*International Journal of Learning, Teaching and Educational Research*
*Vol. 25, No. 4, pp. 251-270, April 2026*
*https://doi.org/10.26803/ijlter.25.4.12*
*Received Jan 1, 2026; Revised Feb 11, 2026; Accepted Mar 25, 2026*

# Advancing Mathematics Teaching with AI: A Conceptual Framework for Instructional Planning and Delivery

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**Abstract.** As artificial intelligence (AI) tools become more prevalent in secondary mathematics classrooms, teachers are discovering new ways to enhance their planning and delivery of instruction. While much discussion around AI focuses on student use, less attention is given to how teachers can utilise these tools in their everyday teaching. This conceptual paper explores how secondary mathematics teachers can integrate AI tools such as ChatGPT, Photomath, Khanmigo, and Wolfram Alpha to support lesson planning, personalise instruction, and improve teaching effectiveness. Drawing on the Technological Pedagogical Content Knowledge (TPACK) model, the paper presents a practical framework that demonstrates how content knowledge, pedagogy, and technology can work together to strengthen instructional practice. Grounded in recent literature and classroom experience, the framework explains how AI can support core teaching tasks such as lesson design, real-time feedback, differentiation, and ongoing professional development. Rather than viewing AI as a threat, the paper encourages teachers to see it as a supportive partner that enhances teaching. Special attention is given to under-resourced classrooms, where the teacher's workload is high and individual support is limited. Through clear strategies and examples, the paper offers guidance on using AI in ways that improve student learning and support meaningful teacher growth.

Citation:
Michelena, T., & Jojo, Z. (2026). Advancing Mathematics Teaching with AI: A Conceptual Framework for Instructional Planning and Delivery. *International Journal of Learning, Teaching and Educational Research, 25*(4), 251–270. https://doi.org/10.26803/ijlter.25.4.12

**Keywords:** Artificial Intelligence; Differentiated Instruction; Lesson Planning; Mathematics Instruction; TPACK Framework

## 1. Introduction

Artificial intelligence (AI) tools are becoming increasingly common in secondary mathematics classrooms (Alonso-Diaz, 2025; Ergene & Caylan-Ergene, 2025). These tools offer features such as step-by-step solutions, quick explanations, and virtual tutoring (Gabriel, Kennedy, & Leonard, 2025; Capinding, 2023). They are transforming how mathematics is taught and learned. While these tools present

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new opportunities, they also compel teachers to rethink their lesson planning and delivery (Mavrikis & Margeti, 2024; Filiz et al., 2025). Students often bring AI-generated answers to class but still require teacher support to grasp the underlying mathematical reasoning and problem-solving processes (Busuttil & Calleja, 2025; Gabriel, Kennedy, & Leonard, 2025). Most research on AI in education focuses on how students utilise these tools. Studies indicate that AI can facilitate personalised learning, enhance problem-solving, and provide instant feedback (Yi et al., 2025; Zhang et al., 2025). In this context, artificial intelligence in education is broadly understood as a set of enabling technologies that shape teaching and learning practices. For example, "Artificial Intelligence (AI) technology such as computer vision (CV), natural language processing (NLP), and machine learning (ML) serves as a fundamental driving force for educational reform" (Wen et al., 2024, p. 131).

Wen et al. (2024) and Chen (2023) report that students' perceptions of AI and their readiness to engage with it shape how effectively they benefit from AI-supported learning. At the same time, teacher-related factors also influence how AI is used in classroom practice. Some studies, including Busuttil and Calleja (2025) and Wang et al. (2025), demonstrate that AI can support teachers' work through lesson design, reflection, and real-time instructional decision-making. Integration also depends on teachers' beliefs, access to tools, and school support (Bakhadirov & Alasgarova, 2024).

The Technological Pedagogical Content Knowledge (TPACK) model offers a helpful framework for understanding how teachers combine technology, pedagogy, and subject knowledge in their practice (Mishra & Koehler, 2006). Although TPACK has been widely discussed and critiqued in the literature, it remains a valuable framework for examining how teachers integrate new technologies into instructional practice when applied with a clear pedagogical focus. While TPACK has been used to guide technology use in teaching, there is limited discussion regarding its application to AI in real classroom settings, especially in mathematics.

Ethical concerns such as data privacy, bias, and responsible use of AI are receiving increasing attention in educational research; however, this discussion has primarily focused on student use rather than on teachers' instructional practices (Celik, 2023; Lan, Feng, & Xiao, 2024). This study positions TPACK as a teacher-centred framework for understanding how AI can support instructional planning and delivery, rather than as a general model of technology adoption. In this study, secondary students refer to learners in Grades 9–12, a stage of schooling where mathematics instruction typically emphasises abstract reasoning, algebraic thinking, functions, and preparation for further education or vocational pathways.

There is still a need for research on how AI can assist teachers with practical tasks such as planning lessons, supporting diverse learners, and providing feedback (Li & Manzari, 2024; Mohamed et al., 2022). While some studies mention the use of AI in lesson creation, fewer focus on how teachers can meet curriculum goals, support all learners, or promote deeper thinking in mathematics (Durham, 2024; Rizos, Foykas, & Georgakopoulos, 2024; Goldman, Carreon, & Smith, 2024). Few studies address the daily instructional challenges that teachers face when integrating AI into mathematics lesson planning. Additionally, there is limited research on how AI can support teaching in rural or under-resourced schools, where access and equity remain significant issues (Payadnya et al., 2025; Marrone et al., 2025). These gaps are important because they impact how practical and inclusive AI can be across different teaching contexts.

