-resourced institutions, intermittent electricity supply and inadequate technical support severely constrain sustained AI tool implementation (Bello et al., 2023).

Cultural and institutional resistance presents another significant hurdle. A recent survey of 450 Nigerian mathematics educators found that 62% expressed skepticism about AI's appropriateness for their classrooms, with concerns ranging from perceived threats to professional autonomy to doubts about cultural relevance (Yusuf et al., 2023). This resistance often stems from inadequate exposure, as teachers who participate in hands-on AI training programs show 3.2 times greater adoption rates than their peers (Okediran et al., 2023).

Theoretical Framework

The foundation of this study rests on an adapted version of the Technological Pedagogical Content Knowledge (TPACK) framework, which provides a robust lens for examining AI integration in Nigerian mathematics education. Originally developed by Mishra and Koehler

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(2006), TPACK identifies seven interconnected knowledge domains that teachers must navigate when implementing educational technologies. In our context, this framework helps explain why awareness of AI tools among pre-service teachers doesn't necessarily translate to classroom utilization.

At its core, TPACK emphasizes three fundamental knowledge areas: content (mathematics), pedagogy (teaching methods), and technology (AI tools). The framework's power lies in the intersections between these domains. Technological Content Knowledge (TCK) examines how AI represents mathematical concepts - a crucial consideration in Nigeria where many AI tools are developed with Western curricula in mind. Studies show these tools often use examples and notation conventions unfamiliar to local students (Adewale, 2023). Technological Pedagogical Knowledge (TPK) addresses how teaching strategies must adapt to incorporate AI effectively, such as designing lessons that balance technology use with essential human interaction (Bower et al., 2023).

For Nigeria's unique educational landscape, we've enhanced the traditional TPACK model with three critical adaptations. First, we incorporate infrastructural realism, acknowledging the technological constraints of Nigerian classrooms. Research indicates that teachers need training in "graceful degradation" strategies - ways to maintain learning when technology fails (Ogunbase, 2023). Second, we emphasize cultural relevance, ensuring AI tools respect local mathematical traditions and communal learning values. Finally, we integrate ethical considerations, particularly important in contexts where data privacy protections may be limited.

Recent African studies demonstrate TPACK's relevance. In Tanzania, teachers scoring higher on TPACK assessments were 23% more likely to sustain technology use (Mtebe, 2023). South African research found TPACK-informed training programs yielded 40% better skill retention than conventional approaches (Yusuf, 2023). These findings suggest that addressing TPACK knowledge gaps could significantly improve AI adoption rates in Nigeria.

This study applies TPACK to analyze three key dimensions: (1) awareness gaps across the seven knowledge domains, (2) utilization barriers at the knowledge intersections, and (3) targeted interventions for pre-service teacher education. The framework guides our research instruments and analysis, ensuring theoretically grounded insights into Nigeria's AI integration challenges while respecting local contextual factors.

Research Gap and Study Positioning

While existing literature thoroughly documents AI's educational potential and Africa's implementation challenges, few studies examine the specific experiences of pre-service mathematics teachers navigating these complex realities. This study fills that critical gap by employing a mixed-methods approach to investigate awareness, utilization, and barriers among Kwara State's next generation of mathematics educators. The research particularly contributes to knowledge by applying the TPACK framework to analyze how institutional, infrastructural, and cultural factors interact to shape technology adoption patterns in Nigeria's unique educational context.

Research Methodology

This study employs a mixed-methods research approach to comprehensively examine the awareness and utilization of artificial intelligence tools among pre-service mathematics teachers in Kwara State, Nigeria. The methodology combines quantitative and qualitative techniques to provide both broad statistical patterns and nuanced contextual understanding of this emerging educational phenomenon.

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The research design follows a sequential explanatory model, beginning with quantitative data collection through structured questionnaires, followed by qualitative interviews to explore significant findings in greater depth. This approach is particularly suited to educational technology studies in developing contexts, as it allows researchers to first establish prevalence rates before investigating the underlying reasons behind observed patterns (Creswell & Plano Clark, 2023). The two-phase design enables comprehensive analysis of both the "what" and "why" of AI adoption among pre-service teachers.

For the quantitative phase, the study population comprised all final-year pre-service mathematics teachers across three major teacher training institutions in Kwara State (N=287). Using stratified random sampling, we selected 50 participants representing key demographic variables including institution type, gender, and geographic location. This sampling strategy ensured the inclusion of diverse perspectives while maintaining statistical rigor. Sample size determination followed Cochran's formula for finite populations, providing 95% confidence level with 5% margin of error.

The research instruments were carefully developed and validated. The quantitative survey consisted of a 35-item questionnaire adapted from established TPACK measurement tools (Schmidt et al., 2023). It included four main sections: awareness of specific AI tools, frequency of utilization, perceived barriers to adoption, and self-assessment of technological pedagogical content knowledge. Prior to full implementation, we conducted pilot testing with 15 pre-service teachers to establish instrument reliability, achieving a Cronbach's alpha coefficient of 0.83, indicating strong internal consistency.

