

**REPOSITIONING MATHEMATICS TEACHER
EDUCATION IN THE ARTIFICIAL INTELLIGENCE (AI)
ERA: DEVELOPING FUTURE-READY TEACHERS FOR
AI-SUPPORTED MATHEMATICS REASONING, REAL-
TIME FEEDBACK AND PROBLEM SOLVING IN NIGERIA**

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Abstract

The advent of artificial intelligence (AI) is a change in the history of mathematics education, far beyond the introduction of digital tools. In contrast to traditional technologies that were mainly used to support computation, AI systems are now providing mathematical answers, offering real-time feedback, and guiding students in solve problems. It is an evolution that requires a paradigm shift in mathematics teacher education. The paper suggests that the modern models of teacher preparation are still highly concentrated on the old-fashioned digital skills and are not enough to teach teachers to become effective and successful in the classroom mediated by AI. It argues that mathematics educators should not just use AI tools. Still, they should be able to critically analyze AI-generated outputs, associate them meaningfully with teaching and learning, and respond ethically and equitably to the new ethical and equity challenges. The article suggests a broader conceptual framework, Artificial Intelligence-Technological-Pedagogical-Content Knowledge (AI-TPACK), to be used in curriculum reform in teacher education. This paradigm highlights pedagogical judgment and critical AI literacy as critical elements of the modern teacher

competence. The paper ends by recommending proactive institutional and policy changes that can guarantee that mathematics teaching preparation keeps up with technological change as opposed to reacting to it a posteriori.

Keywords: Mathematical Answers, Problem-Solving, Real-time feedback, Teachers' Readiness, Educational technology.

Introduction

Mathematics is a fluid science, which has been changing throughout centuries as influenced by current socio-cultural conditions at a given time. Any type of change, be it in scientific development or most noticeably in education, is always initially received with resistance. Technology has long been considered a teaching aid, and the discourse was based on the knowledge of teachers, associated skills, and self-efficacy beliefs to make it fluent and flexible (Williams et al., 2023). The technology usage, however, does not guarantee meaningful learning. The technological tools evolve fast, and there is a need to acquire skills in comprehending their weaknesses and advantages. The teachers must be familiar with the difficulties and the threats that could exist from a pedagogical perspective. Today, the fast development and popularization of Artificial Intelligence (AI), as one of the fast-evolving technological revolutions, have brought up the question of its use in the educational sector, specifically in upper secondary and higher education. We agree with the fact that AI knowledge and skills must be taught to learners to remain competitive (Chiu et al., 2022).

Meanwhile, its irresponsible application might have an adverse effect on the learning process. The outcomes of resistance to change may be harmful, and it is essential to take the concept of AI in education in a balanced and considered way. To start with, it was mainly aimed at creating stringent laws that would govern the use of AI in schools. Nevertheless, we feel that the second and subsequent actions must be centered on rational and constructive adoption of AI in education, to assist students in realizing their strengths and weaknesses by learning

about the challenges and confronting the threats. Teachers, in their turn, must acquire knowledge and skills and their self-efficacy capabilities to employ AI in teaching and establish the relevant framework of its use among the students (Antonenko and Abramowitz, 2023). In recent years, various systematic literature reviews have been carried out, which have revealed that there are several important areas in the field. The current paper, however, does not take a systematic literature review approach. The strengths and weaknesses of artificial intelligence as an educational resource are discussed with the help of mathematics as a case study, which is in line with the teaching and comments on the key application implications in terms of the orientation of the following research. Mathematics also stresses problem-solving as the fundamental learning instrument of the formation of mathematical thinking (Borah, 2025).

