

The Eurasia Proceedings of Educational and Social Sciences (EPESS), 2026

Volume 51, Pages 32-47

ICRESS 2026: International Conference on Research in Education and Social Sciences

Artificial Intelligence in Higher Education Mathematics Classrooms and Its Influence on Teaching and Learning

Ana Paula Lopes

Polytechnic of Porto / ISCAP / CEOS.PP

Abstract: Artificial Intelligence (AI) is increasingly influencing the way mathematics is taught and learned in higher education. From intelligent tutoring systems to generative AI tools, these technologies are creating new opportunities to support students' learning while encouraging educators to rethink traditional teaching practices. Although AI has the potential to improve engagement, provide timely feedback, and promote more personalized learning experiences, its integration into mathematics classrooms also raises important pedagogical and ethical questions. This paper discusses the growing role of AI in higher education mathematics classrooms by examining its potential benefits, current challenges, and implications for teaching and learning. Drawing on recent research and examples from the literature, it explores how AI can support mathematical reasoning, problem-solving, and conceptual understanding, while also considering issues such as academic integrity, students' critical use of AI-generated content, data privacy, and the evolving role of the lecturer. Rather than viewing AI as a replacement for educators, this paper argues that its value lies in complementing effective teaching practices. The successful use of AI depends on thoughtful pedagogical integration, digital literacy, and clear institutional guidelines that encourage its responsible and ethical use. As AI technologies continue to evolve, higher education institutions have an important opportunity to rethink mathematics education in ways that enhance learning while preserving the essential role of human interaction in the educational process.

Keywords: Artificial intelligence, Mathematics education, Teaching and learning, Generative AI.

Introduction

Artificial Intelligence (AI) has become one of the most transformative technologies, shaping higher education in the twenty-first century. Recent advances in machine learning, natural language processing, and generative AI have expanded the range of digital tools available to support teaching and learning across different disciplines (OECD, 2026). In mathematics education, where abstract reasoning, problem-solving, and conceptual understanding are fundamental learning objectives, AI is increasingly being explored as a means of enhancing student learning experiences while supporting educators in designing more effective instructional strategies (Crompton & Burke, 2023; Wang et al., 2024).

The emergence of large language models (LLMs) such as ChatGPT, Microsoft Copilot, Gemini, and Claude have accelerated discussions about the role of AI in higher education. Unlike earlier educational technologies, these systems can generate explanations, solve mathematical problems, provide personalized feedback, and interact with students through natural language. Together with intelligent tutoring systems, adaptive learning platforms, automated assessment tools, and computer algebra systems, generative AI has introduced new possibilities for supporting both independent learning and classroom instruction (Kasneci et al., 2023; Lo, 2023).

Several studies suggest that AI can contribute positively to mathematics education by providing immediate feedback, adapting learning activities to individual students' needs, identifying misconceptions, and promoting greater engagement with mathematical concepts (Alsharidah & Alkramiti, 2024; Awang et al., 2025; Mohamed et al., 2022; Opesemowo & Ndlovu, 2024). AI-assisted environments may also reduce repetitive tasks for

- This is an Open Access article distributed under the terms of the Creative Commons Attribution-Noncommercial 4.0 Unported License, permitting all non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

© 2026 Published by ISRES Publishing: www.isres.org

lecturers, allowing them to devote more time to higher-order pedagogical activities such as facilitating discussion, supporting critical thinking, and designing authentic learning experiences. These developments are particularly relevant in higher education, where increasingly diverse student populations require flexible, personalized, and inclusive teaching approaches (Kadry, 2024; Kamalov et al., 2023; Rahiman & Kodikal, 2024).

Despite these opportunities, the integration of AI into mathematics classrooms presents significant pedagogical, ethical, and institutional challenges. Concerns have been raised regarding academic integrity, students' overreliance on AI-generated solutions, the reliability and accuracy of AI outputs, algorithmic bias, data privacy, and the transparency of AI-supported decision-making processes (Kamalov et al., 2023). In mathematics, where learning often depends on understanding the reasoning behind a solution rather than simply obtaining the correct answer, the inappropriate use of generative AI may delay the development of procedural fluency, conceptual understanding, and critical reasoning skills (Opesemowo & Ndlovu, 2024). Consequently, educators face the challenge of integrating AI in ways that enhance learning without reducing students' active cognitive engagement.

Although the potential of AI to support learning is increasingly recognised, an important distinction must be made between improved task performance and meaningful learning. The ability to obtain a correct answer, complete an exercise, or generate a mathematical solution with the assistance of AI does not necessarily imply that students have developed the conceptual knowledge and skills required to solve similar problems independently. Recent discussions on generative AI in education have therefore highlighted the risk that easy access to AI-generated solutions may reduce the cognitive effort, reflection, and active engagement that are essential for deeper learning (Opesemowo & Ndlovu, 2024). This issue is particularly relevant in mathematics education, where the process used to reach a solution is often as important as the result.

From this perspective, the educational value of AI depends not only on the capabilities of the technology itself but also on the way it is integrated into teaching and learning activities. AI can function as a simple answer generator, but it can also support learning by providing formative feedback, encouraging students to explain their reasoning, presenting alternative solution strategies, identifying possible misconceptions, and supporting reflective dialogue. Research on intelligent tutoring systems has demonstrated the potential of AI-based environments to support learning when technological assistance is combined with appropriate pedagogical design, feedback, and active student engagement (Kulik & Fletcher, 2016; Ma et al., 2014). Similarly, recent studies on generative AI emphasise the importance of using these technologies as tools to support, rather than replace, students' cognitive and problem-solving processes (Awang et al., 2025; Bahroun et al., 2023).

Even though research on AI in education has grown quickly, there is still a need for analyses that focus specifically on the distinctive characteristics of mathematics learning in higher education. Mathematics involves abstraction, symbolic representation, logical reasoning, conceptual understanding, and problem-solving, and these processes may be affected differently by AI-assisted learning. While AI technologies can provide substantial support to both students and educators, their increasing ability to generate mathematical solutions raises a fundamental pedagogical question: how can AI be integrated into higher education mathematics in ways that support learning without replacing the cognitive processes through which mathematical understanding is developed?

This paper addresses this question through a review of the literature, with particular emphasis on recent research, on the role of Artificial Intelligence in higher education mathematics classrooms. It examines the potential of AI to support mathematical reasoning, problem-solving, conceptual understanding, personalized learning, feedback, and assessment. In addition, the paper critically discusses the pedagogical, ethical, and institutional challenges associated with AI integration, with particular attention to students' cognitive engagement, the reliability of AI-generated content, academic integrity, and the evolving role of the lecturer.

Rather than viewing AI as a replacement for educators, this paper adopts a human-centered and pedagogically grounded perspective, arguing that the value of AI lies primarily in its capacity to complement effective teaching practices. The successful integration of AI into higher education mathematics therefore depends not only on technological development but also on thoughtful pedagogical design, AI literacy, critical evaluation, and clear institutional guidelines that promote its responsible and ethical use.

