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AI-Assisted Tools as Support for High School Students in Learning Mathematics

[1] Alcuirez Maegie H, [2] Cabigon Efraulein V, [3] Chiong Lucina Mae B, [4] Quinco-Cadosales Maria Nancy

[1] Prep English Thailand, Pathum Thani, Thailand
[2] Department of Science and Technology, Cebu Normal University, Cebu City, Philippines
[3] ContactPoint 360, Cebu City, Philippines
[4] Cebu Normal University, Cebu City, Philippines

Corresponding Author: **Alcuirez Maegie H**

Abstract

Artificial Intelligence (AI) has created a paradigm shift in Mathematics education, particularly in the teaching and learning process. This meta-synthesis aimed to explore and develop an integrated framework on the interconnected mechanisms that explain how AI-assisted tools support mathematics learning among high school students. This study reviewed 11 qualitative studies published from 2021 to 2026. Throughout the selection process, the PRISMA 2020 flow diagram, together with the CASP checklist, was utilized showing the final studies to be synthesized. There are five themes emerged using the thematic analysis by Braun and Clarke: Facilitating Personalized and Adaptive Mathematics Learning, Supporting Mathematics Learning Through Immediate Feedback and Scaffolding, Deepening Students' Conceptual Understanding of Mathematics, Promoting Active Engagement and Motivation in Mathematics Learning, and Underlying AI-Risks and Pedagogical Challenges in Learning Mathematics. Findings revealed that AI-assisted tools used by high school students in learning mathematics such as Intelligent Tutoring Systems, AI Chatbots, Generative AI, and AI-based Calculators support students' mathematics learning by providing personalized, self-paced, and interactive learning experiences. These AI tools offer fast feedback and guided problem solving which help the students deepen their conceptual understanding, mathematical reasoning, and critical thinking in mathematics. However, significant challenges and risks were divulged along the use of AI tools in Mathematics such as errors and hallucinations, data privacy concerns, lack of teacher training, and infrastructure limitations. This study recommends that policy makers and education stakeholders should integrate AI competency in the High School Mathematics curriculum and teachers should undergo professional development on AI-assisted instruction.

Keywords: AI-Assisted Tools in Learning Mathematics, Artificial Intelligence, High School Mathematics, Learning Support in Mathematics, Mathematics Education

Introduction

Learning Mathematics is indispensable among students, helping them develop human qualities and achieve a successful future career. However, learning Mathematics poses a plethora of challenges as evident in numerous studies. According to Waswa and Al-Kassab (2022) [69], students' poor critical thinking and problem solving skills is extant in different branches of the aforesaid discipline. In Algebra, students are facing difficulties in converting word problems into mathematical statements or symbols. In Calculus, students perceived the concept of rate of change as a challenge. Furthermore, the study of Maryanto *et al*. (2023) [42] has found out that Junior High School students have a superficial understanding of mathematical concepts, the application of such concepts, and grasping the mathematical connection in solving problems.

Harry and Sayudin (2023) [22] stated that Artificial Intelligence (AI) has revolutionized today's ways of teaching and learning Mathematics. AI in education pertains to the application of machine-based systems, such as machine learning, to improve students' learning experiences (Holmes & Tuomi, 2022) [24]. A study showed that generative AI chatbots improved senior high school students analytical proficiency and mathematical resilience when solving difficult mathematical problems (Comidoy &

Salva, 2026) [16]. Moreover, chatbots like Intelligent Tutoring System (ITS) and AI calculators help address learning gaps. Yunizar *et al*. (2026) [74] found that ITS models were more student-centered and effective compared to traditional approaches as it adjusts on the difficulty of the tasks given depending on students' previous assessment result. Similarly, Opesemowo and Ndlovu (2024) [49] reported that AI calculators were effective in supporting students' solving mathematical problems.

The integration of AI-powered tools in Mathematics education such as intelligent tutoring systems and chatbots provide fast and consistent feedback, improve efficiency, and allow opportunities for personalized learning experience, leading to better student outcomes (Harry & Sayudin, 2023) [22]. It also offers automated assessment tools which saves teachers' time. Moreover, the study of Sugiarti and Warneri (2025) [59] revealed that AI-assisted learning tools have significantly accentuated the Grade 7-Indonesian students' mathematics achievement. Based on the study of Yi *et al*. (2024) [72], the significance of AI as an augmenting technology that supports students' positive learning experience and performance in Mathematics is evident as AI tutorial systems help students absorb a deeper conceptual understanding of mathematical concepts since they can learn in a one-on-one approach.

Artificial intelligence (AI) has been widely used for various purposes, especially in education. Last February 2026, the Department of Education launched DepEd Order No. 003, s. 2026, *Foundational Guidelines on Artificial Intelligence in Basic Education*. This order aims to establish guidelines on properly using AI in basic education to strengthen students' learning experiences and empower them to become more innovative students (DepEd, 2026). Moreover, Ragaza (2026) [54] formulated a conceptual model called "AI-Assisted Scaffolding and Conceptualization" in his studies with pre-service Mathematics teachers at Cebu Normal University. This framework revealed the transformation of these Artificial Intelligence (AI) education tools into digital instructional supports that can guide students in decoding complicated mathematical concepts and give sequential prompts for deeper comprehension. However, there are still instructional impediments that educators are facing despite the positive impact of AI-Assisted scaffolding in Mathematics education, and one of the biggest challenges is counteracting students from being excessively dependent when utilizing AI for mathematical tasks (Ragaza, 2026) [54].

While there are multifarious existing studies on AI-assisted learning in mathematics education, most research has focused on measuring academic performance and learning outcomes, while relatively few studies have synthesized qualitative evidence regarding high school students' experiences and learning processes when using AI-assisted tools. Furthermore, there is a lack of an integrated framework that explains how specific AI-assisted learning tools support students in learning mathematics at the high school level. Hence, this study is conducted in order to address this significant gap through an in-depth exploration and synthesis of existing studies concerning the role of specific AI-assisted learning tools in supporting high school students in learning mathematics.

Research Objective

This study seeks to synthesize existing qualitative studies on the role of AI-assisted learning tools in supporting high school students' mathematics learning. Through the synthesis of qualitative evidence, the study seeks to develop an integrated framework that explains the interconnected mechanisms through which AI-assisted tools support mathematics learning.

Literature Review

Artificial Intelligence in Mathematics Education

Students' lack of skills in critical thinking, logical reasoning, and problem solving can be attributed to the confinement of conventional and teacher-led pedagogies (Arifin *et al*., 2025) [6]. This is manifested in a learning environment that teaches and learns Math in a purely standardized and traditional manner. Lee and Quifan (2021) [35] argued that today's classrooms still indubitably practice the one-size-fits-all approach despite cognizing students' differences. This is primarily because of the long-standing problem in student-to-teacher ratio due to financial constraints, affecting students' learning experience. However, Lee and Quifan (2021) [35] enunciated that AI has the potency to address this drawback, making education more accessible, personalized, and equitable. This explicates the opportunity of AI tools to provide engaging and meaningful learning experiences of the students while learning mathematics.