This paper addresses these gaps by presenting a practical framework that focuses on the instructional role of mathematics teachers. The contribution of this study lies in clarifying how AI supports teachers' instructional planning and delivery within a single, teacher-centred framework, rather than extending or redefining TPACK. It demonstrates how teachers can use AI to plan more efficiently, adjust instruction for diverse learners, provide feedback, and grow professionally. Using the TPACK model, the paper highlights practical ways AI can support classroom teaching. Rather than avoiding AI, teachers are encouraged to view it as a partner that can make teaching more flexible, creative, and effective.

### 1.1 Problem Statement

Many secondary mathematics teachers are uncertain about how to use artificial intelligence tools in their everyday teaching practice (Bakhadirov & Alasgarova, 2024; Filiz et al., 2025). Although a growing number of AI tools are available, there is limited practical guidance on how teachers can utilise these tools to support lesson planning, classroom instruction, and diverse student needs (Bakhadirov & Alasgarova, 2024; Busuttil & Calleja, 2025).

Much of the existing research focuses on general technology integration or student use of AI, leaving a gap in teacher-focused, classroom-based guidance for mathematics instruction (Mohamed et al., 2022; Mavrikis & Margeti, 2024). If this gap is not addressed, teachers may struggle to integrate AI in meaningful ways, which can result in uneven instructional support and missed opportunities to enhance student engagement and understanding in mathematics classrooms (Filiz et al., 2025; Yi et al., 2025). This study responds to this need by examining how AI tools can support key teaching tasks in secondary mathematics and guide more effective instructional use.

### 1.2 Rationale

Artificial intelligence is increasingly present in secondary mathematics classrooms; yet many teachers still lack clear guidance on how these tools can support everyday instructional practice (Bakhadirov & Alasgarova, 2024; Filiz et al., 2025). While existing research shows that AI can assist learning through feedback, tutoring, and problem-solving, much of this work focuses on student use rather than on teachers' instructional planning and classroom decision-making (Mohamed et al., 2022; Yi et al., 2025). In this study, instructional planning refers to the work teachers do before instruction, including selecting mathematical content, sequencing concepts, designing learning tasks, and anticipating learner difficulties, while instructional delivery refers to how teachers carry out lessons by explaining mathematical ideas, engaging learners, providing feedback, and adjusting instruction to meet diverse learning needs. Research by Mishra and Koehler (2006), together with Abebe and Trainin (2024), grounded in the TPACK framework, suggests that effective technology use depends on how well teachers integrate content knowledge, pedagogy, and digital tools. However, current studies often emphasise teacher perceptions or readiness for AI adoption, with limited attention to how AI can practically support core instructional tasks such as lesson planning, instructional delivery, student engagement, and differentiation in mathematics classrooms (Busuttil & Calleja, 2025; Filiz et al., 2025).

To address this need, this study proposes a TPACK-informed conceptual framework that illustrates how AI tools can support instructional planning and classroom delivery in secondary mathematics education, with attention to inclusive and teacher-led practice (Celik, 2023; Lan et al., 2024). Guided by this rationale, the study is driven by the following research questions:

- How can artificial intelligence tools support instructional planning in secondary mathematics classrooms?
- How can artificial intelligence tools enhance instructional delivery, including classroom engagement and differentiation, in secondary mathematics teaching?

## 2. Literature Review

This section reviews the literature on the use of artificial intelligence in secondary mathematics teaching, focusing on how AI supports teachers' instructional practices. Guided by the two research questions of this study, the review is organised into two parts. The first part examines how AI tools support instructional planning in mathematics classrooms. The second part focuses on how AI tools enhance instructional delivery, including classroom engagement and differentiation, during mathematics instruction.

### 2.1 AI in Instructional Planning

Instructional planning plays a central role in shaping effective classroom instruction in secondary mathematics (Mishra & Koehler, 2006; Durham, 2024). As mathematics curricula become more demanding and classrooms more diverse, teachers face increasing pressure to plan lessons that are both efficient and responsive. Recent research by Mishra and Koehler (2006) and Mavrikis and Margeti (2024) suggests that artificial intelligence tools can support this planning process by assisting teachers before instruction begins, rather than replacing their professional judgement.

Busuttil and Calleja (2025), along with Gabriel et al. (2025), report that AI tools such as ChatGPT, Khanmigo, and Wolfram Alpha assist teachers in generating curriculum-aligned lesson outlines and practice tasks. Beyond generating materials, these tools help teachers explore multiple ways of explaining the same concept, which is particularly valuable for topics such as algebra, functions, and problem-solving. Alonso-Diaz (2025) notes that human-like AI responses can aid teachers in planning explanations for complex mathematical ideas, contributing to lessons that are clearer and more structured. In addition to supporting explanations, AI can assist teachers in organising lesson components by linking learning objectives to curriculum expectations, suggesting coherent task sequences, and proposing appropriate assessment items. Teachers may also use AI to identify supporting examples or resources that enhance lesson clarity and readiness for instruction, allowing AI to function as a planning aid that expands instructional options rather than dictating content (Mishra & Koehler, 2006; Mavrikis & Margeti, 2024).

Beyond standalone AI tools, artificial intelligence is also embedded within instructional platforms commonly used by teachers for lesson preparation (Busuttil & Calleja, 2025; Filiz et al., 2025). Gamified platforms such as Wayground (formerly Quizizz) incorporate AI features that support teachers in creating, adapting, and personalising review activities, quizzes, and assignments during the planning phase. Muchuweni, Jojo, and Kariyana (2025) demonstrate that AI-supported game formats assist teachers in designing engaging, objective-aligned instructional tasks while reducing planning time and workload. Additionally, the instructional data generated through such platforms informs ongoing planning decisions, as teachers "utilise these insights to plan lessons more effectively and provide timely support" (Muchuweni et al., 2025, p. 118).