The remainder of the paper is organised as follows. The next section reviews the main applications of AI in higher education mathematics, with particular attention to intelligent tutoring systems, adaptive learning, and generative AI. The methodology adopted for the literature review is then presented. Subsequently, the main opportunities, challenges, and pedagogical implications associated with AI integration in mathematics education are discussed. Based on this analysis, the paper proposes a conceptual framework for the responsible and pedagogically

meaningful integration of AI in higher education mathematics. Finally, the paper presents its conclusions, recommendations for educators and higher education institutions, and directions for future research.

Artificial Intelligence in Higher Education Mathematics

Artificial Intelligence has been progressively integrated into educational environments through a variety of technologies designed to support teaching, learning, assessment, and decision-making. In mathematics education, AI-related applications existed long before the recent emergence of generative AI and large language models. Intelligent tutoring systems, adaptive learning platforms, automated assessment systems, computer algebra systems, and learning analytics have been used to provide personalized support, adapt learning activities to students' needs, and assist educators in monitoring learning progress (Kulik & Fletcher, 2016; Ma et al., 2014; Zawacki-Richter et al., 2019).

The increasing interest in AI in education has been associated with its potential to address some of the limitations of traditional learning environments. Mathematics classrooms often include students with different levels of prior knowledge, learning difficulties, motivations, and rates of progress. Providing individualized support in large higher education classes can therefore represent a significant challenge for lecturers. AI-based systems may contribute to addressing this challenge by analyzing student interactions and performance data and providing differentiated learning activities, explanations, feedback, or additional practice opportunities (Alsharidah & Alkramiti, 2024; Barrientos et al., 2024; Hossein-Mohand et al., 2025; Mohamed et al., 2022; Nagaraj et al., 2023; Sousa & Cardoso, 2025; Stefanova & Georgiev, 2024).

Intelligent Tutoring Systems and Adaptive Learning

Among the earliest and most extensively studied applications of AI in education are intelligent tutoring systems (ITS). These systems are designed to provide individualised instruction by modelling aspects of students' knowledge, monitoring their interactions, and adapting instructional support accordingly. Unlike conventional computer-based learning environments that present the same materials to all students, intelligent tutoring systems aim to respond to learners' individual needs and provide feedback during the learning process (Anderson et al., 1995; Paquette et al., 2010; WOOLF, 2010).

Research has demonstrated the potential of intelligent tutoring systems to contribute positively to learning outcomes. Meta-analyses by Ma et al. (2014) and Kulik and Fletcher (2016) found that intelligent tutoring systems can produce positive effects on student learning, particularly when they provide timely feedback and opportunities for active engagement. These findings are relevant to mathematics education, where students often require different levels of support when developing procedural skills and conceptual understanding.

In mathematics learning, intelligent tutoring systems can provide step-by-step guidance, identify possible misconceptions, and offer hints without immediately revealing the complete solution. This type of support may be particularly valuable when it encourages students to remain actively involved in the problem-solving process. Rather than simply providing an answer, a well-designed tutoring system can guide learners through successive stages of reasoning and encourage them to reflect on their choices (Anderson et al., 1995; Niño-Rojas et al., 2023; Son, 2024).

Adaptive learning systems have a similar objective. By using information about students' performance and interactions, these systems can adjust the difficulty, sequence, or presentation of learning activities. Such personalisation may be particularly useful in higher education mathematics, where students frequently enter courses with heterogeneous levels of mathematical preparation. Adaptive systems can potentially allow students who experience difficulties to receive additional support while enabling more advanced students to progress at an appropriate pace (Crompton & Burke, 2023; Wang et al., 2024).

However, personalisation alone does not guarantee meaningful learning. The effectiveness of adaptive technologies depends on the quality of the learning activities, the appropriateness of the feedback provided, and the extent to which students remain cognitively engaged. AI systems that simply adapt the level of difficulty or provide answers may improve task completion without necessarily promoting deeper conceptual understanding. Therefore, the pedagogical design of AI-supported learning environments remains a fundamental consideration.

Automated Assessment, Feedback, and Mathematical Support

Another important area of AI application in mathematics education concerns assessment and feedback. Timely feedback plays an important role in supporting learning because it can help students identify errors, recognize misconceptions, and adjust their problem-solving strategies. However, providing frequent and individualized feedback can be particularly demanding in large higher education classes (Hattie & Timperley, 2007; Morris et al., 2021).

AI-based systems can support automated or semi-automated feedback processes by analyzing students' responses and identifying patterns of error or misunderstanding. In mathematics, such systems may provide feedback not only on the correctness of an answer but also, depending on the design of the system, on intermediate steps and solution strategies. This can allow students to receive support while they are still engaged with a problem rather than waiting for feedback from the lecturer (Niño-Rojas et al., 2023; Son, 2024).

Computer algebra systems have also played an important role in higher education mathematics by enabling students to perform symbolic calculations, visualize mathematical relationships, and explore alternative approaches to problem-solving. These technologies can reduce the time required for routine calculations and allow greater attention to conceptual interpretation and modelling. However, as with other AI-supported technologies, their educational value depends on how they are incorporated into learning activities. If technology is used primarily to generate results, students may have fewer opportunities to develop the underlying reasoning required to understand the mathematical processes involved (Drijvers & Sinclair, 2024; Pierce & Stacey, 2010).

For this reason, automated feedback and mathematical technologies should not be viewed simply as mechanisms for increasing efficiency. Their potential educational contribution lies in their ability to provide feedback that encourages students to reflect, identify errors, reconsider strategies, and develop a deeper understanding of mathematical concepts (Alsharidah & Alkramiti, 2024; Opesemowo & Ndlovu, 2024).

The Emergence of Generative AI in Mathematics Education

The emergence of generative AI represents a significant development in the evolution of AI applications in education. Unlike many earlier systems, which were designed for specific learning environments or educational purposes, large language models can interact with users through natural language and respond to a wide range of questions and requests. Tools such as ChatGPT, Microsoft Copilot, Gemini, and Claude have therefore become easily accessible to students and educators and can be used both inside and outside formal learning environments.

In mathematics education, generative AI can assist students in several ways. It can generate explanations of mathematical concepts, provide worked examples, suggest alternative solution strategies, create practice problems, summarize theoretical content, and respond to questions in a conversational format. Students may also use generative AI to request explanations adapted to their level of understanding or to explore the same mathematical problem from different perspectives (Kasneci et al., 2023; Pepin et al., 2025; Wardat et al., 2023).

This capacity for interaction represents one of the most significant differences between generative AI and many previous educational technologies. Students can ask follow-up questions, request clarification, challenge an explanation, or ask the system to present an alternative approach. When used appropriately, this may create opportunities for a more exploratory and interactive approach to mathematics learning.

Generative AI may also support lecturers in preparing teaching materials, generating examples and exercises, developing preliminary feedback, and creating alternative explanations for complex concepts. This can potentially reduce the time required for certain routine activities and enable lecturers to focus more on instructional design, student interaction, and other pedagogical tasks (Kadry, 2024; Kamalov et al., 2023).

