

Transforming Mathematics Teacher Education Through Artificial Intelligence and Digital Innovation: Extent of Utilization, Challenges, and Strategies in Colleges of Education, Gombe State

Yunusa, Samson (PhD)¹, Etuk Emmanuel Dan², Micah Michael³ and Ismail Uzairu Usman⁴

^{1,2,3&4}Department of Mathematics,
Federal College of Education (Technical), Gombe, Nigeria
<https://doi.org/10.56201/ijcsmt.vol.12.no9.2026.pg87.94>

Abstract

This study investigated the extent of utilization, challenges, and strategies for transforming mathematics teacher education through artificial intelligence (AI) and digital innovation in Colleges of Education in Gombe State, Nigeria. Anchored on the Technological Pedagogical Content Knowledge (TPACK) framework, the study adopted a descriptive survey design involving 75 stakeholders (21 administrators and 54 mathematics lecturers) drawn by census sampling from Colleges of Education in Gombe State. Data were collected using a validated 30-item questionnaire (Cronbach alpha = 0.84) and analysed using mean, standard deviation, and independent-samples t-test at the 0.05 level of significance. Findings revealed that AI and digital tools are utilized to a low extent overall in mathematics teacher education (cumulative mean = 2.70), with only dynamic geometry software and mobile learning applications utilized to a high extent. Ten challenges were affirmed as significant, most notably inadequate ICT infrastructure, high cost of digital devices and data, and lack of institutional policy on AI use (cumulative mean = 4.06), while resistance to change and data-privacy concerns were not strongly endorsed as major challenges. Nine strategies were identified as needed to enhance AI and digital integration, most notably reliable electricity and internet infrastructure and regular capacity-building training for lecturers (cumulative mean = 4.05). The t-test results showed no statistically significant difference between administrators' and lecturers' perceptions across extent of utilization ($t = 1.05$, $p = 0.30$), challenges ($t = 0.55$, $p = 0.58$), and strategies ($t = 0.60$, $p = 0.55$). The study concludes that despite low current utilization, stakeholders strongly endorse both the barriers and the pathways toward meaningful AI-driven transformation of mathematics teacher education, and recommends deliberate infrastructural investment and sustained capacity building as priority interventions.

Keywords: Artificial Intelligence, Digital Innovation, Mathematics Teacher Education, TPACK, Colleges of Education, Gombe State

1.0 Introduction

The global education landscape is undergoing rapid transformation driven by advances in artificial intelligence (AI) and digital technology, and teacher education is no exception (UNESCO, 2023). Mathematics teacher education, in particular, stands at an important juncture: mathematics has traditionally been taught through fixed, procedural methods, yet the discipline is uniquely well-suited to benefit from AI-driven personalisation, dynamic visualisation, and data-informed instruction (Holmes, Bialik & Fadel, 2021). As classrooms increasingly incorporate digital tools,

from dynamic geometry software to intelligent tutoring systems, mathematics teacher education programmes must prepare pre-service and in-service teachers not merely to use these tools, but to integrate them meaningfully into pedagogically sound instruction (Mishra & Koehler, 2006; Zhai, Chu, Wang, Wang & Istenic, 2021).

In Nigeria, Colleges of Education charged with training mathematics teachers face the dual challenge of keeping pace with global digital transformation while contending with infrastructural and resource constraints (Adeoye & Jimoh, 2022). Although the potential benefits of AI and digital innovation are well documented in the literature, there is limited empirical evidence on the actual extent to which these tools are utilised within Nigerian mathematics teacher education, and on which specific challenges and strategies stakeholders on the ground consider most pressing (Adeoye & Jimoh, 2022; Okebukola, 2020). Without such data, policy and institutional interventions risk being generic rather than targeted, potentially misallocating scarce resources.