AI has become more accessible to students in today's time and there are many platforms to choose from. Song *et al*. (2025) [58] even demonstrated that AI tools can now be accessed inside and outside the schools, making mathematics learning continuous. AI in math education has also provided opportunities for students with special needs. In fact, Tang (2025) [62] elucidated that AI technologies promote inclusive mathematics learning by providing personalized and adaptive instruction that addresses the diverse needs of students, particularly those with learning disabilities and special educational needs. Polydoros *et al*. (2026) [53] also said that AI supports inclusive mathematics education by providing early identification, personalized instruction, adaptive learning, and emotional support for students with learning difficulties or disabilities. AI has been a valuable tool for students' learning as it helps reduce anxiety in mathematics and for teachers' instructional practices.

The positive impact of AI on mathematics education has been consistently shown by recent studies. One of the proofs was reported by Yilmaz and Karaoglan Yilmaz (2023) [73] stating that students were motivated to learn when integrating AI to mathematics instructions. Similarly, Jita *et al*. (2026) [27] reported that AI- powered tools enhance students' mathematical solving skills by providing targeted feedback, personalized instructions based on students' learning progress, and creating visual presentations for students to visualize abstract mathematical concepts. Thus, the findings suggest how AI supports learning by individualizing the responses on students' needs while promoting active participation in the entire learning process. However, despite its positive impact, students in the Philippines continue to show a moderate level of negative attitude toward mathematics (Mangarin & Gonzalo, 2024) [39]. Yet, research has found that AI helps improve students' achievement (Min *et al*., 2021) [43], while Kim and Han (2021) [32] reported that through AI-assisted learning, students showed improvement in their problem solving, computing, and thinking skills. These findings suggest that

AI not only develops mathematical performance but also fosters more positive learning experiences.

The rapid growth of AI in education calls attention to an international platform that helps improve the quality and accessibility of education. UNESCO (2023) [65] highlights that AI can expand educational resources, learning gaps, and promote equal learning opportunities for different types of students. Likewise, Zawacki-Richter *et al*. (2019) [75] emphasizes the scope AI-powered platforms can do, it generates different representations of mathematical concepts, individualized practice opportunities, and varies the instruction depending on students' performance. Such capabilities enable students to receive personalized support that is difficult to attain in a traditional classroom. Taken together, the existing literature indicates how AI can transform a more adaptive learning environment that is responsive to students needs.

AI Learning Support in High School Mathematics

Mathematics requires students to build concepts and logically apply reasoning to solve difficult mathematical problems. According to Holman *et al*. (2025) [23], incorporating AI-assisted learning tools such as Intelligent Tutoring Systems (ITS), chatbots and differentiated learning platforms, helps in addressing the challenges by modifying learning activities to students' capabilities, providing immediate feedback, and generating an individualized task based on students' performance. Son (2024) [57] reported that ITS enhances students' conceptual understanding and problem-solving strategies by individualized educational interventions, immediate feedback, and learning support. The review also found that AI-assisted learning tools encourage the students to actively participate to develop critical thinking skills. These findings indicate that AI is not only to support students' academic achievement but also to develop deeper mathematical understanding. Additionally, Eti *et al*. (2026) [20] found that students' mathematical and analytical skills have been enhanced through individualized AI-assisted tools. According to the study, AI-assisted tools help the students to develop their higher order thinking skills that leads to building confidence in solving challenging problems in a way that is flexible, progressive, and personalized.

While above mentioned studies emphasize its cognitive effects, AI-assisted tools also offer to positively influence students' affective learning, such as reducing mathematics anxiety and improving motivation. By delivering responsive, constructive feedback in a supported learning environment, AI systems effectively alleviate adverse emotional barriers toward Mathematics. With these student-centered supports, students are able to develop confidence and strengthen long-term involvement in learning (Hwang, 2022) [26]. Moreover, Artificial Intelligence can be a powerful tool if it is employed purposefully as a scaffold for learning instead of a tool for circumventing learning processes.

Li *et al*. (2025) [36] gives emphasis on a broad system of AI-powered tools in Mathematics education. This includes ChatGPT, intelligent tutoring systems such as ALEKS and MATHia, Khan Academy, chatbots, simulation systems, and augmented reality applications. These aforesaid tools amplify personalized instruction, targeted and fast feedback, and enhanced student engagement. Correspondingly, the study of Awang *et al*. (2025) [7] has elucidated AI tools such as chatbots, adaptive learning systems, AR/VR environments, learning analytics, serious games, and problem-solving tools such as Photomath and GeoGebra. Both aforementioned studies mentioned that these tools enhance conceptual understanding of students in mathematics, computational ability, concretization of abstract mathematical concepts, and problem-solving skills among high school students. Another study from Aleven *et al*. (2023) [3] explained that AI-augmented tutoring systems provide good results in providing individualized support and developing students' foundational knowledge in mathematics. In addition, the integration of AI at the school level is also underlined by Lara *et al*. (2025) [34]. As enunciated in their study, integrating intelligent tutoring systems, adaptive platforms, simulation software, and predictive analytics can support students' learning experience in Mathematics, particularly through personalized instruction, differentiated learning, and improved student performance.

Pepin *et al*. (2025) [52] and Yavich (2025) [71] have both mentioned ChatGPT, WolframAlpha, Khan Academy, and SOWISO as AI-assisted tools that feature self-regulated learning, fast feedback, and mitigates students' anxiety while learning Mathematics. Moreover, the studies of Canonigo (2024) [10] and Remoto (2023) [55] enunciate that tools like GeoGebra, ChatGPT, and Bard can provide step-by-step explanations, visualizations, and scaffolding especially if students find a particular math topic complicated. As a result, it increases student engagement and autonomous learning. Another study from Wardat *et al*. (2023) [68] specifically explores ChatGPT as a generative AI tool in supporting students in learning mathematics. The study mentioned that ChatGPT provides explanation, feedback, and assistance in problem-solving towards particular math branches like algebra and geometry.

Challenges and Concerns of AI-assisted Tools in Learning Mathematics

Aside from the support in education and to students brought by AI, numerous studies have argued that there are still challenges that may affect mathematics education. These challenges limit how well AI tools work in math education. Some problems include that AI tools give inconsistent answers, students relying much on AI, and AI not being reliable for understanding math concepts (Remoto, 2023; Wardat *et al*., 2023) [55, 68]. According to the aforesaid studies, these limitations may reduce students' critical thinking and problem-solving skills if AI is used as a substitute for independent learning. Moreover, Adejumo *et al*. (2026) [1] explained that Generative AI can produce hallucinated or misleading responses, which may confuse learners, increase cognitive load, and negatively affect problem-solving and error detection. Such inaccurate outputs can hinder students' understanding if they are accepted without verification. Articles by Yavich (2025) [71], Canonigo (2024) [10], and Li *et al*. (2025) [36] also tackle problems on the use of AI-assisted tools Mathematics learning. The effectiveness of AI depends only on how it is properly used in terms of how detailed the instruction was.