Nevertheless, the accessibility and versatility of generative AI also create new challenges. Unlike educational systems specifically designed around learning objectives, general-purpose AI tools do not necessarily take into account a student's prior knowledge, course objectives, or curriculum requirements. Furthermore, AI-generated mathematical solutions may contain errors, incomplete reasoning, or explanations that appear convincing but are conceptually misleading. The ability of generative AI to produce fluent and apparently authoritative responses therefore requires students and educators to critically evaluate the information generated rather than accepting it automatically (Kasneci et al., 2023; Lo, 2023).

From Answer Generation to Meaningful Mathematical Learning

One of the central issues associated with the use of generative AI in mathematics education concerns the distinction between obtaining a solution and learning how to solve a problem. Mathematics education is not limited to producing correct answers. Students are expected to develop the ability to understand mathematical concepts, select appropriate strategies, construct logical arguments, analyse errors, and apply their knowledge to new situations.

Generative AI can significantly reduce the effort required to obtain a mathematical answer. A student can submit a problem and receive an immediate solution, often accompanied by an explanation of the steps involved. Although this may be useful in some learning situations, it can also create a risk of cognitive dependency if students rely on AI-generated solutions without actively engaging with the reasoning process.

The educational challenge is therefore not simply whether students should use AI, but how AI should be used to support mathematical learning. An answer-oriented use of AI may focus primarily on efficiency and task completion. In contrast, a learning-oriented use encourages students to engage with the problem, articulate their reasoning, evaluate different strategies, identify errors, and reflect on the mathematical principles involved (Eti et al., 2026; Mohamed et al., 2022). Table 1 presents a conceptual distinction between these two approaches.

Table 1. AI as an answer generator versus AI as a learning facilitator

Dimension	AI as an Answer Generator	AI as a Learning Facilitator
Primary objective	Obtaining the correct answer	Supporting mathematical understanding
Student role	Recipient of information	Active participant in the learning process
Cognitive engagement	May be reduced	Encouraged and supported
AI interaction	Requests solutions	Engages in questioning and dialogue
Feedback	Provides the answer	Supports reflection and error analysis
Problem-solving	AI performs the task	AI guides the problem-solving process
Learning outcome	Task completion	Development of mathematical knowledge and skills

Source: Author's own elaboration.

The distinction presented in Table 1 does not imply that providing answers is always educationally inappropriate. There may be situations in which worked examples or complete solutions are useful, particularly when students need to compare their own reasoning with an alternative approach. However, the pedagogical value of AI is likely to increase when students are encouraged to use the technology as a tool for exploration, questioning, verification, and reflection rather than as a substitute for their own reasoning.

This perspective is consistent with research emphasising the importance of active learning, formative feedback, and self-regulated learning. AI can potentially contribute to these processes when students are encouraged to question AI-generated responses, identify possible limitations, compare different solutions, and justify their own mathematical reasoning. In this context, AI becomes less of a mechanism for replacing student effort and more of a resource for supporting the development of mathematical thinking.

The Changing Role of the Mathematics Educator

The growing availability of AI does not necessarily reduce the importance of the mathematics lecturer. On the contrary, the increasing use of AI may reinforce the importance of pedagogical expertise and professional judgement. As AI becomes more accessible, lecturers must make decisions about when its use is appropriate, how it can be integrated into learning activities, and how students should be encouraged to interact with AI-generated content (Abedin et al., 2026; Holmes et al., 2019; Luckin et al., 2019).

The role of the mathematics educator may therefore increasingly involve designing AI-supported learning environments in which technology is aligned with specific learning objectives. Rather than simply allowing or prohibiting the use of AI, lecturers may need to establish clear expectations regarding appropriate use and help students develop the skills required to interact critically and responsibly with AI systems (Holmes et al., 2019). This includes encouraging students to verify AI-generated mathematical solutions, compare alternative approaches, identify possible errors, and explain their own reasoning. It may also require changes in assessment practices. Traditional assessment methods that focus exclusively on the final answer may become increasingly insufficient when students have easy access to AI-generated solutions. Greater attention may therefore need to be given to reasoning processes, oral explanation, reflection, authentic problem-solving, and students' ability to critically evaluate AI-generated content (Kamalov et al., 2023).

The changing role of the lecturer also extends beyond classroom teaching. Educators may increasingly participate in the development of institutional guidelines, the design of AI literacy initiatives, and the establishment of ethical principles for AI use. Professional development is therefore essential to ensure that lecturers not only understand the technical capabilities and limitations of AI but are also able to make informed pedagogical decisions about its use (Holmes et al., 2019; UNESCO, 2023).

Overall, the literature suggests that AI has considerable potential to transform mathematics education, but its educational impact cannot be understood solely in terms of technological capability. Intelligent tutoring systems, adaptive learning environments, automated feedback, computer algebra systems, and generative AI can provide valuable support to both students and educators. However, their contribution to meaningful learning depends fundamentally on pedagogical design, students' active cognitive engagement, and the continued involvement of educators.

Methodology

This study adopted a structured narrative literature review to examine the role of Artificial Intelligence (AI) in higher education mathematics classrooms and its influence on teaching and learning. This approach was considered appropriate given the interdisciplinary and rapidly evolving nature of the field, which encompasses different forms of AI-supported education, including intelligent tutoring systems, adaptive learning, automated assessment and feedback, computer algebra systems, learning analytics, and, more recently, generative AI and large language models. Rather than seeking to estimate a single effect of AI on learning outcomes, the review aimed to identify, organise, and critically synthesise the main educational applications, opportunities, challenges, and pedagogical implications reported in the literature. The review was guided by the central research question formulated in the Introduction: how can AI be integrated into higher education mathematics in ways that support learning without replacing the cognitive processes through which mathematical understanding is developed?

To address this question, the literature was selected with particular attention to studies concerning the use of AI in mathematics education and higher education, as well as research addressing technologies and pedagogical processes directly relevant to mathematical learning. The review considered peer-reviewed journal articles, systematic and scoping reviews, meta-analyses, and relevant conceptual contributions. Reports from internationally recognised organisations were also considered when they provided relevant evidence or guidance concerning the pedagogical, ethical, or institutional implications of AI use in education.

The literature search was based on combinations of terms covering three main domains: AI technologies, educational context, and teaching and learning processes. Search terms included artificial intelligence, generative AI, large language models, ChatGPT, intelligent tutoring systems, adaptive learning, automated feedback, mathematics education, higher education, mathematics learning, mathematical reasoning, problem-solving, assessment, and personalised learning. These terms were combined in different ways to identify publications addressing both the technological characteristics of AI and their implications for mathematics teaching and learning.

Given the rapid development of AI technologies, particular attention was given to recent publications. Most of the literature considered in the review was published between 2019 and 2026, with particular emphasis on research published from 2022 onwards, reflecting the rapid expansion of the field following the emergence of widely accessible generative AI tools. Earlier publications were retained when they represented foundational contributions to areas directly relevant to the analysis, particularly intelligent tutoring systems, formative feedback, and technology-supported mathematics learning (Anderson et al., 1995; Hattie & Timperley, 2007; Kulik & Fletcher, 2016; Ma et al., 2014; Pierce & Stacey, 2010).