In examining these issues, the present study was anchored on the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006), which posits that effective technology-integrated teaching requires the intersection of content knowledge, pedagogical knowledge, and technological knowledge. Applied to this study, TPACK provides a lens for understanding both why AI and digital tools remain under-utilised where technological knowledge or infrastructure is weak, and what forms of capacity building are needed to bridge content, pedagogy, and technology in mathematics teacher education.

Globally, intelligent tutoring systems, adaptive learning platforms, dynamic geometry software, automated assessment tools, and virtual/augmented reality applications have been shown to personalise instruction, visualise abstract mathematical concepts, and ease assessment workloads (Holmes, Bialik & Fadel, 2021; VanLehn, 2011; Zhai et al., 2021). Dynamic geometry software such as GeoGebra, in particular, has seen relatively wide adoption even in resource-constrained contexts due to its low hardware requirements and free availability, while more infrastructure-intensive tools such as VR/AR and AI tutoring systems remain less accessible (Sinclair & Bruce, 2021). In the Nigerian context, however, infrastructural deficits, including unreliable electricity supply, limited internet connectivity, and inadequate computer laboratories, remain pervasive across many Colleges of Education and teacher training institutions (National Commission for Colleges of Education [NCCE], 2021). Digital literacy gaps among teacher educators themselves often limit the extent to which AI and digital tools are meaningfully integrated into instruction (Adeoye & Jimoh, 2022), while the high cost of data and digital devices further restricts equitable access (Okebukola, 2020). Empirical studies point in the same direction. Adeoye and Jimoh (2022) found that digital technology integration in Nigerian teacher education institutions remained generally low, constrained primarily by infrastructural and funding limitations, though attitudes among staff toward digital tools were largely positive. Okebukola (2020) similarly reported that Nigerian teacher education institutions face significant infrastructural barriers to fourth-industrial-revolution-aligned pedagogy, recommending phased infrastructural investment. These studies affirm the value of investigating utilisation and barriers empirically, but neither focused specifically on mathematics teacher education or on AI tools in particular, a gap the present study addressed by surveying administrators and mathematics lecturers in Colleges of Education in Gombe State. The study was therefore designed to determine the extent of utilisation of AI and digital innovation tools in mathematics teacher education in Colleges of Education in Gombe State, the challenges facing the integration of these tools, and the strategies needed to enhance their integration. Three research questions guided the study: what is the extent of utilisation of AI and digital innovation tools in mathematics teacher education in Colleges of Education in Gombe State;

what are the challenges facing the integration of AI and digital innovation in mathematics teacher education in these Colleges; and what strategies are needed to enhance that integration?

Three null hypotheses were also tested. These stated that there is no significant difference between the mean responses of administrators and lecturers on the extent of utilisation of AI and digital innovation tools in mathematics teacher education in Colleges of Education in Gombe State (H01), on the challenges facing the integration of AI and digital innovation in mathematics teacher education in these Colleges (H02), and on the strategies needed to enhance that integration (H03).

2.0 Methodology

The study adopted a descriptive survey research design. The population comprised 75 stakeholders drawn from Colleges of Education in Gombe State: 21 administrators (Deans of Schools and Heads of Department) and 54 mathematics lecturers. Census sampling was employed given the manageable population size.

Data were collected using a researcher-developed 30-item questionnaire, the "AI and Digital Innovation in Mathematics Teacher Education Questionnaire" (ADIMTEQ), covering three sections: extent of utilization (items 1-10, rated Very High Extent (5) to Not at All (1)), challenges (items 11-20, rated Strongly Agree (5) to Strongly Disagree (1)), and strategies (items 21-30, rated Very Highly Needed (5) to Not Needed (1)). The instrument was validated by three experts in Mathematics Education and Educational Technology, Federal College of Education (Technical), Gombe, and trial-tested on eight respondents outside the main sample, yielding a Cronbach alpha reliability coefficient of 0.84. Research questions were answered using mean and standard deviation, with a cut-off mean of 3.50. Hypotheses were tested using the independent-samples t-test at the 0.05 level of significance.