Teachers have also been identified as factors in a successful AI integration in mathematics classrooms. Lara *et al*. (2025) [34] stated that teachers require proper training on the effective use of AI tools aligned with the curriculum. The study highlighted the responsibility of the teachers as

lifelong learners to continuously engage in professional development to be fully equipped with knowledge specially on the prosper use of AI tools to education. Similarly, Nwoke *et al*., (2025) [46] emphasized the role of teachers to not only properly learn the usability of AI tools but guide students responsibly in using them, learn to evaluate outputs, and to integrate it making a meaningful learning mathematics education. In addition, Tan *et al*. (2024) [60] highlights that curriculum standards should be aligned so teachers can integrate the tools properly that support learning objectives and enhance effective teaching practices.

One of the underlying concerns in the use of AI is data privacy. Many AI-assisted learning platforms collect and store personal information from the students and track their pattern of use. Jose (2024) [29] noted that the collection of personal data raises important privacy concerns due to unauthorized access or security breaches that compromise students' personal information and lessen trust in educational institutions. Likewise, Mst (2025) [45] warned that lack of protection on the students' information increases the risk of misuse or unauthorized disclosure. These findings emphasize the importance of implementing strong data protection policies on students' information while maintaining the benefits AI tools could offer. Moreover, AI tools lack human-like creativity despite the fact that it has an excellent detection pattern and optimization (Benvenuti *et al*., 2023; Marrone *et al*., 2022) [8, 40]. This leads to discouraging students from engaging their brains since AI can automate calculations, overemphasize the basic procedures and computational abilities (Opesemowo & Ndlovu, 2024) [49] that hinders the students in creating their own rhythm. Moreover, AI lacks real-time interaction that is essential in a classroom setting, making it impossible for teachers to handle concerns and inquiry (Almaiah *et al*., 2022) [5], and this leads to delayed assessment and discourage student-teacher interaction (Opesemowo & Ndlovu, 2024) [49].

Methodology

According to Chrastina (2018) [14], meta-synthesis is a qualitative approach that reviews and integrates existing findings and knowledge of inter-related qualitative studies in order to create new insights. Through synthesizing findings from existing qualitative studies, this study is undertaken to provide a more comprehensive understanding on the roles of AI-assisted tools in facilitating students' learning outcomes in mathematics.

Search Strategy

A literature search was undertaken using Harzing's Publish or Perish (version 8.19). Since a wide variety of studies are needed, all three scholarly databases, specifically Crossref, Google Scholar, and Scopus were used. They each provide a high quantity of peer reviewed articles or qualitative studies that have been highly cited within their respective fields of study. In order to obtain current information, the search was limited to studies published between 2021 and 2026. The search was guided by the following keywords derived from the study title and research focus particularly "AI-Assisted Tools in Learning Mathematics," "Artificial Intelligence", "Mathematics Education," "High School Mathematics" and "Learning Support in Mathematics." These keywords were applied across all selected databases to identify relevant articles. The retrieved records were then screened based on the study's inclusion and exclusion criteria to ensure that only pertinent and high-quality studies were included in the meta-synthesis.

Selection/Inclusion Criteria

The inclusion or exclusion of studies was conducted by means of a systematic process to select high-quality and relevant studies to synthesize within this review. Duplicate records which had been accessed through multiple databases were eliminated first. Studies lacking both a digital object identifier (DOI), as well as a citation record, were subsequently eliminated due to the fact that they weaken the ability to track, verify credibility, and assess scholarly influence of publications. Next, existing studies which are not focused on the application of artificial intelligence (AI) tools in mathematics education for high school students were eliminated. In addition, studies with either qualitative or mixed-method designs were deemed eligible for inclusion, however, only those qualitative results from mixed-method studies relevant to the objectives of this review were used. Additionally, studies whose complete text was unable to be accessed after making reasonable attempts were also eliminated. Finally, to provide additional assurance regarding the methodological rigors associated with each study, the Checklist for Qualitative Research CASP (2024) was applied to evaluate the quality of all studies which were ultimately determined to meet the eligibility criteria. Each article selected for evaluation was reviewed independently by each reviewer using the CASP Checklist. Only studies receiving an average rating of at least seven (7) were selected for meta-synthesis. We decided to accept studies having a score of at least 7 as Smith *et al*. (2025) [56] elucidated that studies with an appraisal score of 7 to 10 are considered high quality. Therefore, studies meeting the above mentioned criteria provided high-quality and credible data upon which the meta-synthesis would be based.

Search Result

Fig 1 presents the study selection process for the meta-synthesis using the PRISMA 2020 flow diagram. During the identification phase, a total of 1,515 records were retrieved using three databases, specifically 408 records from Scopus, 1000 records from Crossref, and 107 records from Google Scholar. Prior to screening, 91 duplicate records, 109 studies without DOI, 644 studies without citations, 620 studies not focused on AI tools in high school mathematics learning, and 20 quantitative studies were excluded based on the established inclusion and exclusion criteria. This resulted in 31 records being retained for screening. In the screening and eligibility phases, all 31 records were sought for retrieval, however, 6 reports could not be accessed and were therefore excluded. The remaining 25 studies underwent full-text eligibility assessment and quality appraisal using the CASP Checklist. Moreover, there were 14 studies omitted due to the failure to meet the requisite conditions in CASP checklists subsequent to the quality assessment. Accordingly, the studies retained for the final meta-synthesis were 11 studies that successfully met all requisite criteria.

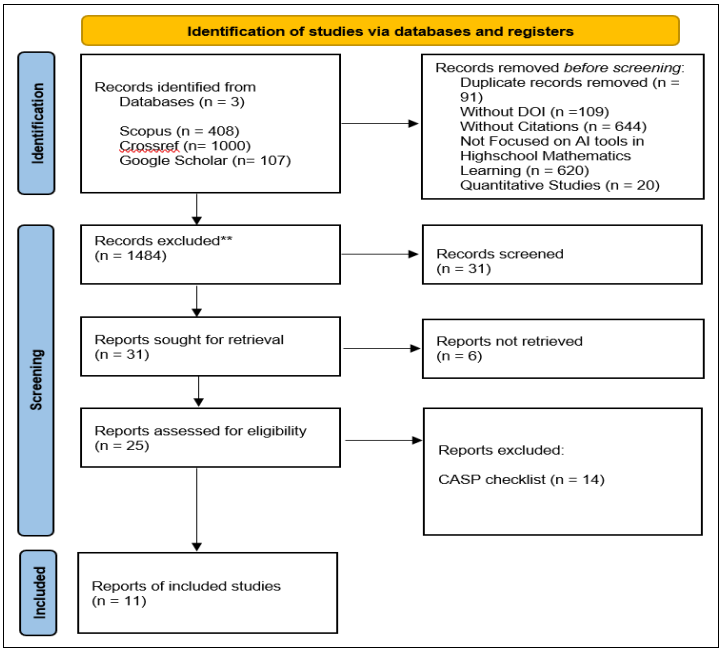

Fig 1: PRISMA 2020 Flow Diagram of the Identification and Selection of Eligible Studies