Studies were considered relevant when they addressed one or more of the following dimensions: AI applications in mathematics education or higher education; intelligent tutoring systems and adaptive learning; AI-supported assessment and feedback; generative AI and large language models in teaching and learning; mathematical reasoning, problem-solving, and conceptual understanding; personalisation and student engagement; or pedagogical, ethical, academic integrity, and institutional implications of AI use. Publications focusing exclusively on the technical development of AI models, without a clear connection to educational processes, were not considered central to the review. The main elements guiding the literature review are summarised in Table 2.

Table 2. Main components of the literature review

Review component	Description
Review approach	Structured narrative literature review
Main focus	AI in higher education mathematics teaching and learning
Period considered	Primarily 2019–2026, with earlier foundational studies retained when relevant
Main search concepts	Artificial intelligence, generative AI, large language models, ChatGPT, intelligent tutoring systems, adaptive learning, automated feedback, mathematics education, higher education, mathematical reasoning, problem-solving, assessment, personalised learning
Types of evidence considered	Peer-reviewed empirical studies, systematic and scoping reviews, meta-analyses, conceptual studies, and relevant institutional reports
Main inclusion focus	AI applications with explicit relevance to mathematics/higher education, teaching and learning processes, reasoning and problem-solving, feedback and assessment, pedagogy, ethics, academic integrity, and institutional implications
Exclusion focus	Studies concerned exclusively with technical AI development without a clear educational dimension
Analysis method	Thematic synthesis and critical comparison of findings
Main analytical dimensions	Opportunities for AI-enhanced learning; challenges and risks; pedagogical conditions for meaningful integration; implications for educators and higher education institutions

Source: Author's own elaboration.

The selected literature included different types of evidence in order to provide a broad and balanced perspective on the field. Systematic reviews and meta-analyses were used to identify established findings and broader research trends (Awang et al., 2025; Eti et al., 2026; Kulik & Fletcher, 2016; Mohamed et al., 2022), while recent studies and reviews focusing on generative AI were used to examine emerging applications and challenges (Kasneci et al., 2023; Opešemowo & Ndlovu, 2024; Pepin et al., 2025; Wardat et al., 2023). Broader reviews of AI in higher education complemented the mathematics-specific literature by providing evidence concerning pedagogical, technological, and institutional developments (Crompton & Burke, 2023; Wang et al., 2024; Zawacki-Richter et al., 2019). The OECD Digital Education Outlook 2026 was additionally considered to contextualise recent developments concerning the effective and responsible educational use of generative AI.

Following the identification and selection of relevant publications, the literature was analysed using a thematic synthesis approach. The analysis focused on identifying recurring concepts, converging findings, contrasting perspectives, and emerging concerns across the literature included in the review. Rather than examining each publication independently, findings were compared and organised according to their relevance to the central research question.

Four interconnected analytical dimensions emerged from this process: (1) opportunities for AI-enhanced mathematics teaching and learning; (2) challenges and risks associated with AI use; (3) pedagogical conditions for meaningful AI integration; and (4) implications for the role of mathematics educators and higher education institutions. Particular attention was given across these dimensions to the distinction between using AI primarily for answer generation and task completion and using AI as a learning facilitator capable of supporting reasoning, reflection, feedback, and conceptual understanding.

The thematic synthesis subsequently provided the basis for developing the conceptual framework proposed later in the paper. The framework integrates the relationships identified in the literature among AI capabilities, pedagogical design, student cognitive engagement, teacher mediation, and meaningful mathematical learning. It should therefore be understood as a literature-informed conceptual synthesis rather than as an empirically tested model.

As a structured narrative review, this study does not aim to provide an exhaustive or statistically representative synthesis of all available research on AI in mathematics education. Moreover, the rapid evolution of generative AI means that technologies, educational practices, and the associated empirical evidence continue to develop. Nevertheless, the combination of foundational contributions, recent empirical studies, systematic and scoping reviews, meta-analyses, and institutional perspectives provides a sufficiently broad basis for examining current developments and identifying the pedagogical conditions that may contribute to the meaningful and responsible integration of AI into higher education mathematics.

Results and Discussion

Analysis of the literature suggests that the role of Artificial Intelligence on higher education mathematics is characterized by a combination of advantages and limitations, rather than by uniformly positive or negative effects. Instead, its educational impact depends on the interaction between technological capabilities, pedagogical design, students' engagement with the technology, and the role assumed by educators. Across the literature reviewed, four interconnected themes emerged: *opportunities for AI-enhanced mathematics teaching and learning*; *challenges and risks associated with AI use*; *pedagogical conditions for meaningful integration*; and *implications for mathematics educators and higher education institutions*. These themes are discussed below.

Opportunities for AI-Enhanced Mathematics Teaching and Learning

One of the most consistently identified advantages of AI in education is its potential to provide more personalised and responsive learning experiences. This is particularly relevant in higher education mathematics, where students frequently enter courses with heterogeneous levels of prior knowledge, mathematical confidence, learning strategies, and rates of progression. AI-supported environments can potentially respond to these differences by adapting the difficulty and sequence of activities, providing additional explanations, generating examples, and offering immediate feedback according to individual learning needs (Mohamed et al., 2022; Crompton & Burke, 2023; Alsharidah & Alkramiti, 2024; Eti et al., 2026).

The evidence concerning intelligent tutoring systems provides an important foundation for understanding this potential. Earlier research demonstrated that appropriately designed ITS can improve learning outcomes by providing individualised guidance and timely feedback (Ma et al., 2014; Kulik & Fletcher, 2016). More recent reviews confirm the continued relevance of intelligent tutoring approaches in mathematics education, particularly when systems support students during problem-solving rather than simply evaluating final answers (Niño-Rojas et al., 2023; Son, 2024). The contribution of such systems lies not only in automating instructional processes but also in delivering targeted support at the exact moment learners face challenges in their understanding or problem-solving efforts.

The emergence of generative AI substantially extends these possibilities. Large language models allow students to interact with AI through natural language, making it possible to request explanations, examples, hints, alternative solution strategies, or clarification of mathematical concepts. Unlike many traditional educational technologies, GenAI enables an iterative dialogue in which students can reformulate questions and request explanations at different levels of detail. Recent literature identifies this conversational flexibility as an important opportunity for mathematics education (Wardat et al., 2023; Opesemowo & Ndlovu, 2024; Pepin et al., 2025).

For example, when confronted with a difficult mathematical problem, a student may ask an AI system not only for a solution but also to explain why a particular method is appropriate, provide an alternative approach, identify an error in the student's reasoning, or generate a similar problem for further practice. Such interactions have the potential to transform AI from a source of answers into a resource for exploration and formative learning. In this respect, the educational potential of GenAI lies partly in its capacity to provide forms of individualised support that would be difficult for a lecturer to deliver continuously to every student, particularly in large classes.