While these tools can quickly generate planning materials, recent work cautions against focusing solely on instructional products. As Gabriel et al. (2025) explain, "the discussion has been too focused on the products of education—the lesson plan, the essay, the multimedia presentation—and not sufficiently on the processes of learning" (p. 1). This perspective reinforces the view that AI should support teachers' planning decisions by strengthening learning processes rather than merely producing lesson artefacts. Khalloufi-Mouha (2025) highlights the value of AI in anticipating student difficulties during lesson preparation, noting that tools such as ChatGPT can generate common misconceptions, alternative solution strategies, and scaffolded questions that help teachers provide targeted support before a lesson is taught.

This approach promotes proactive planning, allowing teachers to enter the classroom with a clearer sense of where students may struggle. Busuttil and Calleja (2025) found that teachers who used AI during planning reported feeling more confident and better prepared to address student questions and errors during instruction. Despite these benefits, teacher confidence and experience strongly influence whether AI is used for planning. Bakhadirov and Alasgarova (2024) report that many teachers hesitate to use AI tools due to limited familiarity, uncertainty about reliability, or concerns about accuracy. Similarly, Li, Vale, Blannin, and Manzari (2025) found that teachers' prior exposure to digital technologies plays a significant role in adoption. These findings suggest that AI-supported planning is most effective when teachers receive appropriate training and time to experiment with tools in low-stakes contexts.

Gabriel, Kennedy, and Leonard (2025) and Mishra and Koehler (2006) emphasise that AI should support, rather than replace, the teacher's role in instructional planning. Teachers remain responsible for selecting appropriate content, aligning lessons with curriculum goals, and ensuring that tasks promote meaningful mathematical thinking. While AI can generate ideas and materials quickly, teachers must evaluate and adapt these outputs to suit their students and teaching contexts. This is especially important in under-resourced or large classrooms, where careful planning is essential for managing time and supporting all students (Payadnya et al., 2025).

Although current studies (Mohamed et al., 2022; Mavrikis & Margeti, 2024) highlight the potential of AI to aid lesson preparation, much of the literature focuses on general benefits or teacher perceptions rather than on structured, classroom-based planning practices. Clear guidance on how teachers can integrate AI into everyday lesson planning routines in secondary mathematics remains limited. Addressing this need, the present study builds on existing research to examine how AI tools can support instructional planning in practical, teacher-led ways that align with curriculum demands and classroom realities.

**2.2 AI in Instructional Delivery, Engagement, and Differentiation**

Instructional delivery plays a pivotal role in shaping how students engage with mathematical concepts during classroom lessons (Mishra & Koehler, 2006; Gabriel et al., 2025). In relation to the second research question, this section examines the potential of artificial intelligence tools to support mathematics teachers during classroom instruction by enhancing student engagement, providing timely feedback, and enabling differentiated learning support. Rather than focusing on student-driven applications of artificial intelligence, the literature reviewed here emphasises teacher-led implementations of these technologies that strengthen classroom interaction and instructional responsiveness.

Several studies, including those by Lee and Yeo (2022) and Xu, Huang, and Jong (2024), indicate that artificial intelligence tools can enhance instructional delivery by providing immediate explanations, alternative representations, and step-by-step guidance during lessons. These studies demonstrate that tools such as ChatGPT, Khanmigo, and AI-based chatbots can assist teachers in addressing student inquiries and clarifying misconceptions in real time. In addition to responding to questions, artificial intelligence is employed by educators to tailor instruction to meet learner needs. As Rizos, Foykas, and Georgakopoulos (2024) explain, "AI applications can be used by the educator to create lesson plans, for notetaking, and as a teacher's assistant.

Moreover, in special education, AI tools could be employed to adapt lesson plans to the specific needs and skills of each individual child" (p. 2). This highlights the instructional role of artificial intelligence as a support mechanism that enables educators to adjust explanations, pacing, and task design during lessons. Such applications allow teachers to supplement their explanations with additional examples or alternative representations, which is particularly beneficial when students encounter difficulties in comprehending a single method or representation. Gabriel, Kennedy, and Leonard (2025) argue that these practical uses of artificial intelligence can render instruction more flexible while maintaining teacher control over learning objectives and classroom discourse.

Research conducted by Son and Lee (2024) demonstrates that artificial intelligence (AI) can enhance student engagement by alleviating anxiety and fostering participation. When AI tools deliver hints or explanations in a manner that is non-judgmental, students may feel more at ease in attempting problems and posing questions. Furthermore, Alissa and Hamadneh (2023) and Wen et al. (2024) suggest that heightened confidence and diminished fear of committing errors can yield greater levels of engagement during mathematics lessons.

For educators, this amplified engagement presents opportunities to engage more students in discussions and to allocate classroom time towards reasoning, justification, and mathematical communication, rather than repetitive procedural explanations. In this regard, AI also plays a role in enhancing instructional accessibility by enabling teachers to rephrase explanations, simplify language, and offer concise summaries or alternative phrasings when students encounter difficulties with instructions or mathematical terminology, thereby further promoting participation during lessons (Son & Lee, 2024; Wen et al., 2024).