Quality Appraisal of Included Studies

By the means of the Critical Appraisal Skills Programme (CASP) Qualitative Checklist, the quality appraisal of the synthesized studies in this meta-synthesis was assessed. Verified against ten quality indicators, the quality appraisal aimed at measuring the methodological soundness, empirical validity, and clear practical applicability of each included study. Moreover, the 11 included studies on the meta-synthesis of AI-assisted learning tools in high school mathematics education based on the findings in the CASP appraisal outlined in Table 1 below. In addition, Table 1 presented the key points of the critical appraisal of methodology in each study and guaranteed that only peer-reviewed, empirically validated research informed this synthesis.

Table 1: Quality Appraisal of Included Studies in the Meta-Synthesis on AI-Assisted Learning Tools as Support for High School Students in Learning Mathematics

Study No.	Author/s & Year	Title	Country of Origin	Research Design	AI Tools Used	Salient Findings
S1	Wardat *et al*. (2023) [68]	ChatGPT: A revolutionary tool for teaching and learning mathematics	United Arab Emirates	Qualitative	1. ChatGPT	1. Provided immediate feedback and support 2. Personalized learning assistant by adapting to students' needs and learning pace. 3. Enhanced students' understanding of mathematical concepts 4. Providing explanations of complex topics in understandable language. 5. Assisted students in solving mathematical tasks efficiently. 6. Increased student engagement and motivation 7. Inaccuracies and errors in answers or solutions
S2	Cho & Kim (2025) [12]	Analyzing AI-based educational platforms for supporting personalized mathematics learning	South Korea	Qualitative	1. ALEKS 2. KnowRe Math 3. MATHia	1. Collects student data to adapt instruction to students' needs and progress. 2. Individualized paths, adaptive content, and instant feedback 3. Personalized experiences that accommodate diverse learning needs.
S3	Choirunisa & Susanti (2024) [13]	Transforming Mathematical Problem Solving Through AI Tools: An Investigation of Photomath Integration in Problem-Based Learning	Indonesia	Qualitative	1. Photomath	1. Enhanced students' mathematical problem-solving skills. 2. Improved understanding, modeling, solution application, and answer verification. 3. Increased interest through instant help and multiple methods. 4. Boosted participation, critical thinking, and independent learning.
S4	Chau *et al*. (2025) [11]	Personalized Mathematics Teaching with The Support of AI Chatbots to Improve Mathematical Problem-Solving Competence for	Vietnam	Qualitative	1. AI Chatbots	1. AI chatbots enhance mathematical problem-solving 2. Chatbots improve learning by providing real-time feedback, error analysis, and adaptive recommendations. 3. AI chatbots create responsive, student-centered

		High School Students in Vietnam				mathematics environments.
S5	Wang *et al*. (2022) [67]	Development and Application of an Intelligent Assessment System for Mathematics Learning Strategy among High School Students—Take Jianzha County as an Example	China	Mixed Method	1. Intelligent Assessment System (IAS)	1. Learning Diagnosis and data-driven feedback. 2. Detects conceptual and problem-solving gaps 3. Students gained clearer awareness of strengths and weaknesses 4. Real-time analytics enhanced instructional decisions and personalization. 5. Increased learning efficiency, better strategy use, and higher mathematics achievement.
S6	Lara *et al*. (2025) [34]	Evaluating the Impact of Artificial Intelligence on Teaching and Learning Mathematics at the Secondary School Level	Philippines	Mixed Method	1. AI-powered learning platforms, intelligent tutoring systems (ITS) 2. AI-based assessment tools 3. Learning analytics dashboards 4. AI chatbots for instructional support and feedback	1. Supports diverse student needs. 2. Boost engagement, conceptual understanding, and personalized learning via immediate feedback. 3. Identify gaps and adjust instruction effectively. 4. Infrastructure limits, varying teacher readiness, and inequitable access.
S7	Besas *et al*. (2026) [9]	AI-Facilitated Self-Directed Learning and Mathematics Performance: A Mixed-Methods Study on ChatGPT Use among Generation Z Students	Philippines	Mixed Method	1. ChatGPT (Generative AI Chatbot)	1. Improved access to mathematics explanations and guidance. 2. Supported self-directed learning and independent study. 3. Increased confidence in solving mathematics problems. 4. Provided personalized and immediate feedback. 5. Encouraged conceptual understanding through iterative questioning. 6. Served as a learning companion and reduced learning anxiety. 7. Risk of overreliance, passive learning, and reduced problem-solving persistence when misused.
S8	Kudaisi (2025) [33]	Artificial Intelligence in Mathematics Classroom-Exploring the Potency of MathGPTPro in Enhancing Secondary School Students' Cognitive Proficiency in Circle Theorems	Nigeria	Mixed Method	1. MathGPTPro (AI-powered Mathematics Tutor/Intelligent Tutoring System)	1. Improved understanding of Circle Theorems and geometry concepts. 2. Enhanced cognitive proficiency, critical thinking, and analytical reasoning. 3. Provided personalized, adaptive learning with instant feedback. 4. Increased student engagement, motivation, and confidence in mathematics. 5. Reduced misconceptions and learning difficulties in geometry. 6. Facilitated visual learning through interactive representations. 7. Accommodated diverse learning styles and individual needs.
S9	Trocado *et al*. (2025) [64]	Learning Quadratic Functions with ChatGPT: An Innovative Experience in High School Mathematics Education	Portugal	Qualitative	1. ChatGPT-3.5 (Generative AI chatbot)	1. Improved understanding of quadratic functions. 2. Enhanced mathematical reasoning and critical thinking. 3. Supported problem-solving and concept exploration. 4. Facilitated self-directed and independent learning. 5. Increased engagement and interest in mathematics. 6. Promoted collaborative learning and discussion. 7. Required teacher guidance to address inaccuracies and misconceptions. 8. Overreliance and acceptance of inaccurate responses when used independently.
S10	Egara *et al*. (2025) [19]	Secondary school students' perceptions of their usage of artificial intelligence-based ChatGPT in mathematics learning	South Africa	Mixed Method	1. ChatGPT (Generative AI Chatbot)	1. Provided step-by-step explanations, instant feedback, and real-time learning support. 2. Improved conceptual understanding and independent learning. 3. Increased confidence and engagement in mathematics learning. 4. Served as a virtual tutor and a complementary

						learning tool. 5. Concerns included occasional inaccuracies and overreliance that may affect independent problem-solving.
S11	Patero (2023) [51]	Revolutionizing Math Education: Harnessing ChatGPT for Student Success	Philippines	Qualitative	1. ChatGPT	1. Provide instant explanations, step-by-step guidance, and alternative solution strategies for mathematical problems. 2. Reduce learning barriers and support independent study. 3. Encouraged student engagement and curiosity 4. Importance of guided use to prevent over-reliance and ensure accuracy of mathematical reasoning.