3.0 Results

3.1 Research Question 1: Extent of Utilization of AI and Digital Tools

Table 1: Mean and Standard Deviation of Respondents on Extent of Utilization of AI and Digital Tools (NA = 21, NL = 54, N = 75)

S/N	Item	Mean (Admin)	Mean (Lecturers)	Grand Mean	SD	Remark
1	Use of intelligent tutoring systems for personalized mathematics instruction	2.60	2.40	2.46	0.65	Low Extent
2	Use of adaptive learning platforms to adjust content to learner needs	2.75	2.50	2.57	0.68	Low Extent
3	Use of dynamic geometry software (e.g., GeoGebra) for visualizing concepts	3.80	3.65	3.69	0.82	High Extent
4	Use of AI-powered lesson planning tools	2.45	2.30	2.34	0.60	Low Extent
5	Use of automated assessment and grading systems	2.90	2.70	2.76	0.70	Low Extent
6	Use of virtual/augmented reality for visualizing abstract concepts	2.30	2.15	2.19	0.58	Low Extent
7	Use of learning management systems with analytics	3.10	2.95	2.99	0.75	Low Extent

8	Use of AI chatbots for student support	2.20	2.05	2.09	0.55	Low Extent
9	Use of mobile learning applications for mathematics instruction	3.65	3.50	3.54	0.79	High Extent
10	Use of AI tools for professional development of mathematics teachers	2.55	2.35	2.40	0.62	Low Extent
	Cumulative Mean	2.83	2.66	2.70	0.67	Low Extent

Table 1 shows that only two of the ten items, dynamic geometry software (mean = 3.69) and mobile learning applications (mean = 3.54), were utilized to a high extent. The remaining eight items, including intelligent tutoring systems, AI-powered lesson planning, and AI chatbots, recorded means below the 3.50 cut-off, with a cumulative mean of 2.70, indicating an overall low extent of AI and digital tool utilization in mathematics teacher education in the Colleges surveyed.

3.2 Research Question 2: Challenges Facing AI and Digital Integration

Table 2: Mean and Standard Deviation of Respondents on Challenges Facing AI and Digital Integration (NA = 21, NL = 54, N = 75)

S/N	Item	Mean (Admin)	Mean (Lecturers)	Grand Mean	SD	Remark
1	Inadequate ICT infrastructure (electricity, computers, internet)	4.50	4.35	4.39	0.75	Agreed
2	Low digital literacy among teacher educators	4.10	4.25	4.21	0.80	Agreed
3	High cost of digital devices and data subscription	4.30	4.40	4.37	0.78	Agreed
4	Inadequate technical support for maintaining digital tools	4.05	3.95	3.98	0.73	Agreed
5	Resistance to change among teacher educators	3.40	3.25	3.29	0.66	Disagreed
6	Lack of institutional policy on AI use in education	4.15	4.00	4.04	0.76	Agreed
7	Inadequate funding for digital tool acquisition	4.40	4.30	4.33	0.79	Agreed
8	Limited training opportunities on emerging AI tools	4.20	4.10	4.13	0.77	Agreed
9	Poor internet connectivity in teacher training institutions	4.45	4.35	4.38	0.81	Agreed
10	Concerns about data privacy and ethical use of AI	3.60	3.45	3.49	0.69	Disagreed
	Cumulative Mean	4.12	4.04	4.06	0.75	Agreed

Table 2 shows that eight of the ten challenge items were affirmed ("Agreed"), with grand means ranging from 3.98 to 4.39, most notably inadequate ICT infrastructure, high cost of digital devices and data, poor internet connectivity, and inadequate funding. Two items, resistance to change (mean = 3.29) and data-privacy concerns (mean = 3.49), fell below the cut-off, suggesting respondents view these as comparatively minor barriers relative to infrastructural and financial

constraints. The cumulative mean of 4.06 confirms that, overall, respondents strongly agree that significant challenges confront AI and digital integration.

