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Impact of AI-Based Teaching on Ninth Graders' Achievement and Attitudes Toward Learning

Awad Tarawneh, Reda S.M. Al-Mawadieh, Mohammad F. Al-Abdallat

University of Jordan, Jordan

Mohammad Alshaar

Early Childhood Department, Faculty of Educational Sciences, Zarqa, Jordan

Majdi Abdullah Ahmad Adheisat

Department of Educational Sciences, Faculty of Arts and Sciences, University of Petra, Amman, Jordan

Abdalmuttaleb Al-Sartawi

Ahlia University, Bahrain

Mohammed Aman*

University of Business and Technology, Jeddah, Saudi Arabia

This study examined the influence of AI-assisted instruction on the mathematics achievement of ninth-grade students at the UMS using a quasi-experimental design. The findings revealed that students receiving AI-supported instruction achieved significantly higher scores on the mathematics achievement test than those in the control group, indicating that AI integration enhances academic performance. Furthermore, participants exposed to the AI-based approach reported highly favourable perceptions of incorporating AI applications into mathematics teaching and learning.

*Correspondence concerning this article should be addressed to Mohammed Aman University of Business and Technology, Jeddah, Saudi Arabia.
Email: m.aman@ubt.edu.sa

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Introduction

Students increasingly encounter academic challenges arising from cognitive development and the rapid integration of AI across multiple aspects of daily life. Education is one of the sectors most profoundly influenced by these technological advances (Bearman & Ajjawi, 2023). Progress in information and communication technology (Haleem et al., 2022), together with innovations such as cloud computing, has fundamentally reshaped teaching and learning practices (Mukul & Büyüközkan, 2023). These developments have prompted educational institutions and practitioners to embrace contemporary instructional approaches that promote learner autonomy, strengthen self-confidence, and extend beyond traditional pedagogical methods (ALshidi & Alsaidi, 2022).

Digital applications have become central to this educational transformation by supporting learner-centred pedagogies and facilitating more effective instructional practices (Timotheou et al., 2023). Their interactive features enable students to acquire knowledge more efficiently while increasing motivation and fostering favourable attitudes towards learning (Al-Shahrani, 2025). Among recent technological innovations, AI has emerged as a particularly influential educational advancement (Kothar Khalfan Al-Jadeedi 2024). AI-powered applications create adaptive learning environments that enable students to acquire knowledge and skills according to their individual pace, personalise instructional pathways, and deliver intelligent tutoring tailored to individual learning requirements (Tapalova & Zhiyenbayeva, 2022). Furthermore, AI facilitates the design, administration, and implementation of educational activities through advanced analytics and recognition technologies involving images, patterns, and speech, thereby enriching interactions between teachers and learners and supporting the achievement of educational objectives (Chen et al., 2020; Dabingaya, 2022).

The integration of AI further strengthens mathematics education by enabling adaptive and personalised instruction. Intelligent systems continuously diagnose learners' strengths and weaknesses, allowing instructional content to be modified according to individual learning needs, thereby improving learning effectiveness and academic outcomes (Kan’an, 2025; Son, 2024; Vieriu & Petrea, 2025). Likewise, ITS deliver continuous formative assessment, monitor learner progress in real time, and provide immediate feedback that enables teachers to refine instruction based on students' evolving understanding (Orhani, 2021). AI-supported instructional approaches also promote highly interactive learning environments through visual simulations and gamified activities, increasing engagement while reducing the perceived complexity and monotony of mathematics learning (ÖZDEN, 2025).

Simultaneously, AI automates routine administrative responsibilities, including grading and assessment, allowing teachers to devote greater attention to curriculum planning, instructional improvement, and the cultivation of higher-order thinking skills (Celik et al., 2022; Hetmanenko & Khoruzha, 2025). Although AI enhances creativity and mathematical problem-solving, it complements rather than replaces the essential role of teachers (Holmes & Tuomi, 2022). Consequently, integrating AI into mathematics education has considerable potential to improve instructional effectiveness while creating new opportunities for learners to develop deeper conceptual understanding (Hwang & Tu, 2021). Given the growing diversity of AI technologies, it is essential to examine their educational value, distinguish between available applications, and determine which tools are most appropriate for specific learner groups and instructional contexts. Since the educational effectiveness of AI varies across technologies and learning situations, identifying the most suitable applications remains an important research priority (Mohammad et al., 2023). Accordingly, this study investigates AI applications in mathematics education to evaluate their contribution to improving instructional practices and enhancing students' learning outcomes.