Feedback represents another important area of opportunity. The educational importance of timely, meaningful feedback is well established (Hattie & Timperley, 2007; Morris et al., 2021). In mathematics, where misconceptions or procedural errors can affect subsequent stages of a solution, receiving feedback while the student is still engaged with the task can be particularly valuable. AI may therefore complement lecturer feedback by providing students with additional opportunities to identify errors, reconsider strategies, and attempt revised solutions.

AI can also support lecturers. Applications include generating examples and exercises, preparing differentiated learning materials, producing preliminary feedback, suggesting alternative explanations, and assisting with routine educational tasks. Such support may allow lecturers to devote more attention to activities requiring distinctly human pedagogical judgement, including discussion, mentoring, interpretation of student difficulties, and the design of meaningful learning experiences (Crompton & Burke, 2023; Kamalov et al., 2023; Rahiman & Kodikal, 2024).

Taken together, these findings suggest that the principal educational opportunities associated with AI in mathematics can be grouped around personalisation, accessibility of support, immediacy of feedback, interactive explanation, and support for teaching practice. However, these benefits cannot be considered independently of the way students use AI. The same system that provides productive scaffolding can also provide a complete solution that eliminates the need for students to engage with the mathematical problem.

Challenges and Risks Associated with AI Use

The literature also identifies substantial risks associated with the increasing availability of AI, particularly generative AI. A central concern is the reliability of AI-generated content. Large language models can generate fluent and apparently convincing explanations even when their reasoning is incomplete or incorrect. In mathematics, this presents a particular problem because errors may occur not only in the final result but also in intermediate reasoning, assumptions, symbolic manipulation, or the choice of an appropriate method (Kasneci et al., 2023; Opesemowo & Ndlovu, 2024).

Students who lack sufficient prior knowledge may find it particularly difficult to identify such errors. Consequently, the apparent authority and fluency of an AI-generated explanation may create a false sense of confidence. The ability to critically evaluate AI outputs therefore becomes an important component of mathematical and AI literacy. Students need to learn that an AI-generated solution should be treated as an output to be examined, verified, and questioned rather than as an automatically reliable answer.

A second major concern is overreliance on AI-generated solutions. Mathematics learning requires sustained engagement with problems, including unsuccessful attempts, reconsideration of strategies, recognition of errors, and revision of reasoning. If students routinely delegate these processes to AI, they may successfully complete tasks without developing the underlying knowledge required to solve similar problems independently. The distinction between performance and learning is therefore particularly important. Improved performance on an AI-assisted task should not automatically be interpreted as evidence of improved mathematical competence.

This concern is consistent with the central argument emerging from the reviewed literature: AI can reduce unnecessary barriers to learning, but it can also reduce productive cognitive effort. The critical issue is determining which forms of effort technology should reduce and which forms of effort remain necessary for learning. Automating routine calculations, for example, may enable students to focus more attention on modelling or interpretation. By contrast, outsourcing the reasoning that constitutes the intended learning objective may undermine the learning process itself.

Generative AI also presents substantial challenges for assessment and academic integrity. Students can now generate mathematical solutions, explanations, written interpretations, and even code within seconds. Consequently, assessment tasks that can be completed directly by a general-purpose AI system may provide limited evidence of students' independent knowledge and competence. Concerns regarding academic integrity and the attribution of AI-generated work are therefore increasingly prominent in higher education (Barrientos et al., 2024; Sousa & Cardoso, 2025).

The response to this challenge cannot rely exclusively on detecting or prohibiting AI use. Instead, the increasing accessibility of AI requires reconsideration of what assessment is intended to measure. In mathematics, greater emphasis may be required on reasoning, justification, interpretation, comparison of methods, oral explanation,

error identification, and application to unfamiliar situations. Tasks that ask students to evaluate or correct an AI-generated solution may themselves become valuable forms of assessment because they require mathematical understanding and critical judgement.

Other concerns identified in the literature include data privacy, algorithmic bias, transparency, unequal access to advanced AI systems, and uncertainty regarding the appropriate use of student data (Kamalov et al., 2023; OECD, 2026). These issues indicate that responsible AI integration cannot depend solely on individual lecturers or students but also requires institutional governance. The main opportunities and challenges identified through the thematic synthesis are summarised in Table 3.

Table 3. Main opportunities and challenges of AI in higher education mathematics

Dimension	Opportunities	Challenges and risks
Personalisation	Adaptation to students' needs and pace	Inappropriate or inaccurate adaptation
Feedback	Immediate and individualised support	Incorrect or misleading feedback
Mathematical problem-solving	Alternative strategies, hints, explanations	Delegation of reasoning to AI
Conceptual learning	Multiple explanations and representations	Superficial understanding
Student autonomy	On-demand support and independent exploration	Dependency and cognitive offloading
Assessment	Formative feedback and new assessment possibilities	Academic integrity and authorship concerns
Teaching	Support for material preparation and routine tasks	Need for new pedagogical and AI competencies
Accessibility	Support available beyond classroom time	Digital inequality and unequal access
Institutional practice	Opportunities for innovation	Privacy, transparency, governance, and ethical concerns

Source: Author's own elaboration.

Table 3 highlights an important pattern: many of AI's greatest educational opportunities have a corresponding risk. Immediate assistance can become dependency; personalisation can become inappropriate guidance; automation can create efficiency but reduce cognitive engagement; and easy access to information can support autonomy while simultaneously facilitating academic misconduct. The educational consequences of AI therefore depend substantially on the conditions under which the technology is used.

Pedagogical Conditions for Meaningful AI Integration

The findings suggest that the central question is not whether AI should be used in higher education mathematics, but how it should be used. Technology alone does not determine learning outcomes. Its educational value depends on how AI capabilities are aligned with learning objectives, pedagogical strategies, assessment practices, and students' cognitive activity.

A fundamental principle emerging from the analysis is that AI should support mathematical reasoning rather than substitute for it. This requires a shift from answer-oriented interactions towards learning-oriented interactions. Instead of simply asking an AI system to solve a problem, students can be encouraged to use prompts that require guidance, questioning, comparison, explanation, and verification. For example, the difference between the following interactions is pedagogically significant:

- *Solve this problem and show me the answer.*
- and
- *Do not give me the final answer. Help me identify the mathematical concepts involved, ask me questions that guide my reasoning, and provide a hint if I become stuck.*

Both interactions use the same technology, but they create substantially different cognitive demands. In the first case, much of the reasoning may be transferred to the AI system. In the second, AI can potentially function as scaffolding while the student remains responsible for the mathematical reasoning.

A second condition is the development of critical AI literacy. Students need to understand both what AI can do and where its limitations lie. In mathematics education, AI literacy should include the capacity to verify calculations, examine assumptions, identify logical inconsistencies, compare alternative solutions, and question explanations that appear plausible. AI-generated content can therefore itself become a learning object. Asking students to analyse an incorrect or incomplete AI-generated solution may encourage deeper mathematical reasoning than simply asking them to produce a conventional answer.