Data Analysis

The data were analyzed using Clarke and Braun's (2006) [15] six-phase thematic analysis. The researchers familiarized themselves with the selected studies, generated initial codes, identified and reviewed themes, defined and named the final themes, and presented the findings in a narrative synthesis. This systematic approach enabled the identification of recurring patterns regarding the role of AI-assisted tools in supporting students in learning mathematics (Ahmed *et al*., 2025; Clarke & Braun, 2006) [2, 15].

Intercoder Reliability

To enhance the credibility of this meta-synthesis research, the researchers collaboratively coded the findings from the included studies using shared Microsoft Excel spreadsheets. The research findings in each study were entered in the spreadsheets. Through collaborative discussion, the researchers identified the similar context and assigned the initial codes then being highlighted. The final decision for the coding was done jointly to ensure common understanding of the meanings represented in each study. Throughout the entire coding process, the research continuously read and reviewed the findings to compare and refine the codes across studies. When there are differences in the codes, a discussion will be done until a consensus decision will be made. Together with the help of a research adviser, refined codes were produced. This process ensured that the final coding framework accurately represented the findings of the included studies and served as the basis for arriving at the result and discussion.

Results and Discussion

The results of this meta-synthesis study are anchored on its primary objective of synthesizing the roles of AI-assisted tools as support to high school students in learning Mathematics. There are eleven (11) studies that met the inclusion-exclusion criteria and were included in the synthesis providing mixed-method and qualitative findings on how AI assisted tools help students in learning mathematics. Consequently, five themes emerged from synthesizing the aforesaid studies which include (1) Facilitating Personalized and Adaptive Mathematics Learning, (2) Supporting Mathematics Learning Through Immediate Feedback and Scaffolding, (3) Deepening Students' Conceptual Understanding of Mathematics, (4) Promoting Active Engagement and Motivation in Mathematics Learning, and (5) Underlying AI-Risks and Pedagogical Challenges in Learning Mathematics. The succeeding sections will further discuss the foregoing themes together with their respective subthemes being derived.

Facilitating Personalized and Adaptive Mathematics Learning

The integration of AI tools in Mathematics education has significantly brought opportunities to high school students for personalized and adaptive learning experiences while learning Mathematics. The synthesis of the reviewed studies explicated that AI tools have the capability to transform the process of learning Mathematics as dynamic and responsive to individual student differences. These tools recognize the varying prior knowledge, cognitive readiness, learning speed, and areas of difficulty of the students (Patero, 2023 [S11]; Wang *et al*., 2022 [S5]) [51, 67]. Consequently, AI-assisted tools help high school students engage in mathematical concepts and skills that are anchored to their individual learning trajectories.

Contextualizing Instruction Based on Individual Learning Needs

AI tools provide contextualized instruction that is aligned to the individual needs of the students at the high school level. Intelligent tutoring systems (ITS) and Adaptive learning systems make use of AI algorithms which have the potential to diagnose students' learning and mastery level (Chau *et al*., 2025 [S4]) [11]. AI tools such as ALEKS, DreamBox Learning, Mathia, MathGPTPro, KnowRe Math, and Khan Academy understand and emphasize the strengths, weaknesses, misconceptions, and overall mastery level of the students and adjust the learning content and resources based on these aforesaid diagnoses (Cho & Kim, 2025 [S2]; Wang *et al*., 2022 [S5]; Kudaisi, 2025 [S8]) [12, 67, 33]. Instead of presenting uniform content to students, these AI tools provide customized learning materials and problems and targeted assignments which are appropriate to the students' current mathematics mastery level. Chau *et al*. (2025) [S4] [11] reported that AI chatbots analyze students' performance and their preferences which are then utilized to recommend tailored learning activities and resources. These tools act as accessible and free tutors, like those of human tutors, who adjust instruction, content, materials, and problems based on the real-time needs of the high school students.

This finding is consistent with the work of Opesemowo (2024) [48], who emphasized that AI algorithms can analyze student data and provide personalized instruction based on students' individual needs, learning styles, and mathematical performance. Aimed at addressing knowledge deficits and offering targeted support to students as required, the customized educational approach described by the author also provides a mechanism to assist students in bridging learning gaps through the use of AI-assisted learning technologies. In addition to helping students develop an increased level of awareness of their own knowledge

deficits, George and Jaleel (2025) [21] reported that students who used AI-assisted learning technologies demonstrated improved academic achievement.

AI learning tools are capable of supporting more inclusive opportunities for students to learn and develop their understanding of mathematical concepts. These tools provide a means to create learning experiences that are specifically designed to meet the unique needs, talents, deficiencies and level of proficiency of the individual learner.

Empowering Self-Paced Learning and Student Autonomy

High school students learn mathematics at their own pace with the help of AI tools. The majority of the studies reviewed indicate that AI instruments help the students learn as fast or slow as needed. For example, Wardat *et al*. (2023) [S1] [68] and Lara *et al*. (2025) [S6] [34] found that both intelligent tutoring systems and AI Chatbots allowed the students to go through the math concepts they were being taught at an individual pace. In addition, Kudaisi (2025) [S8] [33] showed that MathGPTPro provided personalized problem-solving assistance based upon each student's individual learning rate in Geometry. Further, Egara *et al*. (2025) [S10] [19] indicated that ChatGPT allowed students to receive individualized plans and feedback to be responsive to their individual learning processes.

Additionally, supporting these findings Torres-Peña *et al*. (2024) [63], stated that AI allows for an adaptable learning environment where it promotes student engagement and motivation and increases the level of personalization in the learning experience so students are able to advance at their own pace and receive instant feedback on their performance. They further explained that the benefits of this type of approach include the ability for students to gain mastery over complex math concepts, and develop a better overall understanding of the material. By adapting to the students' needs, rather than using a one-size-fits-all approach, teachers can reduce the amount of stress students feel due to their academic responsibilities, and allow students to have more input into how much time they need to complete tasks and assignments. George and Jaleel (2025) [21] added that AI-instructional technology allows students to be more autonomous learners and reduces the amount of anxiety associated with learning new content.

The results suggest that AI-based tools used in Mathematics instruction can facilitate students' learning autonomy as well as providing them with the opportunities to actively engage in their learning, including taking charge of the amount of time spent reviewing topics, spending extra time working on areas they find challenging until they demonstrate an adequate level of proficiency.