Moreover, AI-supported game-based platforms are increasingly employed during instructional delivery to facilitate lesson review, practice, and formative assessment. When integrated into instruction, these platforms allow educators to sustain engagement while monitoring student comprehension through adaptive questioning and feedback. Research on Quizizz-based instruction indicates that such platforms furnish teachers with actionable instructional insights. As Muchuweni, Jojo, and Kariyana (2025) report, "its feedback tools and performance reports help teachers identify learning gaps, track student progress, and adapt instruction… providing real-time insights that allow for timely interventions" (p. 118). This feedback supports responsive teaching without diminishing instructional control exercised by the teacher.

Visualisation and dynamic representations constitute another avenue through which AI bolsters instructional delivery (Castelvecchi, 2024; Ergene & Caylan-Ergene, 2025). AI-powered tools can instantaneously generate graphs, tables, and symbolic representations, thereby enabling educators to elucidate relationships between mathematical concepts with greater clarity. Castelvecchi (2024) underscores the potential of AI to transform the presentation of abstract mathematical ideas, while Ergene and Caylan-Ergene (2025) report that students often find AI-supported visual explanations more accessible than text-based instruction alone. These features are particularly advantageous in large or mixed-ability classrooms, where teachers require efficient methods to support understanding across diverse learner populations.

Differentiation represents a pivotal element of effective instructional delivery, particularly in classrooms characterised by diverse student abilities (Durham, 2024; Yi et al., 2025). The literature indicates that AI tools can facilitate differentiation by modulating task difficulty, pacing, and feedback tailored to the specific needs of students (Yi et al., 2025; Rizos, Foykas, & Georgakopoulos, 2024). For instance, tools such as Photomath are capable of offering step-by-step solutions that assist struggling students in reviewing concepts at their own pace, while more adept students can be engaged with extension tasks generated by AI (Capinding, 2023). When effectively guided by teachers, these tools provide differentiated support without fragmenting the lesson structure or exacerbating teacher workload.

Several studies, including those conducted by Mohamed et al. (2022) and Létourneau et al. (2025), highlight that AI platforms can yield valuable feedback on student performance throughout instruction. Systems such as ASSISTments and intelligent tutoring platforms have the capacity to identify common errors or areas where students may be experiencing difficulties, thereby enabling teachers to modify explanations or offer targeted support during or subsequent to lessons. As emphasised in these studies, this approach bolsters responsive teaching, whereby instructional decisions are informed by real-time or near-real-time student data, rather than by delayed assessment outcomes.

Although the benefits of these tools are evident, researchers caution against the potential substitution of teacher judgement with AI interventions, as well as the reduction of opportunities for students to engage in mathematical thinking. Opesemowo and Ndlovu (2024) warn that an over-reliance on automated solutions may hinder the development of students' reasoning and problem-solving abilities. Consequently, effective instructional delivery necessitates that teachers retain oversight of how and when AI is employed, ensuring that students engage with foundational concepts rather than merely accepting AI-generated responses. Mavrikis and Margeti (2024) underscore that AI is most efficacious when integrated within robust pedagogical practices and well-defined instructional objectives.

The literature indicates that AI has the potential to enhance instructional delivery, engagement, and differentiation when utilised as a teacher-led support tool, rather than as an autonomous instructor. However, the majority of studies predominantly focus on student experiences or the capabilities of the tools themselves, with insufficient attention to how educators integrate AI into real-time classroom instruction. There is a clear need for more explicit, practice-oriented guidance on how mathematics teachers can employ AI to foster inclusive participation, address misconceptions, and accommodate diverse learning needs during lessons (Filiz, Kaya, & Adiguzel, 2025; Gabriel et al., 2025).

This study aims to fulfil this need by investigating the application of AI tools to enhance instructional delivery in secondary mathematics classrooms in pedagogically sound and teacher-directed ways. The reviewed studies underscore the necessity of a coherent understanding of how AI supports both instructional planning and delivery within a unified teacher-centred framework, which this study explores through the TPACK framework.

## 3. Theoretical Framework: Technological Pedagogical Content Knowledge (TPACK)

This study is grounded in the Technological Pedagogical Content Knowledge (TPACK) framework, which explains how teachers integrate subject matter knowledge, pedagogy, and technology in instructional practice (Mishra & Koehler, 2006). Within mathematics education, TPACK provides a useful basis for understanding how teachers make informed decisions about when and how digital tools should be used to support learning. In this study, TPACK is used to frame how artificial intelligence (AI) can be integrated into secondary mathematics teaching in ways that are both pedagogically sound and teacher directed.

Research by Abebe and Trainin (2024), Oved and Alt (2025), and Segal et al. (2024) indicates that teachers with well-developed TPACK are more confident and purposeful in their use of digital and AI-based tools. Rather than focusing on specific tools or instructional strategies, these studies emphasise the importance of teachers' ability to balance content knowledge, pedagogical intentions, and technological affordances. From this perspective, effective AI integration depends less on the technology itself and more on how teachers align it with instructional goals and student needs (Li & Li, 2024). Recent extensions of the TPACK framework further highlight considerations that are especially relevant in AI-supported teaching. The GenAI-TPACK model incorporates ethical and professional responsibilities related to data use, access, and teacher judgement (Lan et al., 2024).

Similarly, the Technological Pedagogical Content Ethical Knowledge (TPCEK) framework positions ethical awareness as a necessary component of technology integration (Deng & Zhang, 2023), while Celik (2023) emphasises the role of digital ethics in teacher preparation for AI-based tools. These perspectives reinforce the idea that AI integration must be guided by responsibility, fairness, and professional accountability. In this study, TPACK is not used to evaluate tools or measure teacher competence. Instead, it serves as an organising framework for interpreting how AI can support instructional planning and delivery in secondary mathematics classrooms, in direct alignment with the two research questions. By adapting TPACK to the context of AI-supported teaching, this study provides a conceptual model that clarifies the teacher's central role in deciding how AI is used to support instruction. A visual representation of this adapted framework is presented in Figure 1.