Third, AI integration should preserve an appropriate level of productive cognitive engagement. Not all cognitive effort is equally valuable, and technology has always been used in mathematics to reduce certain forms of routine work. Calculators, computer algebra systems, and mathematical software have already transformed which processes students perform manually (Pierce & Stacey, 2010; Drijvers & Sinclair, 2024). The pedagogical objective should therefore not be to maximise effort, but to ensure that technology does not automate the cognitive processes that constitute the intended learning outcome. For example, when the objective is understanding differentiation, asking AI to differentiate a function and copying the result may have little educational value. Once differentiation techniques have been understood, however, using technology to perform complex symbolic manipulation may allow greater attention to interpretation, modelling, or optimisation. The appropriate role of AI is consequently dependent on the learning objective, the student's stage of development, and the context of the task.

Fourth, assessment needs to be aligned with this changing environment. If students are expected to use AI in professional and academic contexts, assessment should increasingly evaluate their ability to use it critically and responsibly rather than simply reproduce information that AI can readily generate. This does not imply that all assessments should permit AI. There remain situations in which independent mathematical competence must be demonstrated without technological assistance. Instead, a balanced assessment strategy may combine AI-free tasks with activities in which students are explicitly required to use, document, critique, or improve AI-generated solutions. Based on the synthesis, six pedagogical principles can be proposed for meaningful AI integration:

- 1. Align AI use with explicit mathematical learning objectives.*
- 2. Use AI to scaffold reasoning rather than routinely replace it.*
- 3. Require students to critically evaluate and verify AI-generated mathematical content.*
- 4. Preserve productive cognitive engagement and opportunities for independent problem-solving.*
- 5. Design assessment around reasoning, justification, reflection, and authentic application.*
- 6. Make human pedagogical judgement central to decisions concerning when and how AI is used.*

These principles suggest that the educational value of AI is not an inherent property of the technology. Rather, it emerges from the relationship between technological affordances and pedagogical design.

Implications for Mathematics Educators and Higher Education Institutions

The growing presence of AI has important implications for the role of the mathematics lecturer. Rather than making educators less relevant, the findings indicate that AI may increase the importance of their pedagogical expertise. When students can obtain explanations and solutions instantly, the lecturer's role becomes less centred on transmitting information and more focused on designing learning experiences, facilitating reasoning, developing critical judgement, and guiding appropriate technology use.

Mathematics educators therefore need to make deliberate decisions about when AI should be permitted, encouraged, restricted, or temporarily removed from the learning process. These decisions should be based on learning objectives rather than on a general position either for or against AI. For some activities, AI may provide useful scaffolding; for others, independent work may be essential to determine whether students have developed the required competence.

Lecturers also have an increasingly important role in developing students' capacity to question AI. Rather than presenting AI as an authoritative source, educators can design activities in which students compare AI-generated solutions with their own work, identify errors, evaluate different approaches, improve explanations, or investigate

why different prompts produce different mathematical responses. Such activities can transform the limitations of generative AI into opportunities for critical learning.

These changes require corresponding professional development. Educators need not become AI specialists, but they require sufficient knowledge to understand the capabilities and limitations of commonly used systems, design appropriate AI-supported activities, address ethical issues, and reconsider assessment practices. Recent research on AI in higher education indicates that institutional support and educator preparedness are central to effective adoption (Crompton & Burke, 2023; Rahiman & Kodikal, 2024).

Higher education institutions consequently have responsibilities that extend beyond providing access to AI technologies. Clear policies are required concerning acceptable AI use, transparency, academic integrity, privacy, and responsibility for AI-generated content. However, policies based exclusively on restriction may rapidly become outdated as technologies evolve. Institutional strategies should therefore combine governance with AI literacy, staff development, assessment redesign, equitable access, and pedagogical support.

A human-centred approach is particularly important. Decisions affecting learning and assessment should remain subject to meaningful human judgement and oversight. AI can assist educators by identifying patterns, generating resources, or providing preliminary feedback, but responsibility for educational decisions should remain with lecturers and institutions. This perspective positions AI as a means of augmenting educational practice rather than replacing the professional expertise on which effective teaching depends.

Towards a Conceptual Framework for Meaningful AI Integration

The four themes identified through the literature review indicate that meaningful AI integration in higher education mathematics results from the interaction of several elements rather than from technology alone. Based on the thematic synthesis, this paper proposes a conceptual framework connecting AI capabilities, pedagogical design, student cognitive engagement, teacher mediation, and meaningful mathematical learning. At the first level, AI provides a set of technological capabilities, including personalisation, immediate feedback, conversational interaction, explanation generation, problem-solving assistance, and automated support. These capabilities represent educational opportunities, but they do not independently produce learning.

The second level is pedagogical design, which determines how those capabilities are incorporated into learning activities. Learning objectives, task design, assessment strategy, the timing and degree of AI assistance, and expectations concerning student interaction with AI all influence whether the technology supplements or substitutes students' reasoning. The third level concerns student cognitive engagement. Meaningful mathematical learning requires students to reason, question, explain, verify, reflect, and apply knowledge. AI integration should therefore preserve student agency and intellectual responsibility for the learning process. A fourth element, teacher mediation, connects technological possibilities with pedagogical objectives. Mathematics educators determine when AI assistance is appropriate, design learning experiences, support students in evaluating AI outputs, and exercise professional judgement regarding assessment and learning progression.

When these elements are appropriately aligned, AI has the potential to contribute to meaningful mathematical learning, including conceptual understanding, mathematical reasoning, problem-solving, critical thinking, and learner autonomy. When alignment is weak, however, the same technology may primarily facilitate task completion, dependency, or superficial engagement.

Figure 1 illustrates the relationships among the main elements that influence the educational impact of AI in higher education mathematics. At the centre of the framework is a progression from AI Capabilities to Meaningful Mathematical Learning, mediated by Pedagogical Design and Student Cognitive Engagement, and supported throughout by Teacher Mediation and Human Oversight. Surrounding these elements are the broader conditions that enable their responsible and ethical use: AI Literacy, Academic Integrity, Institutional Governance, and Ethics and Responsible Use.

The framework therefore shifts the focus from the question of what AI systems are capable of doing to the more fundamental question of what students do cognitively when interacting with AI. This distinction is central to understanding the influence of AI on learning in mathematics. The ability of AI to generate correct answers or solve complex problems is not, by itself, evidence of educational value. Its true value depends on whether its use supports students in becoming more competent, independent, critical, and reflective mathematical thinkers.