3.3 Research Question 3: Strategies Needed to Enhance Integration

Table 3: Mean and Standard Deviation of Respondents on Strategies Needed to Enhance AI and Digital Integration (NA = 21, NL = 54, N = 75)

S/N	Item	Mean (Admin)	Mean (Lecturers)	Grand Mean	SD	Remark
1	Provision of reliable electricity and internet infrastructure	4.55	4.45	4.48	0.83	Needed
2	Regular training/capacity building for lecturers on AI tools	4.40	4.50	4.47	0.85	Needed
3	Institutional policies guiding responsible AI use	4.15	4.00	4.04	0.76	Needed
4	Government funding for digital infrastructure in Colleges of Education	4.50	4.35	4.39	0.80	Needed
5	Integration of AI/TPACK training into mathematics methodology courses	4.05	4.20	4.16	0.78	Needed
6	Partnerships with technology companies for tool access and training	3.85	3.70	3.74	0.71	Needed
7	Piloting AI tools before wide-scale adoption	3.70	3.55	3.59	0.66	Needed
8	Provision of technical support units in institutions	4.10	3.95	3.99	0.74	Needed
9	Subsidized data/device access for teacher educators and trainees	4.25	4.10	4.14	0.77	Needed
10	Continuous monitoring and evaluation of AI tool effectiveness	3.65	3.50	3.54	0.64	Needed
	Cumulative Mean	4.12	4.03	4.05	0.75	Needed

Table 3 shows that all ten strategy items were affirmed as needed, with grand means ranging from 3.54 to 4.48. Reliable electricity and internet infrastructure (mean = 4.48) and regular capacity-building training for lecturers (mean = 4.47) were rated as the most urgently needed strategies. The cumulative mean of 4.05 confirms that respondents strongly endorse the listed strategies as necessary to enhance AI and digital integration in mathematics teacher education.

3.4 Hypotheses Testing

Table 4: t-test Analysis of Difference between Mean Responses of Administrators and Lecturers on Extent of Utilization

Respondents	N	Mean	SD	df	t-value	p-value	Decision
Administrators	21	2.83	0.72				
Lecturers	54	2.66	0.60	73	1.05	0.30	Accepted

With $t = 1.05$, $df = 73$, and $p = 0.30$ ($p > 0.05$), the null hypothesis was accepted, indicating no statistically significant difference between administrators' (mean = 2.83) and lecturers' (mean = 2.66) perceptions of the extent of AI and digital tool utilization.

Table 5: t-test Analysis of Difference between Mean Responses of Administrators and Lecturers on Challenges

Respondents	N	Mean	SD	df	t-value	p-value	Decision
Administrators	21	4.12	0.70				
Lecturers	54	4.04	0.58	73	0.55	0.58	Accepted

With $t = 0.55$, $df = 73$, and $p = 0.58$ ($p > 0.05$), the null hypothesis was accepted, indicating no statistically significant difference between administrators' (mean = 4.12) and lecturers' (mean = 4.04) perceptions of the challenges facing AI and digital integration.

Table 6: t-test Analysis of Difference between Mean Responses of Administrators and Lecturers on Strategies

Respondents	N	Mean	SD	df	t-value	p-value	Decision
Administrators	21	4.12	0.72				
Lecturers	54	4.03	0.60	73	0.60	0.55	Accepted

With $t = 0.60$, $df = 73$, and $p = 0.55$ ($p > 0.05$), the null hypothesis was accepted, indicating no statistically significant difference between administrators' (mean = 4.12) and lecturers' (mean = 4.03) perceptions of the strategies needed to enhance AI and digital integration.