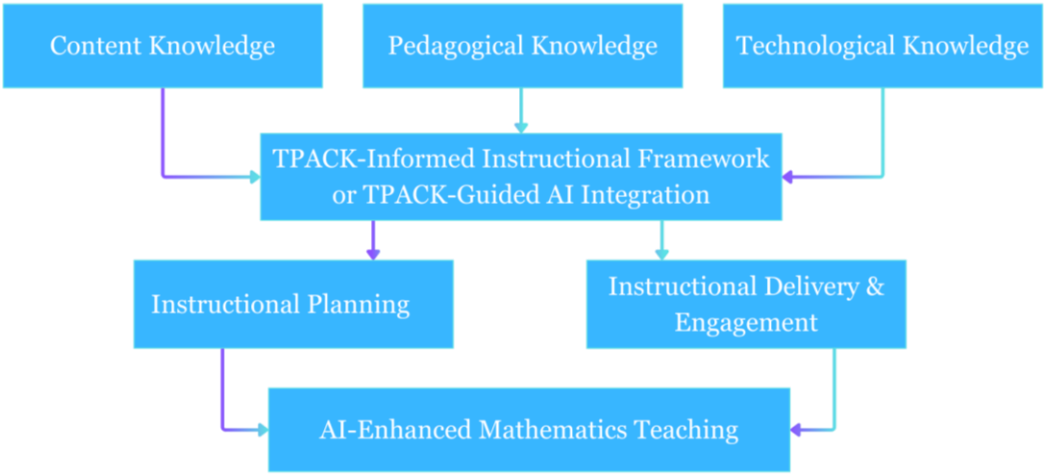


**Figure 1: TPACK-guided framework for AI-enhanced mathematics teaching**

## 4. Methodology

This study adopts a conceptual research design informed by a structured review and synthesis of recent literature. A conceptual approach was selected because the purpose of the study was to organise and clarify existing knowledge rather than to collect new empirical data. The aim of the review was not to conduct a full systematic literature review, but to identify, synthesise, and organise key research that explains how artificial intelligence (AI) tools are being used to support instructional planning and delivery in secondary mathematics classrooms. The reviewed literature provided both the theoretical and empirical grounding for the conceptual framework proposed in this paper.

To ensure transparency and rigor in identifying relevant studies, the literature search was guided by the PRISMA 2020 framework (Page et al., 2021) as an organising structure. Although PRISMA was used to guide transparency in study identification and selection, this study does not claim to be a full systematic review. The search was conducted in March and April 2025 using three academic databases commonly used in mathematics education and educational technology research: ERIC, ScienceDirect, and SpringerLink. These databases were selected because they offer broad access to peer-reviewed journal articles and book chapters related to AI, mathematics education, and instructional design.

Search terms were developed to align closely with the focus of the study and included combinations such as "artificial intelligence" and "mathematics education"; "ChatGPT," "Photomath," or "Khanmigo" combined with "classroom teaching"; "TPACK" combined with "AI integration" and "lesson planning"; and "AI tools" combined with "instructional delivery" and "secondary school." Boolean operators (AND/OR) were used to refine the search and improve the accuracy and relevance of the retrieved studies. Studies were included if they were published between 2015 and 2025, focused on secondary mathematics education, and examined the use of AI tools in relation to instructional planning, classroom delivery, student support, feedback, or teacher professional practice. Studies were excluded if they focused only on student perceptions, were not mathematics-specific, or were not published in English.

Following title and abstract screening, selected full-text articles were read and analysed. Relevant studies were then grouped thematically according to their contribution to instructional planning and delivery. As this is a conceptual study, methodological rigour was ensured through transparent selection criteria, the use of peer-reviewed sources, and systematic thematic organisation aligned with the research questions, rather than through empirical instrument validation. These themes informed the structure of the literature review and directly shaped the development of the TPACK-guided conceptual framework presented in this paper. In total, 34 studies met the inclusion criteria and informed the development of the proposed conceptual framework. An overview of the study identification and selection process is presented in Figure 2, using a PRISMA-style flow diagram.