Research Problem and Questions

Academic achievement is a key indicator of the extent to which intended learning outcomes are attained, reflecting students' acquisition of the knowledge, skills, and competencies expected at a particular educational stage. As mathematics is a core subject for evaluating educational attainment, improving instructional approaches is essential for enhancing student achievement and ensuring effective learning outcomes (Bin Mohamed et al., 2022). Nevertheless, despite increasing technological integration in education, mathematics instruction continues to rely predominantly on conventional approaches that emphasise memorisation and procedural practice with limited connection to authentic contexts. Such methods often fail to actively engage learners or accommodate individual learning differences, contributing to lower academic performance and reduced attainment of intended learning outcomes (Al-Shahrani, 2025; Samaher Ahmed Al-Qarni 2021).

Contemporary educational practices advocate adopting innovative instructional strategies that not only improve academic achievement but also foster higher-order cognitive and scientific skills. Among these, AI applications have gained considerable attention as effective tools for enhancing teaching and learning (Zhai et al., 2021). Simultaneously, the demands of the digital era require students to develop the competencies necessary to adapt to technological advancements and effectively utilise emerging digital technologies across diverse contexts (Van Laar et al., 2020). Consequently, investigating AI-based educational applications has become essential for improving the quality and effectiveness of students' learning experiences (Alnsour et al., 2025).

Mathematics occupies a central position in knowledge economy reforms because of its role in developing analytical and problem-solving skills, reinforcing the need to integrate digital technologies, particularly AI, into instructional practice (Abd Algani, 2024). Drawing upon previous studies, classroom observations, and the researchers' professional experience, persistent deficiencies in students' mathematics achievement and learning motivation were identified. These concerns underscore the need to examine the educational value of AI applications in mathematics instruction, particularly at the ninth-grade level, while also exploring students' perceptions of their classroom use. A clear disparity remains between the recognised educational potential of AI and its limited implementation within current teaching practice. Accordingly, this study investigates the effect of AI-supported mathematics instruction on ninth-grade students' academic achievement and their attitudes towards integrating AI applications into the teaching and learning process. The study addresses the following research questions:

1. Are there statistically significant differences at the significance level ($\alpha = 0.05$) in students' mathematics achievement between instruction delivered through the traditional method and AI-based applications?
2. What are students' attitudes towards the use of AI in the classroom?

Study Objectives

This study aims to:

1. Examine the effect of AI applications on the mathematics achievement of ninth-grade students.
2. Investigate students' attitudes towards learning mathematics through AI-based tools.
3. Assess the role of AI applications in enhancing students' motivation and engagement in mathematics learning.

Study Terminology

1. **AI Applications:** Software systems that employ AI technologies to perform specific functions or enhance the performance of systems across various domains by simulating capabilities such as learning, reasoning, and decision-making (Mahmoud Zakaria Al-Astal, 2021).
2. **Academic Achievement:** The level of proficiency or educational attainment achieved in a particular subject, typically evaluated

through standardised assessments or teacher evaluations (Moghrabi, 2021).

3. **Attitudes:** A relatively stable predisposition to respond consistently towards particular objects, situations, or individuals, encompassing an individual's feelings and perceptions regarding educational programmes. In this study, attitudes are operationally defined as the mean scores obtained from participants' responses to a purpose-designed questionnaire (Hamdani, 2022).

Theoretical Framework and Previous Studies

Artificial intelligence (AI) has emerged as a major driver of educational transformation worldwide, extending far beyond its traditional applications in industry and technology to become an integral component of contemporary teaching and learning. As digital transformation accelerates, incorporating AI into education has become increasingly important for addressing the evolving demands of twenty-first-century learning and meeting the diverse educational needs of students through more effective instructional approaches (Kothar Khalfan Al-Jadeedi 2024). AI-powered educational applications have demonstrated considerable potential to strengthen both teaching and learning by facilitating adaptive instruction, delivering personalised educational content, supporting automated assessment, analysing learner performance, and recommending suitable instructional strategies. Consequently, educational systems across many countries are progressively adopting AI technologies to promote data-driven and technology-enhanced learning environments (Ogoke et al., 2025).