4.0 Discussion of Findings

The finding that AI and digital tools are utilized to a generally low extent (cumulative mean = 2.70) in mathematics teacher education in Gombe State Colleges of Education is consistent with Adeoye and Jimoh (2022), who similarly found low overall digital technology integration in Nigerian teacher education institutions despite generally positive staff attitudes. Notably, dynamic geometry software and mobile learning applications were the only tools utilized to a high extent, likely reflecting their comparatively low infrastructural and cost demands relative to AI tutoring systems, VR/AR, or automated assessment platforms, a pattern consistent with Sinclair and Bruce's (2021) observation that low-barrier tools see wider adoption in resource-constrained settings. The challenges findings, particularly the strong endorsement of inadequate ICT infrastructure, high costs, and lack of institutional policy, align closely with Okebukola (2020) and the National Commission for Colleges of Education (2021), both of which identify infrastructural and funding constraints as the dominant barriers to technology-driven transformation in Nigerian teacher education. Notably, resistance to change and data-privacy concerns were not strongly endorsed as major challenges, suggesting that, contrary to assumptions sometimes made in the literature (UNESCO, 2023), attitudinal resistance may be a less pressing barrier than material and infrastructural constraints in this context. The strategies findings, with reliable infrastructure and lecturer capacity-building rated most urgent, directly mirror the challenges identified, reinforcing the internal consistency of the findings and lending credibility to the TPACK-based argument that technological knowledge and infrastructure must be addressed before pedagogical integration of AI can meaningfully advance (Mishra & Koehler, 2006). Across all three research questions, the non-significant t-test results indicate that administrators and lecturers share a broadly consistent understanding of current utilization, challenges, and needed strategies, suggesting that institutional

interventions informed by this study would likely receive support from both groups of stakeholders.

5.0 Conclusion

The study concludes that while AI and digital tools remain under-utilized in mathematics teacher education in Colleges of Education in Gombe State, stakeholders clearly recognise both the infrastructural and policy challenges constraining this integration and the strategies needed to address them. Administrators and lecturers converge in identifying reliable infrastructure, adequate funding, and sustained capacity-building as the most urgent priorities. Addressing these priorities would create the foundation necessary for AI and digital innovation to meaningfully transform mathematics teacher education in the state.

6.0 Recommendations

Based on the findings, the following recommendations are made:

1. Government and institutional authorities should prioritise investment in reliable electricity and internet infrastructure in Colleges of Education, given that this was rated the most urgently needed strategy.
2. Regular, sustained capacity-building training on AI and digital tools should be organised for mathematics lecturers, moving beyond occasional workshops.
3. Colleges of Education should develop clear institutional policies guiding the responsible use of AI, even though data-privacy concerns were not rated a top-tier challenge, to pre-empt future risks as adoption increases.
4. Given the comparatively high current utilization of low-barrier tools such as dynamic geometry software and mobile learning applications, institutions should build on this existing familiarity as a foundation for introducing more advanced AI tools.
5. The National Commission for Colleges of Education should consider targeted funding mechanisms specifically for AI and digital infrastructure in mathematics teacher education programmes.

References

- Adeoye, M. A., & Jimoh, H. A. (2022). Digital technology integration in Nigerian teacher education: Challenges and prospects. *African Journal of Educational Technology*, 10(2), 45-61.
- Holmes, W., Bialik, M., & Fadel, C. (2021). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.
- National Commission for Colleges of Education. (2021). Minimum standards for teacher education programmes in Nigeria. NCCE Publications.
- Okebukola, P. A. (2020). Repositioning teacher education in Nigeria for the fourth industrial revolution. *Nigerian Journal of Educational Research*, 18(1), 1-15.
- Sinclair, N., & Bruce, C. D. (2021). New opportunities in geometry education at the primary school. *ZDM Mathematics Education*, 47(3), 319-329.
- UNESCO. (2023). Guidance for generative AI in education and research. UNESCO Publishing.
- VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, 46(4), 197-221.
- Zhai, X., Chu, X., Wang, M., Wang, J., & Istenic, A. (2021). Applications of artificial intelligence to enhance mathematics education: A systematic review. *Journal of Educational Technology & Society*, 24(3), 100-115.