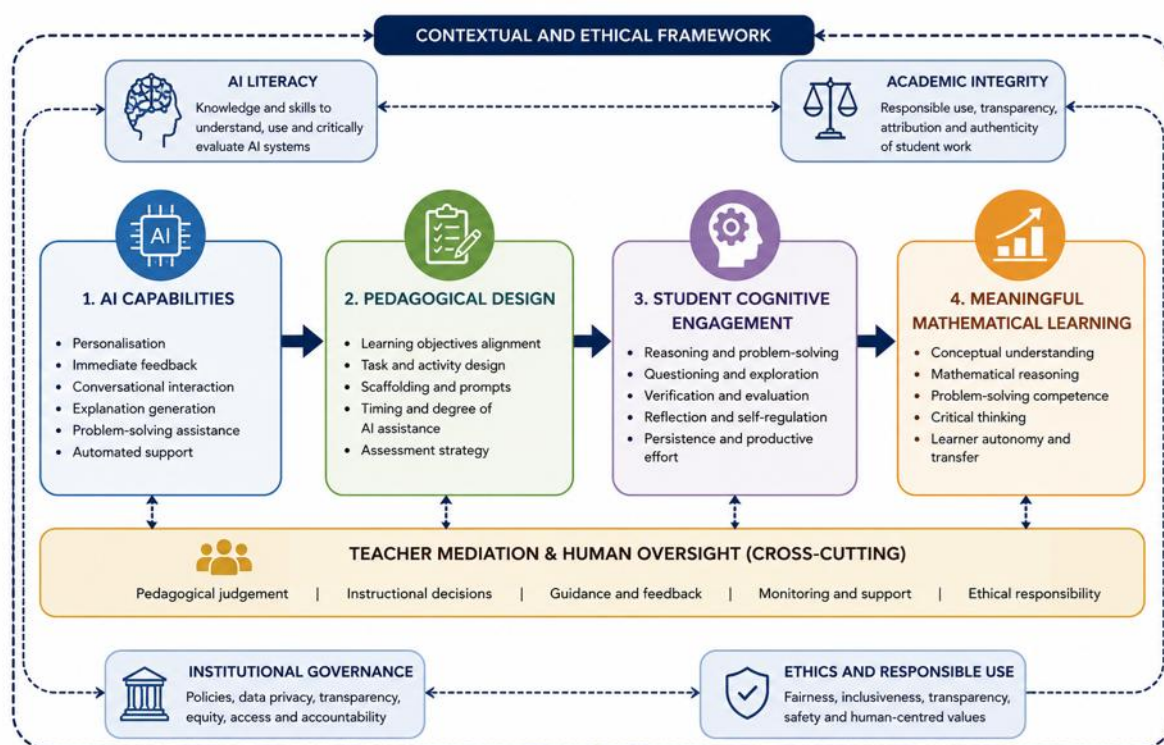


Figure 1. Conceptual framework for meaningful integration of AI in higher education mathematics.

When the elements represented in Figure 1 are appropriately aligned, AI can meaningfully enhance mathematical learning. In such conditions, AI supports students in developing deeper conceptual understanding, engaging in mathematical reasoning and problem-solving, exercising critical thinking, and building greater autonomy in their learning. However, when alignment is weak or inconsistent, the same technologies may reduce opportunities for cognitive engagement and reflection. In these cases, AI risks becoming a shortcut that prioritises task completion over understanding, encouraging dependency on automated solutions and limiting the development of essential mathematical competences.

Conclusion

Artificial Intelligence is creating significant opportunities to rethink the teaching and learning of mathematics in higher education. Intelligent tutoring systems, adaptive learning environments, automated feedback, and, more recently, generative AI can provide students with personalised support, immediate feedback, alternative explanations, and new opportunities to explore mathematical concepts and problem-solving strategies. At the same time, these technologies can assist lecturers in developing learning resources, supporting diverse student needs, and reducing the burden associated with some routine teaching activities.

However, the analysis presented in this paper indicates that the educational value of AI cannot be determined by its technological capabilities alone. In mathematics education, the ability of an AI system to generate a correct answer or a detailed solution does not necessarily imply that meaningful learning has occurred. Mathematical learning requires students to engage actively in reasoning, problem-solving, verification, reflection, and conceptual interpretation. If AI replaces rather than supports these cognitive processes, its use may encourage dependency, superficial engagement, and task completion without corresponding development of mathematical competence.

The central issue is therefore not whether AI should be used in higher education mathematics, but under what pedagogical conditions its use can contribute to meaningful learning. The literature reviewed suggests that AI is most educationally valuable when it functions as a learning facilitator rather than simply as an answer generator. This requires learning activities that encourage students to question AI-generated outputs, verify solutions, compare alternative approaches, explain their reasoning, identify errors, and use AI as a source of guidance and feedback while retaining intellectual responsibility for the problem-solving process.

The conceptual framework proposed in this paper reflects this perspective by positioning meaningful mathematical learning as the result of an interaction between AI Capabilities, Pedagogical Design, and Student Cognitive Engagement, supported throughout by Teacher Mediation and Human Oversight. The framework further recognises that AI integration takes place within a broader contextual and ethical environment shaped by AI Literacy, Academic Integrity, Institutional Governance, and Ethics and Responsible Use. Consequently, the same AI technology may produce very different educational outcomes depending on how it is incorporated into teaching, learning, and assessment.

This perspective also reinforces rather than diminishes the role of the mathematics educator. As access to AI-generated mathematical content becomes increasingly widespread, lecturers' pedagogical judgement becomes essential in deciding when AI should support learning, when students should work independently, and how assessment can provide valid evidence of mathematical understanding. Educators also have an important role in developing students' AI literacy and helping them become critical users of AI-generated content rather than passive consumers of automated solutions.

Higher education institutions, in turn, need to move beyond responses based exclusively on either unrestricted adoption or prohibition. Responsible integration requires clear and adaptable institutional policies, professional development for educators, appropriate safeguards for privacy and academic integrity, equitable access to AI resources, and assessment practices that increasingly value reasoning, justification, reflection, and authentic problem-solving. AI literacy should therefore be considered an important competence for both students and educators.

The structured narrative nature of this review and the rapid evolution of generative AI should be recognised as limitations. The conceptual framework proposed is derived from the thematic synthesis of the literature and has not yet been empirically validated. Future research should therefore investigate how different forms of AI-supported mathematical activity influence conceptual understanding, reasoning, problem-solving, self-regulation, and learner autonomy over time. Particular attention should be given to comparing answer-oriented and learning-oriented uses of generative AI and to examining whether improvements observed during AI-assisted activities are retained when students subsequently work independently.

Finally, the future of AI in higher education mathematics should not be evaluated primarily according to how effectively technology can perform mathematical tasks. A more meaningful measure is whether its integration helps students become more capable, autonomous, critical, and reflective mathematical thinkers. From this perspective, AI should not replace the intellectual effort or human interaction that characterises meaningful mathematics education; rather, it should be deliberately designed and pedagogically mediated to enhance them.

Scientific Ethics Declaration

* The author declares that the scientific ethical and legal responsibility of this article published in EPSS journal belongs to the author.

Conflict of Interest

* The author declares that there is no conflict of interest.

Funding

* No funds have been received.

Acknowledgements or Notes

* This article was presented as a poster presentation at the International Conference on Research in Education and Social Sciences (www.icress.net) held in Batumi/Georgia on July 09-12, 2026.