The application of AI in problem-solving might harm crucial role of persistence in applying flexible and problem-solving strategies and self-regulatory procedures to overcome cognitive barriers (Panaoura, 2017). Conversely, the adaptive tools can provide the relevant personalized feedback with notes regarding the required cognitive and regulatory measures. In education, mathematics is an important subject in the development of logical ability as well as the thinking ability of students. Through good teaching and education, students can build their ability to think logically, thereby developing the capacity for independent thinking (Gao, 2020). In this paper, the implications of Artificial Intelligence (AI) for mathematics teaching and learning are discussed focusing especially on mathematics teacher education. It summarizes important issues and suggestions based on the latest research and evidence in the field of AI in secondary and tertiary education. The perception of students' learning of mathematics and the use of AI have been investigated in recent years, and the findings have informed the design of teaching and assessment strategies that embrace technology tools and contexts that connect mathematics with other subjects (Panaoura et al., 2024;

Charalambides et al., 2023). In addition, some students have already encountered AI in their secondary school education, either to aid in their learning or to assist in their schoolwork (Panaoura et al., 2025).

Next, there is a focus on analyzing their beliefs and attitudes toward the use of artificial intelligence in learning mathematics. In the preliminary results, we have also revealed that a significant proportion of our students have already used AI at the secondary education level either due to curiosity or to get answers to the given assignment (Panaoura et al., 2025). Despite the growing exposure to the utilization of artificial intelligence tools, the users still cannot explain why they should be recommended to be used more widely because there is a lack of evidence of clearly defined positive changes in the outcomes of learning. Such ambiguity is an indicator that there is a deep-seated issue with the introduction of AI in the teaching of mathematics and that there is a critical question of whether it is a useful or ineffective addition to the learning process. It also highlights unanswered questions and the risks that may be involved in the teaching and learning processes in AI-mediated settings, thus the urgency of the academic and policy response.

Transformation in Learning Mathematics through Technology

The normal way of teaching mathematics has been deeply changed with the rapid introduction of digital technologies. The conventional teaching methods which focus on memorization and procedural learning are gradually being overtaken by interactive and learner-centered learning methods with the aid of technological tools. Artificial intelligence (AI), dynamic mathematical software, and virtual learning platforms have revolutionized the ways mathematical knowledge is created, presented and evaluated (Meylani, 2025). The innovations can facilitate real-time feedback, adjustable learning paths, and the visualization of abstract concepts, which helps students become more interested and understand the material better. Although these have been made, there is still an

unequal use of technology in mathematics education especially in developing nations where infrastructure and teaching issues continue to prevail and there is always a role played by technological innovation in changing the essence of Mathematics education. The rise of Artificial Intelligence (AI), however, is a much more radical phenomenon. AI-based products like intelligent tutoring systems, automatic evaluation systems, and language generators are slowly becoming part of the education setting. These technologies can transform the role of teachers, learners and academic institutions. Being one of the fields closely interconnected with logic, algorithms, and data analysis, mathematics takes center stage in the creation and use of AI technologies. Not all mathematics teacher education programs, however, are ready to change their curricula to deal with these new technological realities. The training of teachers is usually based on the classical models that focus on the knowledge of processes and the customary approaches to instruction instead of on computational thinking and on the algorithmical logics.

In Nigeria, mathematics performance at the secondary school level has consistently been affected by factors such as mathematics anxiety, teacher quality, inadequate instructional materials, and large class sizes. Research indicates that many mathematics teachers still rely heavily on traditional lecture-based approaches with limited integration of digital tools (Awofala, 2020). The introduction of AI technologies into this context presents both opportunities and challenges. On one hand, AI can support individualized learning and remedial instruction; on the other hand, poor teacher preparedness may lead to misuse or over dependence on technology without pedagogical alignment.