Qualitative data collection involved semi-structured interviews with 10 purposively selected participants representing varying levels of AI tool awareness and utilization. The interview protocol contained 12 open-ended questions exploring personal experiences with AI tools, institutional support mechanisms, cultural and infrastructural challenges, and suggestions for improvement. These interviews, averaging 35 minutes each, were audio-recorded and professionally transcribed to ensure accuracy.

Data analysis followed established mixed-methods procedures. Quantitative data analysis employed descriptive statistics to determine awareness and utilization rates, with chi-square tests examining relationships between key variables. Qualitative data underwent thematic analysis using NVivo software, following the constant comparative method to identify and refine emerging themes. For mixed-methods integration, we employed joint display analysis to compare and contrast findings from both data strands, enhancing the validity of conclusions through methodological triangulation.

The study incorporated multiple validation strategies to ensure reliability and credibility. Quantitative measures included pilot testing and expert validation of instruments, while qualitative approaches involved prolonged engagement in the field, peer debriefing sessions, and maintenance of a detailed audit trail. These rigorous validation procedures helped mitigate potential limitations including regional sampling constraints and self-report biases inherent in survey research.

This methodology provides a robust framework for investigating AI tool integration in Nigerian teacher preparation programs. By combining quantitative breadth with qualitative depth, the study design captures both the prevalence and complexities of technology adoption in this specific educational context. The rigorous approach ensures findings will contribute meaningfully to ongoing discussions about digital transformation in teacher education across sub-Saharan Africa.

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Results and Discussion

Demographic Profile of Respondents

Table 1:

Demographic Characteristics of Respondents (N = 50)

Variable	Category	Frequency	Percentage (%)
Gender	Male	17	34%
	Female	33	66%
Age Group	Below 20 years	1	2%
	20–25 years	18	36%
	26 years and above	31	62%
Years of Study	Year 1	0	0%
	Year 2	9	18%
	Year 3	20	40%
	Year 4	21	42%

A total of 50 pre-service mathematics teachers participated in this study. As shown in Table 1 above, the majority were female (66%), with most respondents aged 26 years and above (62%). Additionally, 82% were in either their third or fourth year of study, indicating advanced exposure to both teaching pedagogy and field experiences. This demographic profile suggests that participants have had considerable academic exposure and are thus in a credible position to evaluate the relevance and applicability of AI tools in mathematics instruction.

Awareness of AI Tools among Pre-Service Teachers

Respondents were asked whether they were aware of AI tools relevant to mathematics education.

Table 2:

Awareness of AI Tools for Mathematics Education

Awareness Level	Frequency	Percentage (%)
Aware	29	58%
Not Aware	21	42%

Table 2 reveals that 58% of respondents reported awareness of AI tools for mathematics education, while 42% indicated they had no prior knowledge. Despite this moderate awareness, qualitative data from interviews showed that understanding was often superficial gained from informal channels like social media rather than formal training. This suggests a critical gap in structured AI literacy programs. The TPACK framework identifies this as a weakness in Technological Knowledge (TK), limiting the potential for effective AI integration.

Table 3:

Utilization of AI Tools

Utilization Level	Frequency	Percentage (%)
Regular use	5	10%
Occasional use	12	24%
Never used	33	66%

Utilization rates were notably low. Only 10% of respondents reported regular use of AI tools, while 24% used them occasionally, and 66% had never used any AI-based platform for teaching or learning. This finding reinforces the disconnection between awareness and practice. According to the TPACK model, effective teaching with technology requires the intersection of Technological, Pedagogical, and Content Knowledge; a synergy that appears underdeveloped among the participants.

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Perception of AI Tools' Effectiveness

Pre-service teachers were asked to rate their agreement with various positive statements about AI tools in mathematics education.

Table 4:

Perceptions of AI Tools among Respondents

Statement	Strongly Agree(%)	Agree (%)	Disagree (%)	Strongly Disagree(%)
AI tools make teaching mathematics easier	50	20	16	14
AI tools improve students' engagement	36	22	20	22
AI tools are valuable additions to traditional methods	34	38	12	16
I would recommend AI tools for teaching mathematics	38	32	18	12
AI tools will positively impact mathematics learning	40	36	16	8

As illustrated in Table 4, over 70% of respondents agreed or strongly agreed that AI tools could simplify mathematics teaching, enhance student engagement, and complement traditional methods. However, enthusiasm was not matched by competence or practice, as many admitted lacking the skill or support to implement AI effectively. This positive disposition indicates readiness and willingness to adopt AI, suggesting that with proper training and support, utilization could improve significantly. This aligns with findings by Fahimirad and Kotamjani (2018), who emphasized that favorable perceptions are a precursor to successful adoption provided structural constraints are addressed.

Barriers to AI Utilization

Respondents identified key challenges that hinder their ability to use AI tools effectively.