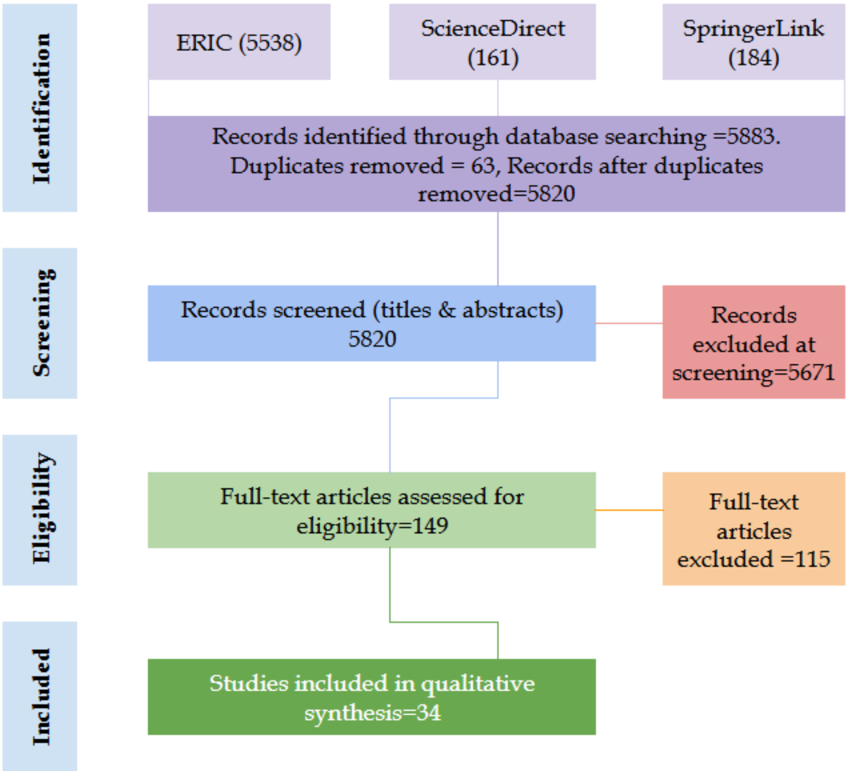


**Figure 2: PRISMA 2020 diagram for the study selection process informing the AI–TPACK framework**

## 5. Results

This section presents key insights drawn from the 34 studies reviewed, which informed the development of the proposed conceptual framework. The results are organised around two core areas of mathematics teaching addressed in this paper. The first part reports on how artificial intelligence (AI) tools are used to support instructional planning in secondary mathematics classrooms. The second part discusses how AI tools are used to enhance instructional delivery, including classroom engagement and student differentiation. This section reports patterns of use identified in the literature, without interpretation or evaluation. Broader explanations and implications are addressed in the discussion section.

### 5.1 AI Support for Instructional Planning

Across the 34 reviewed studies, a consistent pattern is that mathematics teachers use AI tools to support lesson planning and preparation (Busuttil & Calleja, 2025; Gabriel et al., 2025; Alonso-Diaz, 2025). These planning applications often involve generating lesson outlines, selecting examples, designing practice tasks, and anticipating areas where students may experience difficulty. Such supports are typically employed before lessons and are primarily teacher-directed.

Several studies, including those by Khalloufi-Mouha (2025) and Wijaya et al. (2025), report that tools such as ChatGPT and Khanmigo are utilised to create curriculum-aligned lesson content, including warm-up activities, guided examples, and practice questions at varying levels of difficulty. Teachers employ these tools to adjust lesson materials based on time constraints, class size, and student readiness. Research by Khalloufi-Mouha (2025) further indicates that AI-generated explanations are often used to help teachers clarify mathematical concepts before instruction, particularly for topics that students typically find challenging. The studies reviewed by Busuttil and Calleja (2025) and Capinding (2023) also suggest that AI tools enhance planning efficiency. Teachers report reduced preparation time when using AI to draft lesson structures or generate alternative explanations. This efficiency is especially evident in large classes and resource-limited settings, where teachers manage high workloads and limited instructional materials.

Additionally, studies such as those by Mohamed et al. (2022) and Li and Li (2024) demonstrate that AI tools are employed during planning to anticipate student needs. AI-generated questions, worked examples, and error explanations assist teachers in identifying potential misconceptions in advance and preparing targeted support. These planning practices enable teachers to design lessons that incorporate scaffolding and multiple entry points for learners. Across the reviewed studies, AI tools are consistently described as planning assistants rather than decision-makers. Teachers remain responsible for selecting content, aligning lessons with curriculum goals, and determining appropriate instructional strategies, while AI supports these planning processes by providing ideas, resources, and adaptable materials that teachers can refine and contextualise for their classrooms.

### 5.2 AI Support for Instructional Delivery, Engagement, and Differentiation

A clear trend in the literature is that AI tools are used during mathematics lessons to support explanation, feedback, and student participation (Lee & Yeo, 2022; Xu et al., 2024; Yi et al., 2025). These tools are most often employed to respond to student questions, present concepts in multiple ways, and support students at different levels during instruction. Studies by Gabriel et al. (2025) and Son and Lee (2024) report that tools such as ChatGPT, Khanmigo, and AI-supported tutoring systems provide step-by-step explanations and worked examples while lessons are in progress. These explanations clarify procedures, revisit earlier content, or support students who need additional guidance without interrupting the flow of the lesson. Research by Son and Lee (2024) indicates that AI responses are commonly used alongside teacher explanations rather than as replacements.

The reviewed studies by Castelvecchi (2024) and Ergene and Caylan-Ergene (2025) also show that AI tools support student engagement during instruction. Interactive explanations, immediate responses to questions, and visual representations generated by AI help sustain student attention, particularly during abstract topics such as algebra and functions. Son and Lee (2024) further note that students may be more willing to ask questions or attempt problems when AI support is available, especially in large or mixed-ability classrooms. Additionally, research by Capinding (2023), Létourneau et al. (2025), and Rizos et al. (2024) highlights the use of AI tools to support differentiation during lessons. Tools such as Photomath, intelligent tutoring systems, and adaptive platforms provide targeted support based on student needs, offering simpler explanations for some learners and extension tasks for others. Teachers use this support to manage varied learning levels within the same classroom while continuing whole-class instruction.

Studies by Mohamed et al. (2022) and Yi et al. (2025) further report that AI tools provide real-time feedback during instruction. Immediate hints, error identification, and alternative solution paths help students correct mistakes as they occur, allowing teachers to monitor progress and identify areas requiring further explanation. Across the reviewed studies, AI tools are used during instructional delivery to support explanation, engagement, and differentiation in mathematics classrooms. Teachers remain responsible for guiding learning, managing classroom interactions, and making instructional decisions, while AI tools provide flexible, on-demand assistance during lessons. Table 1 summarises the AI tools discussed in the reviewed studies and the instructional purposes they were reported to serve in secondary mathematics classrooms.