Artificial Intelligence in Mathematics is based on mathematical concepts including probability, linear algebra, optimization, and algorithm design. Machine learning algorithms depend extensively on statistical modeling and data analysis, whereas neural networks depend on mathematical models of interconnected packets of computations. With the advent of AI technologies that are becoming

more profoundly ingrained within society, mathematical literacy is gaining more and more nuances. Mathematical abilities that were traditional (calculating, finding solutions) are inadequate now. Rather, they need to learn skills associated with data interpretation, algorithmic thinking and solution of computational problems (Wing, 2006). Indicatively, to know how machine learning models arrive at their predictions, one should have knowledge of concepts like data sets, training processes, and minimization of errors. In the same manner, it is important to think critically when analyzing the reliability of the outputs of algorithms to consider the bias of statistical values, data quality, and model limitations. Such changes mean that mathematics teachers not only need to have traditional knowledge in mathematics, but also interdisciplinary skills that would bridge mathematics, computer science and data science. In the absence of such preparation, teachers might find it difficult to help students learn the mathematical basis of AI technologies.

Development of AI-TPACK Competencies.

Technological Pedagogical and Content Knowledge (TPACK) has been a framework that has been employed extensively to explain what teachers should know to be able to use technology in teaching. Due to the advent of AI, researchers suggest the creation of AI-TPACK, which combines AI knowledge with pedagogical and content knowledge (Xie & Luo, 2025). Research has shown that most mathematics teacher education learners are now only at the level of basic AI-TPACK, which may be a reason to initiate systematic reforms in teacher education programs. The expertise of AI-TPACK will allow teachers to successfully integrate mathematical content and knowledge, pedagogical strategies, and AI technologies in instruction.

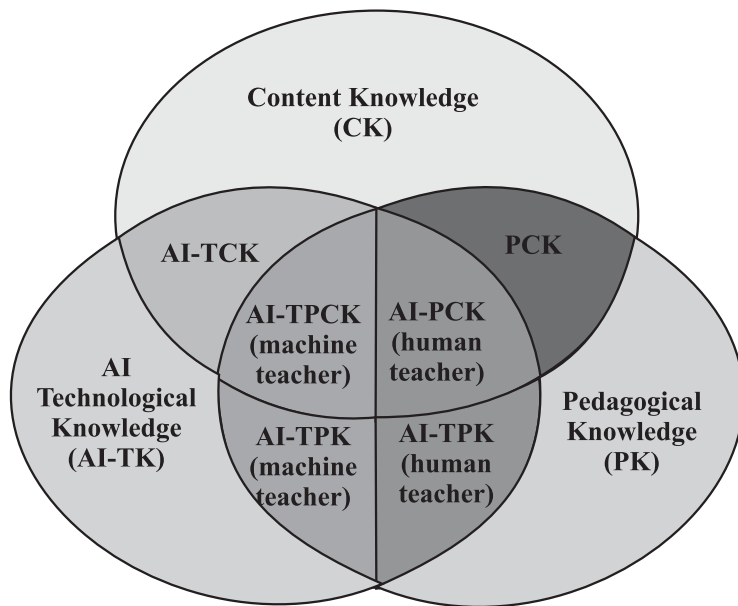


Figure 1: Key Components of AI-TPACK Competency Development (An et al., 2026)

The diagram above shows the key components of AI-TPACK Competency Development.

Constructs	Items
AI-TK	AI-TK1. I know that AI can recognize and understand human speech signals and translate them into corresponding and readable text or commands
	AI-TK2. I know that AI can enable machines to learn like humans and continuously optimize their knowledge structure to improve their performance
	AI-TK3. I know that AI can make machine hardware act like humans or animals, e.g., move forward and backward according to certain rules, avoid obstacles, etc
	AI-TK4. I know that AI can allow computers to automatically simulate the human tone of voice to read aloud fluently
	AI-TPK-M1. I know that AI-based tools can provide students with automated answers to questions