Supporting Mathematics Learning Through Immediate Feedback and Scaffolding

The synthesis of reviewed studies explicated that AI-assisted learning tools support high school students' mathematics learning through providing real-time feedback and guidance. Without having the need to wait for the teacher's feedback, AI tools have the capacity to provide instant correction to students' answers and solutions and offer step-by-step solutions with explanations on how to accurately solve the problem. These tools also help students receive support and learning companions whenever they encounter difficulties throughout the learning process. These features allow students to figure out their mistakes, refine their understanding, and continue learning independently.

Providing Real-Time Feedback to Promote Continuous Learning

AI-assisted learning tools provide immediate feedback which helps high school students immediately correct their mistakes and misconceptions in mathematics activities and tasks. Chau *et al*. (2025) [S4] [11] elucidated that AI-driven feedback systems and AI Chatbots provide immediate response to the questions of the students. They receive prompt responses from these AI tools whenever they are working on their quizzes and assignments. By doing so, the students are supported in improving their learning outcomes in mathematics. Wardat *et al*. (2023) [S1] [68] and Besas *et al*. (2026) [S7] [9] reported that ChatGPT provides instant feedback to students especially when they need assistance while working on mathematical problems. As explanations and step-by-step solutions can be quickly generated, it makes their problem solving skills during independent study efficient (Egara *et al*., 2025 [S10]) [19]. Furthermore, Intelligent tutoring systems identify logical inconsistencies and incomplete reasoning of students' solutions which encourage them to refine their answers and solutions (Lara *et al*., 2025 [S6]) [34]. These findings suggest that AI tools provide continuous learning opportunities and self-correction to which support high school students' mathematics learning.

These findings are consistent with the study of Xia *et al*. (2023) [70] who emphasized that AI tools can analyze student work and generate feedback, allowing students to identify errors and improve their understanding in a timely manner. The findings are also aligned to what Pepin (2025) reported that ChatGPT's ability to provide immediate feedback and solutions to basic mathematical problems can enhance students' engagement and confidence. Park and Manley (2024) [50], concluded that ChatGPT was effective at providing students with feedback on their mathematical argumentations especially when it came to clarity, justification, and generality. The feedback provided by ChatGPT enabled students to revise and improve their own proof efforts as a direct result of the suggestions made by ChatGPT.

The inclusion of AI learning tools in education may support formative learning processes for Mathematics by providing students with real-time and constant feedback. Feedback in a typical classroom setting is often delayed until after students have completed a lesson or assessment. However, AI learning tools allow students to identify mistakes immediately, so that those mistakes do not become ingrained into their thought process. Through this continuous loop of correcting mistakes as they occur during the learning process, AI tools encourage continued improvement in student's thought processes, promote reflective thinking, and foster development of problem-solving skills in math.

Scaffolding Mathematical Problem Solving Through Guided Support

AI tools also provide scaffolding to high school students by giving step-by-step explanations, hints, and guided problem solving procedures. These tools do not only show the answers but also provide guidance to students on how the answer is being derived and also provide more examples on

how to solve the problem using the outlined steps or procedures. The studies of Besas *et al*. (2026) [S7] [9] and Wardat *et al*. (2023) [S1] [68] elucidated that ChatGPT provides students with instructional guidance whenever they encounter difficulties in solving mathematical tasks. Through interactive and step-by-step explanations, the tool scaffolds students' learning by modeling solution procedures, guiding them through problem-solving processes, and gradually encouraging independent application of concepts (Trocado *et al*., 2025 [S9]; Egara *et al*., 2025 [S10]; Patero, 2023 [S11]) [64, 19, 51]. In addition, AI-based calculators such as Wolfram Alpha and Photomath do not only present direct answers to students but also step-by-step explanations to each solution of a specific mathematical problem (Choirunisa & Susanti, 2024 [S3]) [13]. Besas *et al*. (2026) [S7] [9] also mentioned that intelligent tutoring systems like MATHia closely mirror the decision making of a human tutor as they identify gaps in reasoning, provide step-by-step explanation, and encourage students to revise their thinking before proceeding.

The results reported herein are well-supported by sociocultural theory (Vygotsky, 1978) [66] as applied through his concept of the "Zone of Proximal Development" (ZPD). This ZPD refers to the fact that students will be capable of completing more complicated or advanced tasks if the teacher provides the proper amount of support for those students. The AI tool scaffolding has been modeled after the teacher-provided scaffold as described by Vygotsky (1978) [66] that both provide students with prompts, hints, explanations, and guided support to assist the student in bridging the gap between what the student currently understands and the goal or intended learning objective. Like Vygotsky (1978) [66], Holmes *et al*. (2019) [25] argue that an intelligent scaffold using artificial intelligence can adaptively provide support to students based upon their demonstrated need for assistance while providing timely guidance during problem-solving tasks. Scaffolding in the area of mathematics education is particularly beneficial since it allows students not only to determine the correct numerical solution, but also how to arrive at that solution. Malik *et al*. (2026) [38] used ChatGPT-based scaffolding that was aligned with Polya's (1957) problem-solving model to demonstrate significant increases in the number of high school students who were able to successfully solve systems of linear equations. Students used these ChatGPT-based scaffolds to receive adaptive prompts and guided reasoning throughout the problem-solving process.

High school students will develop better procedural fluency when given AI-assisted scaffolding that supports them from being able to use a procedure correctly and independently. Students will gain confidence through receiving step-by-step explanations, hints and guided reasoning so they can progressively internalize a variety of math concepts. As a result, students will have a greater chance of being able to complete problems independently and become more competent in all areas of Math.

Deepening Students' Conceptual Understanding of Mathematics

Through the interactive, personalized, and adaptive learning opportunities provided by AI tools such as visual representations, scaffold, and hints, students at the high school level gain a deeper grasp on mathematical concepts, translating abstract ideas into real-life contexts. As a result, they can apply their knowledge to different mathematical problems which amplify the utilization of their mathematical reasoning and critical thinking skills.

Strengthening Students' Mathematical Reasoning

ChatGPT and MathGPTPro as generative AI chatbots help high school students with step-by-step explanations and flexible guidance that improve reasoning and decrease misperceptions and errors in algebra and geometry (Wardat *et al*., 2023 [S1]; Kudaisi, 2025 [S8]) [68, 33], while intelligent tutoring systems such as ALEKS and MATHia assist students through the delivery of personalizable learning and adaptive feedback, that close the gap on proficiency in algebra and increase procedural fluency (Cho & Kim, 2025 [S2]) [12]. Therefore, based upon the research studies above, it appears that including AI-based educational tools, similar to those discussed in this section (ChatGPT, MathGPTPro, ALEKS, and MATHia) in the teaching of mathematics will greatly support high school students' development of their ability to reason mathematically. These tools enable students to be active participants in developing an understanding of mathematical concepts rather than being mere consumers of mathematical procedure.