**Table 1: AI tools and reported purposes in secondary mathematics instruction**

| Instructional Area | AI Tools | Purpose |
|---|---|---|
| Lesson Planning | ChatGPT, Khanmigo | Assist with lesson outlining and topic-specific content preparation |
| Instructional Delivery | ChatGPT, Khanmigo | Provide explanations, visualisation of concepts, and responses to student questions |
| Differentiation and Feedback | Quillionz, Khan Academy, ASSISTments | Support adaptive tasks and timely feedback for learners |
| Teacher Development | ChatGPT | Facilitate access to research summaries and instructional ideas |

## 6. Discussion

This section discusses the findings presented in the results section by interpreting how the identified uses of artificial intelligence (AI) tools relate to mathematics teaching practice and the proposed conceptual framework. While the results describe patterns of AI use in instructional planning and delivery, this discussion focuses on the implications of these patterns for mathematics teachers and their connection to the Technological Pedagogical Content Knowledge (TPACK) framework. The discussion is organised into two parts. The first part examines how AI-supported instructional planning reshapes teachers' preparatory work and professional decision-making. The second part discusses how AI-supported instructional delivery influences classroom engagement, differentiation, and the teacher's instructional role.

**6.1 Interpreting AI-Supported Instructional Planning in Mathematics Teaching**
The findings pertaining to instructional planning indicate that artificial intelligence (AI) tools are transforming the methods by which mathematics educators prepare for lessons. When analysed through the lens of the TPACK framework, these findings underscore the role of technology in facilitating teachers' pedagogical and content-related decisions, without supplanting professional judgment (Mishra & Koehler, 2006). Educators retain the responsibility for selecting content, determining instructional approaches, and ensuring that lessons conform to curriculum expectations.

In practice, AI tools support teachers in their role as lesson designers. Teachers may use AI to generate lesson ideas, draft materials, or prepare examples, but they decide which resources are suitable for their students and learning goals. This reflects a core principle of TPACK: technology supports pedagogy and content rather than directing them (Mishra & Koehler, 2006). From a TPACK perspective, this demonstrates how AI strengthens the interaction between pedagogical knowledge and content knowledge during lesson preparation, rather than shifting responsibility to technology (Busuttil & Calleja, 2025; Gabriel et al., 2025). AI-supported planning also appears to enhance teachers' professional efficiency. By reducing the time spent on routine preparation tasks, teachers are better able to focus on how mathematical ideas will be explained, how lessons will be structured, and how different learners will be supported. This efficiency reflects the role of technology knowledge in TPACK as a support for, rather than a substitute for, pedagogical decision-making.

At the same time, the findings highlight the importance of teacher judgement when using AI for planning. Teachers must review AI-generated materials for accuracy, adapt tasks to suit student needs, and ensure that explanations reflect accepted mathematical reasoning and curriculum standards. This reinforces the role of strong mathematical and pedagogical knowledge in the effective use of AI. AI-supported instructional planning is most effective when guided by teacher expertise, with AI serving as a support tool that enhances efficiency while preserving teacher control over instructional goals and classroom practice (Mishra & Koehler, 2006).

**6.2 Interpreting AI-Supported Instructional Delivery, Engagement, and Differentiation**
The findings related to instructional delivery suggest that artificial intelligence (AI) tools influence how mathematics teachers support learning during lessons. When interpreted through the Technological Pedagogical Content Knowledge (TPACK) framework, these practices demonstrate that technology can support instructional decisions while the teacher remains central to classroom teaching (Mishra & Koehler, 2006). AI tools do not replace the teacher's role; instead, they assist teachers in responding to student needs during instruction. Within TPACK,

this reflects the coordinated use of technology to support pedagogical actions aligned with mathematical content goals.

From a teaching perspective, the use of AI during lessons supports the teacher's role as a facilitator of learning. AI tools can provide explanations, feedback, or worked examples when students need support, but teachers decide when and how this support is used to ensure alignment with lesson goals. This reflects the TPACK principle that technology should be integrated in ways that strengthen pedagogy and content, rather than directing instruction (Mishra & Koehler, 2006). In this way, AI supports instructional delivery while teachers retain control over classroom interactions and learning outcomes (Busuttil & Calleja, 2025; Gabriel et al., 2025).

In terms of engagement, AI-supported delivery can help create learning conditions that encourage student participation and confidence. Immediate responses, visual explanations, and step-by-step guidance can lower barriers to participation and support students who may hesitate to attempt tasks. However, engagement is shaped primarily by teachers' decisions. Teachers influence engagement through how they frame questions, guide discussions, and integrate AI responses into classroom interactions.

From a TPACK perspective, engagement emerges from purposeful pedagogical choices rather than from technology use alone. AI-supported delivery also has implications for differentiation during lessons. AI tools allow teachers to offer additional support to some students while others continue working independently or on more advanced tasks. This enables teachers to respond to diverse learning needs without separating students or changing lesson goals. This balance reflects teachers' ongoing coordination of technology, pedagogy, and content within TPACK.