Constructs	Items
AI-TPK (machine teacher)	AI-TPK-M1. I know that AI-based tools can provide students with automated answers to questions
	AI-TPK-M2. I know that AI-based tools can collect multidimensional data from students, intelligently analyze student learning and automatically generate visual reports
	AI-TPK-M3. I know that AI-based tools can recommend personalized learning resources for students based on the analysis of their characteristics and performance
	AI-TPK-H1. I know how to adjust the teaching progress with the learning data provided by AI-based tools
	AI-TPK-H2. I know how to use the learning data provided by AI-based tools to design teaching assessment and evaluate students' learning effectiveness from multiple perspectives
AI-TPK (human teacher)	AI-TPK-H3. I know how to use AI-based tools to achieve tiered teaching, such as providing different test questions for students with different abilities
	AI-TCK1. I know that AI-based tools can enable human-computer dialog in English
	AI-TCK2. I know that AI-based tools can support the conversion of English in pictures into computer-editable text
	AI-TCK3. I know that AI-based tools can be used for international conference communication to convert English speech into Chinese automatically in real time
	AI-TCK4. I know that AI-based tools can identify English grammatical errors
AI-TCK	AI-TCK5. I know that AI-based tools can be implemented to recommend English films and videos news, etc. that users may be interested in. (Deleted)

Constructs	Items
AI-TPCK (machine teacher)	AI-TPCK-M1. I know that AI-based tools can identify English pronunciation accuracy and evaluate students' pronunciation level
	AI-TPCK-M2. I know that AI-based tools can give students feedback on grammatical errors in English composition
	AI-TPCK-M3. I know that AI-based tools can answer students' English learning queries
	AI-TPCK-M4. I know that AI-based tools can analyze and push English learning resources based on student preferences
AI-TPCK (human teacher)	AI-TPCK-H1. I know how to use AI-based tools to design teaching activities that provide students with real-time feedback on spoken English
	AI-TPCK-H2. I know how to use AI-based tools to understand students' listening and speaking practice and provide students with process feedback
	AI-TPCK-H3. I know how to use AI-based tools to understand individual student learning and design tiered reading assignments
	AI-TPCK-H4. I know how to design learning activities that use intelligent listening and speaking practice systems to increase opportunities for students to use English
	AI-TPCK-H5. I know how to design self-directed learning activities that allow students to access recommended resources for English language interests with the help of AI-based tools.

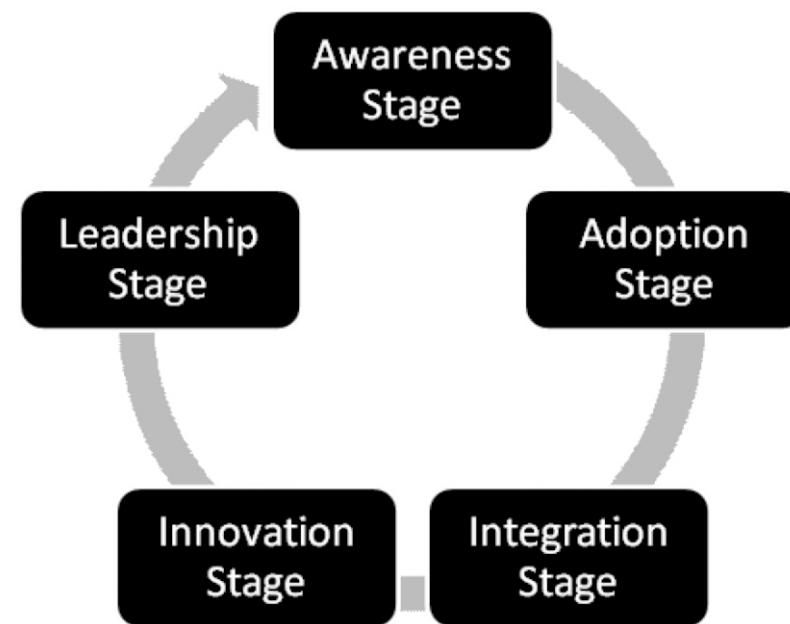


Figure 2: Stages in Developing AI-TPACK Competency

The stages of developing AI-TPACK is explained in the above diagram. It explains the stages in a cyclic order i.e., from the Awareness stage to the Adoption stage to the Integration stage to the Innovation stage and then to the final stage which is the Leadership stage. At the awareness stage, teachers develop basic knowledge of what AI is all about, how AI tools function and their possible applications in education. At the adoption stage, teachers move from awareness to actual use of AI tools. They begin experimenting with AI applications to support their existing teaching activities. The integration stage follows the adoption stage. At this stage, teachers move from adoption to practical interaction with AI technologies and understand that AI should support learning goals rather than simply replace traditional teaching methods, where it becomes part of their instructional approach. At the innovation stage, teachers move