Additionally, research conducted by Dilling and Hermann (2024) [18] supports the idea that using ChatGPT as a resource to develop geometric reasoning and the process of constructing proofs provides value to students. Likewise, intelligent tutoring systems that use scaffolding and provide real-time feedback are effective at increasing both procedural fluency and conceptual understanding. Students who experience these types of interventions demonstrate greater success in progressing from basic to more complex algebraic and geometric problems (Junpeng, 2025; Marwiang *et al*., 2025) [30, 41].

The integration of AI technologies into mathematics education has the potential to foster critical thinking skills, promote improved reasoning capabilities and provide students with personalized learning opportunities. Teachers can potentially integrate the technology described above as complimentary instructional resources to foster deeper student understanding of mathematics, while also promoting the critical evaluation of solutions and processes of reasoning.

Cultivating Critical Thinking in Mathematical Learning

The study of Choirunisa and Susanti (2024) [S3] [13] revealed that Photomath with AI features can help students become independent learners and critical thinkers through modeling and application and verification of solutions provided by the tool. Kudaisi (2025) [S8] [33] also revealed that MathGPTPro provides step-by-step explanation and guide on how to solve problems, asks questions to students for reflection, and facilitates students in correcting their misconceptions and incorrect applications of theorems in Geometry which in turn cultivates students' critical thinking. Patero (2023) [S11] [51] also elucidated that the integration of ChatGPT enhanced critical thinking skill among high school students as they dissected the mathematical concepts and problems provided by ChatGPT. According to Kasneci *et al*. (2023) [31], AI tools improve students' critical thinking skills by providing students the opportunity to verify, question, and scrutinize mathematical problems and proofs presented.

These trends infer that the integration of AI-powered tools

in mathematics learning supports critical thinking among students as these tools allow students to verify their reasoning and proofs rather than merely generating the answers. Through comparison and feedback, AI-assisted tools encourage the students to think deeply about how a concept, answer, or problem is being solved and derived.

Promoting Active Engagement and Motivation in Mathematics Learning

Another recurring theme emerged from the thematic analysis is the opportunity of AI-assisted learning tools in promoting active engagement and motivation among high school students while learning mathematics. Since these AI tools offer more personalized, adaptive, and interactive instruction and learning experiences to students, it helps sustain the interest and proactive involvement of students in their own learning.

Encouraging Active Participation in Mathematics Learning

Generative AI Chatbots such as ChatGPT offers an interactive and supportive environment for students, allowing them to create conversations with the tool as if they are chatting with a real human. This encourages high school students to ignite their curiosity and seek answers to their questions, hence making them more active participants in learning mathematics (Wardat *et al*., 2023 [S1]; Chau *et al*., 2025 [S4]; Egara *et al*., 2025 [S10]) [68, 11, 19]. Trocado *et al*. (2025) [S9] [64] also mentioned that Generative AI Chatbots can maximize students' volunteerism or willingness to participate in math discussions and activities because of its immediate feedbacking and personalized interaction features. Choirunisa and Susanti (2024) [S3] [13] also revealed that Photomath provides fast assistance to struggling students with a variety of solution strategies which encourages students to actively explore different ways on how to solve mathematical problems. According to Kasneci *et al*. (2023) [31] and Zawacki-Richter *et al*. (2019) [75], mathematics learning supported with AI-powered tools makes the learning process more interactive and responsive to the individual needs of the students rather than pressured which boosts students' engagement and classroom participation while learning mathematics. These aforesaid findings elucidate that AI tools have the power to activate students' curiosity and volunteerism which maximizes their deep involvement and participation in the learning process.

Sustaining Students' Interest and Motivation in Mathematics

AI platforms such as intelligent tutoring systems like ALEKS and KnowRe help sustain the attention and motivation of the students (Cho & Kim, 2025 [S2]) [12]. The immediate nature of the response helps support the continued engagement of the student because it ensures the student receives assignments that will neither overwhelm them nor bore them (Lara *et al*., 2025 [S6]) [34]. This maintains a constant sense of challenge and interest in mathematics. Additionally, AI Chatbots and Intelligent Tutoring Systems provide students with instant feedback, step-by-step directions, tasks at an appropriate level of difficulty, and encouraging statements designed to promote self-confidence and diminish frustration (Chau *et al*., 2025 [S4]; Kudaisi, 2025 [S8]) [11, 33]. These programs also enable students to inquire about anything they need clarification on, review previous areas where they struggled, and discover new methods of completing mathematical problems.

The results mentioned previously were consistent with those of a recent study performed by Lotey *et al*. (2026) [37]. They reported that the use of AI technology resulted in increased interest in math studies by Senior High School STEM students who demonstrated a higher perceived performance of their knowledge. Therefore, based upon their results, this offers potential opportunities for these students to develop improved retention of their math concept knowledge. Comidoy and Salva (2026) [16], also investigated persistence in motivating factors toward math education among senior high school students utilizing ChatGPT. Their data indicated that students displayed a persistent level of determination to pursue additional learning, solve math-based tasks, and maintain a positive interest in the subject matter via the introduction of generative AI. Therefore, these researchers concluded that proper incorporation of AI into teaching enhances student engagement in a student-centered manner.

Underlying AI-Risks and Pedagogical Challenges in Learning Mathematics

Despite numerous benefits for mathematics learning at the high school level, the incorporation of AI tools into high school math education consists of a number of pedagogical threats or risk factors which must be addressed so as to ensure the maximum potential academic success of all students.

Fostering Overdependence and Reduced Cognitive Persistence

Besas *et al*. (2026) [S7] [9] indicates that while ChatGPT supported self-directed learning, a significant risk associated with both passive learning and a reduction in a student's ability to persist through difficult problem solving situations exists when the technology is misused. Additionally, as outlined in the work done by Trocado *et al*. (2025) [S9] [64], a very high risk of students relying too heavily on generative AI when working independently exists. Furthermore, the work completed by Egara *et al*. (2025) [S10] [19] highlights several issues with how students perceive using generative AI to aid them in achieving independent problem-solving abilities. Specifically, the authors note that using generative AI to explain each step of an answer to a complex math question can have negative effects on a student's overall ability to reason analytically in assessments where access to AI is limited.

In order to avoid having students become overly reliant on technology, Patero (2023) [S11] [51] stated that educators need to facilitate AI literacy, and design assignments that assess mathematical processes and reasoning, instead of the final product. Many math teachers are fearful that the AI tools are going to cause students to treat math like a transactional experience rather than a cognitive development experience, therefore, many math teachers actively encourage students not to use them (Johnston *et al*., 2024) [28].