Table 5:

Challenges Faced in Using AI Tools

Challenge	Frequency	Percentage (%)
Lack of training	38	76%
Insufficient infrastructure	35	70%
Unavailability of AI software	30	60%
High cost of AI tools	28	56%
Resistance to change	20	40%

The most reported challenges were lack of training (76%), poor infrastructure (70%), software unavailability (60%), and cost (56%). These findings are consistent with Wilson and Murphy (2024), who identified infrastructural deficits and professional development gaps as central obstacles to AI adoption in African education systems. The data reflect a deficiency in the enabling environment required for technological innovation. These constraints prevent the realization of Technological Pedagogical Knowledge (TPK) and restrict the capacity to apply AI tools effectively in the classroom.

Hypothesis Testing

A chi-square test was conducted to examine the relationship between awareness and utilization of AI tools. Results are presented in Table 6.

Table 6:

Chi-Square Test Result

Variables Compared	χ^2 Value	Df	p-value	Decision
Awareness vs. Utilization of AI	26.289	15	0.03	Significant – Reject H_0

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The null hypothesis (**H_0) stated that "there** is no significant difference in the awareness and utilization of AI tools among pre-service teachers in Kwara State". However, the chi-square test results indicate that:

The calculated chi-square value (**χ^2) = 26.289 exceeds the critical table value (24.996) at a degree of freedom (df) of 15.**

The p-value (0.03) is less than the significant level ($\alpha = 0.05$).

Conclusion: The p-value (0.03) is below the significance level ($\alpha = 0.05$), indicating a statistically significant difference between awareness and utilization. Thus, awareness of AI tools does not automatically translate into their use in educational practice. This finding affirms the need for more than superficial exposure, it calls for structured, skills-based training.

Synthesis of Quantitative and Qualitative Results

The table below synthesizes insights from both quantitative data and qualitative interviews.

Thematic Area	Quantitative Result	Qualitative Insight
Awareness	58% aware of AI tools	Mostly learned from informal sources
Utilization	Only 10% use AI tools regularly	Most lacked hands-on training
Perceived Benefits	70%+ viewed AI tools as helpful	Many unsure how to use them in class
Barriers	76% cited lack of training	Echoed need for local support and facilities

Summary of Findings

This study underscores a fundamental tension: pre-service teachers recognize the value of AI in mathematics education but are unable to operationalize it due to systemic limitations. The TPACK framework proves instrumental in diagnosing the competency gaps particularly at the intersections of technology with pedagogy and content. Without targeted interventions, the enthusiasm for AI may remain unactualized, widening the gap between potential and practice.

Conclusion

This study examined the awareness and utilization of artificial intelligence (AI) tools for mathematics education among pre-service teachers in Kwara State, Nigeria. Despite moderate awareness levels (58%), actual utilization of AI tools was markedly low (10%), indicating a significant disconnect between knowledge and practice. The statistical analysis further confirmed that awareness alone does not translate into implementation, as evidenced by a significant relationship between awareness and utilization ($\chi^2 = 26.289$, $p < 0.05$).

Findings also revealed that while most respondents held positive perceptions regarding AI's potential to enhance student engagement, personalization, and instructional efficiency, their ability to implement such tools was hindered by a lack of formal training, inadequate infrastructure, software inaccessibility, and occasional resistance to technological change. These constraints reflect broader systemic challenges prevalent in sub-Saharan Africa's education systems, particularly in teacher preparation.

The results underscore the relevance of the Technological Pedagogical Content Knowledge (TPACK) framework in understanding the multidimensional nature of technology integration. The observed gaps in technological and pedagogical competencies highlight an urgent need for a structural and pedagogical overhaul of teacher education curricula to accommodate 21st-century instructional technologies.

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Recommendations

In light of the findings, the following actionable recommendations are proposed to stakeholders in teacher education, policy, and curriculum development:

1. Curricular Integration of AI Literacy: Teacher education programs should embed AI literacy and hands-on training modules into the mathematics curriculum. This should go beyond theoretical awareness to include application-based workshops using local and global AI platforms.
2. Investment in Infrastructure: Federal and state governments, in collaboration with institutional management and private sector partners, should invest in providing reliable electricity, internet connectivity, and access to AI-supported digital learning environments.
3. Localized and Context-Aware AI Tools: Educational technology developers should work with local curriculum experts to design AI tools that reflect indigenous contexts, language preferences, and culturally relevant pedagogies.
4. Professional Development for Teacher Educators: Continuous capacity-building initiatives should be introduced for university lecturers and teacher mentors to ensure they are equipped to train the next generation of teachers in AI-integrated instruction.
5. Policy and Institutional Support: National education policies should explicitly prioritize AI integration as a core element of digital transformation strategies. Institutional frameworks should provide incentives and clear guidelines for AI implementation in classrooms.
6. Awareness and Sensitization Campaigns: Awareness initiatives targeting both teacher trainees and teacher educators are necessary to demystify AI and dispel misconceptions, thereby fostering a positive attitude toward adoption.

These recommendations, if systematically implemented, have the potential to close the awareness-utilization gap and position AI as a transformative force in mathematics education. The study serves as a foundation for future research on AI readiness and pedagogical transformation in resource-constrained teacher education contexts across Africa and the Global South.

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