beyond using existing AI tools and begin to design new ways of teaching with AI. The leadership stage is the last stage of the developing AI competencies; teachers become advocates, mentors and change agents who support wider AI adoption in schools and professional communities.

Adoption of AI in Mathematics Teaching and Learning

The implementation of Artificial Intelligence (AI) in education has established new possibilities of changing teaching and learning activities. AI can be defined as computer systems that can handle functions which would otherwise be handled by human intelligence like reasoning, problem solving, recognising patterns etc. Intelligent tutoring systems, adaptive learning platforms, and automated assessment tools are considered AI-powered products used in mathematics education more and more to help students and teachers. Scientific, technological, and economic growth is based on mathematics (Borah, 2025). Nonetheless, abstract thinking and cognitive requirements present several challenges to many students in terms of learning mathematical concepts. Experts indicate that AI technologies can be used to improve the teaching of mathematics through individual learning and teaching, real-time feedback, and data-driven information for educators. Artificial Intelligence in education can be explained as the application of smart computer systems in teaching, learning, and administrative functions in education (Sardar et al., 2024). These systems use algorithms like machine learning, natural language processing and data analytics to replicate human cognitive functions. Intelligent tutoring systems, automated problem-solving tools, virtual assistants, and adaptive learning platforms are some of the applications of AI in mathematics education (Fawehinmi et al., 2025). These technologies are used to study the learning patterns of students and offer them specific instructional assistance, which enhances their comprehension of the mathematical concepts. Learning can be made more efficient and more engaging as AI-driven systems can determine learning gaps, suggest relevant learning resources, and offer immediate feedback.

Reasoning for Adopting AI in Teaching and Learning Mathematics.

Personalized learning is one of the most important advantages of AI in mathematics education. Artificial intelligence systems can understand the progress of separate learners and adjust the teaching materials based on their skills and speed. The adaptive learning systems also offer focused practice questions, hints, and explanations, which help students get over the learning problems (Sardar et al., 2024). Research indicates that learners can enhance their mathematical performance and interactions with AI-enabled learning environments.

Intelligent Tutoring Systems (ITS) represents the simulated work of a human tutor, which assists students in working on problems. These systems have step-by-step explanations, and they identify the errors of the students and correct them by giving feedback (Son, 2024). The studies have shown that ITS may be a key to the improvement of learning results, as it helps learners achieve independent learning and strengthen conceptual knowledge. AI tools may also be used to automatically mark assignments, quizzes, and examinations and give students immediate feedback. Feedback is also provided immediately so that the learners correct themselves on any errors and thus understand the mathematical concepts faster. The use of automated assessment also lessens the workload of the teachers, giving them more time to devise instructional planning and attend to the learning needs of the students.

The AI systems gather huge volumes of learning information which can be used to determine the patterns and the misconceptions of student learning. This data can help teachers to change teaching approaches, create specific interventions, and enhance teaching. Mathematical decision-making based on data can help improve the performance of students to a great extent (Yi et al., 2024). The next strategy is to improve student engagement. Simulations, educational games, and visual representations of mathematical concepts are some of the AI technologies that assist in an interactive learning

environment. These are used to provide learners with more tangible and interesting abstract mathematics. Mathematics anxiety can be decreased as well, and the confidence of the students to solve mathematical problems can be enhanced with the help of such technologies.