Generating Inaccurate Responses and Algorithmic Errors

Generative AI tools sometimes create inaccuracies in the form of algorithmic errors and logical hallucination. Wardat *et al*. (2023) [S1] [68] discovered that ChatGPT has some inaccuracies and errors in its answers or solutions to both calculus and algebra problems. Since generative AI models

determine text through probability instead of generating mathematical logic, they will often give students highly confident yet mathematically inaccurate answers (Besas *et al*., 2026 [S7]) [9]. If a student lacks a solid foundation in mathematics, he or she will be unable to detect such inaccuracies, which then leads to significant mathematical misconceptions being embedded within the student's cognitive framework (Trocado *et al*., 2025 [S9]) [64].

The direct implication of this is that the role of the mathematics teacher should transition from providing instructional content to validating student-produced work generated via AI. Additionally, Egara *et al*. (2025) [S10] [19], found that even occasional inaccuracies can negatively impact the degree of independence in problem solving that students experience. Relying solely on the AI eliminates the need for a critical evaluation process inherent in mathematics education, and if a student is confronted with an AI error that they cannot decipher, this situation results in increased anxiety regarding mathematics and decreased self-efficacy. Patero (2023) [S11] [51], determined that ensuring accurate reasoning in mathematics requires teacher supervision, which supports the previous assertion that AI must augment, not supplant, human instruction. Other studies indicate that outside of educational contexts, AI hallucinations in reasoning require students to remain skeptical (OpenAI *et al*., 2023), therefore developing the ability for students to identify these hallucinations is rapidly emerging as a new pedagogical goal for modern math curricula.

Constraining AI Integration Through Infrastructural and Systemic Limitations

The use of AI-assisted learning tools in classrooms is also limited by larger systemic infrastructure issues. Even though an AI-assisted learning tool may be pedagogically sound, there may be numerous other obstacles that limit its usefulness in actual practice within a school. Lara *et al*. (2025) [S6] [34] cite the lack of appropriate infrastructure, unequal availability or accessibility of digital platforms, and variability in teachers' level of preparedness for using such tools to significantly impact the delivery of secondary math. Moreover, Msomi and Behara (2026) [44] reported that there is significant social and economic risk of increasing the digital divide so that disadvantaged schools with low bandwidth internet connection or old hardware do not have the ability to take advantage of AI-based systems, thus causing their students to fall further behind those from well-funded districts.

Furthermore, the effectiveness of implementing AI-assisted learning tools is directly dependent upon human-related factors. No matter how advanced the intelligent tutoring system is, it will fail if the educator does not have sufficient Technological Pedagogical Content Knowledge (TPCK) to effectively incorporate this into his/her teaching (Tan *et al*., 2025) [61]. An important implication is that teacher training programs are generally lagging far behind the development of technology, thereby providing current educators insufficient knowledge to successfully navigate the transformation to AI-based technologies. As a result, many institutions are forced to implement restrictive policies instead of establishing an environment conducive to constructive integration of AI-assisted learning tools (Al-Farani & Al-Hajili, 2020) [4].

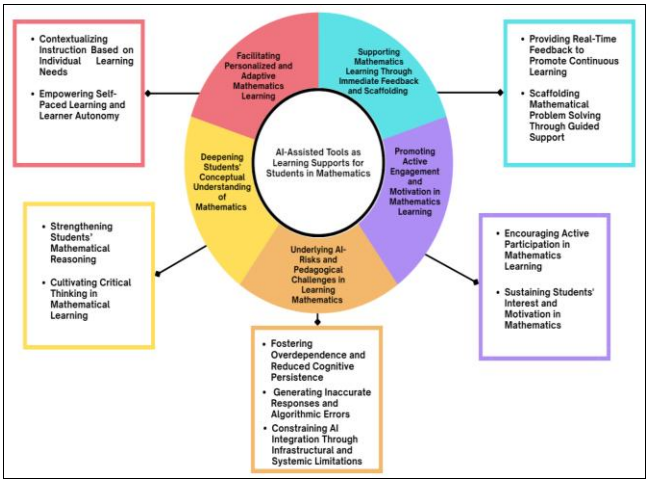

Fig 2: Thematic Framework on the Roles of AI-Assisted Tools as Learning Supports in Mathematics

Conclusion and Recommendations

The AI-assisted learning tools such as Intelligent Tutoring Systems (ITS), Adaptive Learning Systems, Generative AI, AI Chatbots, and AI-based Calculators focused on this meta-synthesis ascertained that these tools effectively act as mathematical scaffolds through implementing a responsive, individualized instructional framework, cultivating student agency, employing targeted, formative intervention strategies, and advancing cognitive mastery. By means of these mechanisms, AI-assisted learning tools support high school students to cultivate analytical reasoning, self-regulated learning, and logical reasoning. Conversely, significant barriers such as overreliance on AI, inaccurate responses, unequal access to technology, and teacher preparedness continue to be critical priorities in contextualizing AI-assisted tools as support for high school students in learning Mathematics.

To address these concerns, it is recommended that Mathematics education should incorporate AI Competency Models within the high school Mathematics curriculum to alleviate the lack of skepticism of systemic errors. To examine AI-driven mathematical solutions, curriculum specialists should develop norm-referenced scoring guides for all secondary education levels. This timely update should be integrated into the curriculum by the conclusion of the second academic year to pivot toward cutting-edge technological developments. To strengthen self-efficacy, high school students should also ensure AI tool usage remains within strict boundaries for self-regulated learning and algorithmic verification. Additionally, students should document self-directed learning time and resolve five advanced mathematical problems every week through independent reasoning to strengthen subject matter mastery. Fostering autonomous problem-solving capabilities by the end of the semester will nurture their own creative and logical intuition without solely relying on external tools. For Mathematics teachers facilitating high school students, they should maintain expertise through the completion of at least two annual certifications or workshops focused on AI integrations and responsible AI practices and regularly embed at least one AI-assisted assessment or project per grading period to foster digital literacy. Rather than quick-fix, one-off solutions, tool developers should prioritize fading support models to foster self-directed learning. By a

minimum of 15% in future iterations, tool developers must refine algorithmic accuracy to improve result reliability. Moreover, tool developers in collaboration closely with Mathematics teachers will ensure the launch of specialized, curriculum-aligned AI iterations by the onset of the 2027 academic school year. To promote digital inclusion, policy makers should enhance current frameworks through regular infrastructure updates. Furthermore, policy makers should guarantee specific budgetary allocations to modernize at least 80% of underserved secondary schools with high-speed internet and digital tools. Additionally, educational institutions should institutionalize a multidisciplinary team to supervise AI integration specifically ensuring full transparency in AI usage through universal faculty participation. In addition, this institutional AI handbook requires formal publication and immediate implementation before the start of the upcoming academic term, in order to mitigate privacy concerns and risks associated with cognitive automation. Furthermore, future researchers are encouraged to investigate the long-term impact of AI-assisted tools on students' mathematical achievement, reasoning skills, and learning experiences across different educational contexts.

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