References

- Abedin, M. Z., Hayajneh, A., & Raahemi, B. (2026). Pedagogical use of responsible generative AI in higher education; opportunities and challenges: A systematic literature review. *AI in Education*, 2(2), 11.
- Alsharidah, M. A., & Alkramiti, A. M. (2024). Teachers' perceptions towards using artificial intelligence in mathematics education. *Amazonia Investiga*, 13(84), 43–60.
- Anderson, J. R., Corbett, A. T., Koedinger, K. R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *Journal of the Learning Sciences*, 4(2), 167–207.
- Awang, L. A., Yusop, F. D., & Danaee, M. (2025). Current practices and future direction of artificial intelligence in mathematics education: A systematic review. *International Electronic Journal of Mathematics Education*, 20(2), em0823.
- Bahroun, Z., Anane, C., Ahmed, V., & Zacca, A. (2023). Transforming education: A comprehensive review of generative artificial intelligence in educational settings through bibliometric and content analysis. *Sustainability*, 15(17), 12983.
- Barrientos, A. A., Del Mundo, M. A., Inoferio, H. V., Adjid, M. A., Hajan, H. B., Ullong, M. M., ... Espartero, M. M. (2024). Discourse analysis on academic integrity generative AI: Perspectives from science and mathematics students in higher education. *Environment and Social Psychology*, 9(9), 2927.
- Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education*, 20(1), 22.
- Drijvers, P., & Sinclair, N. (2024). The role of digital technologies in mathematics education: Purposes and perspectives. *ZDM—Mathematics Education*, 56(2), 239–248.
- Eti, N., Mosia, M., & Egara, F. O. (2026). The role of AI-driven personalised learning in enhancing mathematics problem-solving skills: A systematic review. *Frontiers in Computer Science*, 8, 1813431.
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81–112.
- Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Boston, MA: Center for Curriculum Redesign.
- Hosseini-Mohand, H., Hosseini-Mohand, H., Albanese, V., & Olmos Gómez, M. C. (2025). AI in mathematics education: A bibliometric analysis of global trends and collaborations (2020–2024). *Eurasia Journal of Mathematics, Science and Technology Education*, 21(2), em2576.
- Kadry, S. (Ed.). (2024). *Artificial intelligence and education: Shaping the future of learning*. IntechOpen.
- Kamalov, F., Santandreu Calonge, D., & Gurrib, I. (2023). New era of artificial intelligence in education: Towards a sustainable multifaceted revolution. *Sustainability*, 15(16), 12451.
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., ... Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, 102274.
- Kulik, J. A., & Fletcher, J. D. (2016). Effectiveness of intelligent tutoring systems: A meta-analytic review. *Review of Educational Research*, 86(1), 42–78.
- Lo, C. K. (2023). What is the impact of ChatGPT on education? A rapid review of the literature. *Education Sciences*, 13(4), 410.
- Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. London, UK: Pearson.
- Ma, W., Adesope, O. O., Nesbit, J. C., & Liu, Q. (2014). Intelligent tutoring systems and learning outcomes: A meta-analysis. *Journal of Educational Psychology*, 106(4), 901–918.
- Mohamed, M. Z. B., Hidayat, R., Suhaizi, N. N. B., Sabri, N. B. M., Mahmud, M. K. H. B., & Baharuddin, S. N. B. (2022). Artificial intelligence in mathematics education: A systematic literature review. *International Electronic Journal of Mathematics Education*, 17(3), em0694.
- Morris, R., Perry, T., & Wardle, L. (2021). Formative assessment and feedback for learning in higher education: A systematic review. *Review of Education*, 9(3), e3292.
- Nagaraj, B. K., Kalaivani, A., Begum, R. S., Akila, S., Sachdev, H. K., & Kumar, N. S. (2023). The emerging role of artificial intelligence in STEM higher education: A critical review. *International Research Journal of Multidisciplinary Technovation*, 5(5), 1–19.
- Niño-Rojas, F., Lancheros-Cuesta, D., Jiménez-Valderrama, M. T. P., Mestre, G., & Gómez, S. (2024). Systematic review: Trends in intelligent tutoring systems in mathematics teaching and learning. *International Journal of Education in Mathematics, Science and Technology*, 12(1), 203–229.
- OECD. (2026). *OECD digital education outlook 2026: Exploring effective uses of generative AI in education*. Paris, France: OECD Publishing.
- Opesemowo, O. A. G., & Ndlovu, M. (2024). Artificial intelligence in mathematics education: The good, the bad, and the ugly. *Journal of Pedagogical Research*, 8(3), 333–346.

- Paquette, L., Lebeau, J. F., & Mayers, A. (2010). Authoring problem-solving tutors: A comparison between ASTUS and CTAT. In R. Nkambou, J. Bourdeau, & R. Mizoguchi (Eds.), *Advances in intelligent tutoring systems* (pp. 377–405). Berlin, Germany: Springer.
- Pepin, B., Buchholtz, N., & Salinas-Hernández, U. (2025). A scoping survey of ChatGPT in mathematics education. *Digital Experiences in Mathematics Education*, 11(1), 9–41.
- Pierce, R., & Stacey, K. (2010). Mapping pedagogical opportunities provided by mathematics analysis software. *International Journal of Computers for Mathematical Learning*, 15(1), 1–20.
- Rahiman, H. U., & Kodikal, R. (2024). Revolutionizing education: Artificial intelligence empowered learning in higher education. *Cogent Education*, 11(1), 2293431.
- Son, T. (2024). Intelligent tutoring systems in mathematics education: A systematic literature review using the substitution, augmentation, modification, redefinition model. *Computers*, 13(10), 270.
- Sousa, A. E., & Cardoso, P. (2025). Use of generative AI by higher education students. *Electronics*, 14(7), 1258.
- Stefanova, T., & Georgiev, S. (2024). Possibilities for using AI in mathematics education. *Mathematics and Education in Mathematics*, 53, 117–125.
- Miao, F., & Holmes, W. (2023). *Guidance for generative AI in education and research*. Paris, France: UNESCO.
- Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications*, 252, 124167.
- Wardat, Y., Tashtoush, M. A., AlAli, R., & Jarrah, A. M. (2023). ChatGPT: A revolutionary tool for teaching and learning mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(7), em2286.
- Woolf, B. P. (2010). *Building intelligent interactive tutors: Student-centered strategies for revolutionizing e-learning*. Morgan Kaufmann.
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39.

Author(s) Information

Ana Paula Lopes

Polytechnic of Porto / Technical University of Porto
Rua Dr. Roberto Frias, 712 4200-465 Porto Portugal
ORCID iD: <https://orcid.org/0000-0003-1603-6959>

*Contact e-mail: aplopes@iscap.ipp.pt

*Corresponding author(s) contact email

To cite this article:

Lopes, A.P. (2026). Artificial intelligence in higher education mathematics classrooms and its influence on teaching and learning. *The Eurasia Proceedings of Educational and Social Sciences (EPESS)*, 51, 32-47.