The Reason to Change and Reform Areas in Mathematics Teacher Education.

The teacher education programs are very important in equipping teachers to deal with changes in society and technology. Nevertheless, most of the existing programs are still based on the models of instruction that were created before the massive use of digital technologies. There are a few key gaps that can be pointed out in modern mathematics teacher education.

Problem solving entails processes of computational thinking that include decomposition, pattern recognition, abstraction, as well as design of algorithms (Flaggs, 2025). These are the skills that are needed to know about the functioning of AI systems, but they are not always highlighted in the conventional mathematics teacher preparation programs. Smart implementation of AI means that teachers need to be technologically competent and pedagogically ready to utilize AI tools. Teachers will not be able to use AI in instruction in the classroom without appropriate training. The teachers are not always familiar with AI technologies and potential ways to use them in education. In the absence of proper training, teachers will either not use AI tools or will blindly use them without realising their limitations. In most schools, especially those in developing nations, there is an insufficient technological facility such as the internet, data management, devices, and electricity to use AI technologies (Nwoke et.al. 2025). The contemporary AI systems are based on data analysis. The teachers need to learn to analyze information, critique algorithmic results, and instruct students on how the data affects automated decision-making. The ethical concerns associated with AI technologies are privacy, prejudice, transparency, and accountability (Floridi et al., 2018). It is necessary to equip teachers to counter such problems in classroom discourses

and guide students to have responsible attitudes towards technology. AI is able to gather much student data, which is causing issues of privacy of data and ethical information utilization. Schools need to make sure that the data is responsibly handled and the personal information of the students is safeguarded.

Among the top reform areas, there should be updating the program curriculum of mathematics teacher education to incorporate AI-related skills. It is necessary to introduce future teachers to courses covering the basics of AI, data literacy, computational thinking and to pedagogical uses of AI tools. AI-related topics should be introduced into mathematics methods to allow pre-service teachers to develop lessons that use AI technologies. According to research, teacher education institutions should modify the curriculum to accommodate the emerging technology and equip teachers with digital learning environments (Gabriel et.al., 2025). In teaching, AI is revolutionizing the strategies used to teach since it creates individual and adaptive learning experiences. The training of teachers to employ AI-assisted pedagogical strategies is therefore one of the aspects of mathematics teacher education that should be prioritized. As an illustration, smart tutoring systems can also take students through tutorials on solving mathematical problems, whereas AI-based applications can create tailored learning content depending on the needs of a student. Research indicates that AI systems have the potential to assist teachers in planning differentiated learning activities as well as assist learners with varied learning capabilities (Meylani & Kutluca, 2025). The focus of teacher educators' programs should hence be on such innovative pedagogies as inquiry-based learning, blended learning, and AI-assisted problem-solving methodologies.

The use of AI technologies in mathematics teaching should also change the assessment practices. AI-based assessment systems can automatically mark assessments, give instant feedback, and analyze student learning information. Future teachers should be taught to be effective in using AI-based assessment tools in teacher education programs. These tools enable teachers to track student progress, diagnose misconceptions, and develop targeted interventions. The

use of AI-assessed assessments can thus lead to the improvement of efficiency and effectiveness of assessment procedures in mathematics education (Lora et.al., 2025). Another area of reform in the teacher education of mathematics is continuous professional development. A large number of teachers are currently not technologically skilled to incorporate AI in teaching. According to the research, the willingness and self-efficacy of teachers are crucial to a successful implementation of AI in education (Ayanwale et.al., 2025). The teacher training programs should thus offer workshops, seminars, and hands-on experiences that would assist teachers in acquiring AI-related competencies. Professional development programs are to be oriented at assisting teachers to learn to use AI tools, analyze AI-generated data, and responsibly apply AI to classrooms.