At the same time, the findings clearly show limits on the role of AI during instruction. While AI can provide quick assistance, teachers remain responsible for guiding students to explain their thinking, justify solutions, and reflect on mathematical reasoning. Teachers help students understand why a solution works, not just what the answer is. This reinforces the importance of teacher guidance and ethical AI use in mathematics classrooms. AI-supported instructional delivery can make teaching more responsive and inclusive when it is guided by strong pedagogy, professional judgement, and clear instructional purpose (Mishra & Koehler, 2006). The professional competencies required to support this form of AI-integrated teaching are summarised in Figure 3.

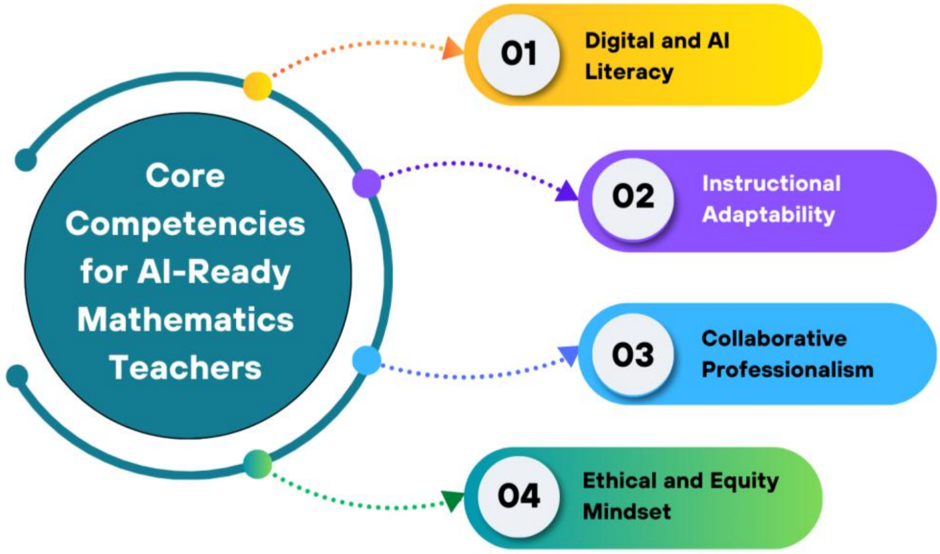


**Figure 3: Core competencies for AI-ready mathematics teachers**

## 7. Limitations

This study is a conceptual paper informed by existing literature rather than original empirical data. Consequently, the findings reflect how AI use in secondary mathematics teaching has been described in published studies and may not capture all classroom practices. The review focused on English-language publications from selected academic databases, which means that relevant studies published in other languages or in practitioner-focused outlets may have been excluded. Furthermore, although PRISMA 2020 was used as an organising guide, the review did not aim to provide a full systematic literature review. Lastly, the conceptual framework proposed in this paper has not yet been tested in classroom settings. While it is grounded in existing research and theory, further empirical studies are needed to examine its application in practice.

## 8. Conclusion

This paper examines how artificial intelligence (AI) tools can support key aspects of secondary mathematics teaching, with a focus on instructional planning and instructional delivery. Drawing on existing literature and guided by the TPACK framework, the study organises current evidence to clarify how AI can be integrated into mathematics instruction in ways that strengthen, rather than replace, the teacher's role. The findings indicate that AI tools can assist teachers with lesson preparation, classroom explanations, engagement, and student support when used with clear pedagogical intent. However, effective use depends on teachers' professional judgment, subject knowledge, and understanding of how technology aligns with instructional goals. AI is most valuable when it functions as a supportive resource that enhances teachers' capacity to respond to student needs and manage classroom complexity.

By presenting a TPACK-guided conceptual framework, this study contributes a structured approach for teachers and researchers to consider AI integration in mathematics education. The framework highlights the importance of balancing technology use with pedagogy, content knowledge, and ethical responsibility. Future research should investigate how the framework operates in real classroom settings and how teachers apply it across different contexts. This paper positions AI as a tool that can support more responsive and inclusive mathematics teaching when guided by robust professional practice. Thoughtful integration of AI has the potential to improve instructional coherence and support meaningful learning experiences in secondary mathematics classrooms.

## 9. Recommendations for Practice and Policy

### 9.1 Short-Term Classroom and School-Level Recommendations

Schools and education systems should develop clear guidance to support the responsible use of artificial intelligence (AI) in secondary mathematics classrooms. Policies should outline acceptable classroom use, address data privacy and ethical considerations, and be reviewed regularly as technologies evolve. Clear guidance can help teachers feel supported and reduce uncertainty when using AI in instruction. Education authorities and school leaders should ensure that mathematics teachers have access to reliable AI tools that align with curriculum goals.

Access to these tools should be accompanied by practical professional development that focuses on classroom application rather than technical features alone. Training should help teachers understand when and how AI can be used to support lesson planning, instructional delivery, and student support. Schools should also create opportunities for teachers to collaborate, reflect, and share experiences related to AI use. Time for professional dialogue can support thoughtful adoption, help teachers address challenges, and encourage responsible experimentation. Collaborative spaces may assist teachers in adapting their instructional roles while maintaining clear educational goals.

### 9.2 Longer-Term Teacher Education and Policy Recommendations

Teacher education programmes should incorporate structured learning opportunities focused on educational AI. Pre-service mathematics teachers should be introduced to AI tools in a manner that emphasises pedagogical purpose, subject knowledge, and ethical responsibility. Such preparation can assist future educators in cultivating confidence and professional judgement when integrating AI into classroom practice.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

## 10. Acknowledgements

All research activities, analysis, interpretations, and academic contributions were completed entirely by the authors. The manuscript remains an accurate and original representation of the author’s work. The authors acknowledge the limited use of ChatGPT (OpenAI) only for minor grammar and language checking.

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