The ethical and responsible use of AI is a topic that has both been controversial and has also caused much debate and discussion among all stakeholders in the field of AI. The other significant area of reform is also the ethical concerns related to the use of AI in education. The AI systems gather significant data on the students and bring up issues of privacy, data security, and algorithmic discrimination. Teacher education programs should thus equip the teachers to apply AI with responsibility by focusing on ethical aspects like privacy of data, transparency, and justice of the algorithmic decision-making. Researchers emphasize the role of ethical sensitivity in order to make AI technologies help to provide equitable and inclusive mathematics education (Meylani & Kutluca, 2025).

Conclusion

Artificial Intelligence can bring changes in the teaching and learning of mathematics since it offers a more personalized approach to learning, intelligent tutoring, and data-driven insights. When properly integrated into the educational systems, AI may become useful in improving student engagement and learning outcomes and allowing teachers to provide quality delivery of mathematics education. Nonetheless, to be effective in adoption, proper infrastructure, teacher training, ethics, and supportive policies are

needed. The ability of educational stakeholders to deal with these factors will result in the maximization of AI potential in enhancing mathematics education and equipping learners to live in a technologically advanced world. Due to the fast adoption of Artificial Intelligence in the field of education, mathematics teacher education programs need to be changed as well. The primary areas of reform that need to be taken care of are curriculum development, pedagogical innovation, assessment reform, professional development, ethical awareness, and AI-TPACK competency development. Through these reforms, mathematical teacher training centers will be able to nurture mathematics teachers who can effectively embrace AI technologies in teacher education to improve teaching practices and student learning outcomes. Finally, AI implementation in the field of mathematics can only be successfully implemented with the help of well-trained teachers who possess the ability to balance technological creativity and good pedagogical practices.

Recommendations

Based on the discussions about curriculum reform, AI-TPACK competency building, pedagogical changes, assessment methods, ethical use of AI in education, and institutional readiness, the following recommendations are suggested:

1. Curriculum Reform

The mathematical teacher education curriculum needs to be updated at teacher education institutions and curriculum developers to explicitly include the AI-TPACK competencies. The updated curriculum needs to provide pre-service teachers with the skills and knowledge needed to critically analyze AI-generated mathematical solutions, to incorporate AI in lesson planning, and to ethically use AI to assist students in grasping mathematical concepts and problem-solving.

2. Professional Development of Mathematics Teachers

The Ministries of Education, Teacher Education Institutions, and professional bodies should offer continuous professional

development programmes that specifically address AI literacy, prompt engineering, designing lessons with AI, use of AI in an ethical manner, and critical analysis of the output from AI. These programmes should provide pre-service and in-service mathematics teachers with confidence to successfully utilize AI in mathematics classroom instruction with their sound pedagogical judgment.

3. Pedagogical and Assessment Reform

Instructors of mathematics should rethink teaching and evaluation approaches in their lessons for the new context of AI-enhanced learning. Teaching should focus on mathematical thinking and reasoning, problem solving in a collaborative way, creativity and justifying results produced by the AI instead of just focusing on routine computation. The way students have used AI technologies and their understanding and reasoning should also be assessed.

4. Development of Ethical AI Competencies.

Schools need to develop clear policies for the responsible use of AI in mathematics education. Future teachers should be taught specifically about topics like academic integrity, data privacy, algorithmic bias, transparency, equity, and making responsible decisions when using AI in learning to ensure future teachers can use AI fairly and inclusively.

5. Institutional and Policy Support.

The government, teacher education institutions, and education stakeholders should create national policies and institutional frameworks that foster the responsible use of AI in mathematics teacher education. This should involve investment in digital infrastructure, access to AI-based learning resources, faculty training, and continuous review of the curriculum to align it with new technological advancements.

6. Research and Evaluation

The effectiveness of teacher preparation programmes using AI-TPACK in enhancing teachers' instructional competence, students'

mathematical achievement, their critical thinking, and their ethical use of AI in teaching needs to be further studied in various educational environments. These will be studies which will give evidence to inform future curriculum development and educational policy.

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