Mathematics remains one of the most challenging academic disciplines because of its abstract concepts and the learning difficulties experienced by many students (Bin Mohamed et al., 2022). Accordingly, AI has gained increasing attention as an effective means of enhancing mathematics instruction by simplifying complex concepts, generating adaptive practice activities, and creating interactive virtual learning environments that promote conceptual understanding and mathematical reasoning (Hetmanenko & Khoruzha, 2025). AI applications encompass a broad range of technologies, including the following (Mohammad et al., 2023):

1. **Machine Learning and Deep Learning:** AI techniques that enable systems to learn from data, supporting functions such as prediction, classification, image recognition, and speech recognition.
2. **Expert Systems:** AI-based systems that emulate specialist knowledge and reasoning to generate expert-level decisions and recommendations.

3. **Recommendation Systems**: Applications that analyse user behaviour to deliver personalised recommendations across educational, commercial, and entertainment platforms.
4. **Big Data Analytics:** AI tools designed to process extensive datasets, identify hidden relationships, and generate insights that support informed decision-making.
5. **Robotics and Intelligent Systems:** AI-enabled robots and autonomous systems capable of interacting with their surroundings and making decisions based on environmental information.
6. **Machine Translation:** AI applications that improve automated language translation and facilitate communication across different languages.

The widespread integration of technology has fundamentally transformed educational practices by enabling personalised learning experiences and supporting a deeper understanding of students' cognitive characteristics (Haleem et al., 2022; Tapalova & Zhiyenbayeva, 2022). AI facilitates the development of customised learning schedules that accommodate individual cognitive differences while assisting educators in designing instruction aligned with students' specific learning needs (ÖZDEN, 2025). Furthermore, AI enhances instructional efficiency through the generation of intelligent educational content, including digital textbooks, study guides, electronic learning resources, and continuously updated online instructional materials (Kasneci et al., 2023; Vieriu & Petrea, 2025). Within mathematics education, AI contributes substantially to improving instructional quality by supporting personalised learning, intelligent guidance, and highly interactive educational experiences (Hwang & Tu, 2021). Several applications illustrate these capabilities (Bin Mohamed et al., 2022):

1. **Intelligent Learning Systems:** AI-driven tutoring systems evaluate students' learning progress, diagnose strengths and weaknesses, and provide personalised instruction and practice activities.
2. **Educational Robots:** AI-powered robotic systems interact with learners by explaining mathematical concepts, assisting with problem-solving, and providing instructional guidance.
3. **Mobile and Tablet Applications:** AI-enabled educational applications allow students to practise mathematical concepts interactively while monitoring their individual learning progress (Criollo-C et al., 2021).
4. **Game-Based Learning:** AI supports the development of educational games that incorporate mathematical challenges, increasing learner motivation and strengthening mathematical competencies (Zainuddin et al., 2020).

5. **Intelligent Performance Analysis:** AI analyses students' mathematical achievement and produces comprehensive reports that assist teachers and parents in identifying learning strengths and areas requiring improvement (Ifenthaler & Yau, 2020).

Despite these advantages, implementing AI in mathematics education presents several challenges alongside significant opportunities (Orhani, 2021).

Challenges

1. **Privacy and Ethical Concerns:** Educational institutions must ensure responsible collection, management, and protection of students' personal information while maintaining ethical standards.
2. **Teacher Preparation and Professional Support:** Effective implementation requires comprehensive teacher training and continuous technical and pedagogical support.
3. **Technological Constraints:** Successful deployment often depends on reliable internet connectivity, appropriate digital devices, and sufficient institutional resources.

Opportunities (Imran et al., 2024)

1. **Personalised and Effective Learning:** AI enables customised instruction, adaptive exercises, and targeted guidance based on each learner's individual requirements, thereby strengthening mathematical understanding and performance (Tapalova & Zhiyenbayeva, 2022).
2. **Enhanced Interaction and Individualised Support:** AI continuously monitors student performance, providing immediate feedback and personalised assistance to overcome learning difficulties (Mousavinasab et al., 2021).
3. **Motivating Learning Environments:** Interactive AI applications and educational games increase student engagement and make mathematics learning more enjoyable.
4. **Performance Monitoring and Progress Evaluation:** AI-generated analytics enable teachers and administrators to assess individual progress, identify learning gaps, and improve instructional programmes and curricula (Kyambade et al., 2025).

Nevertheless, several barriers continue to influence AI implementation, including financial costs, unequal access to technological infrastructure, limited teacher preparedness, and ethical issues associated with collecting, storing, and analysing learners' personal data (Ogoke et al., 2025). AI-supported mathematics instruction creates innovative learning opportunities by adapting educational experiences to individual learner characteristics (Chiu et al., 2023). Through continuous analysis of student performance, AI systems identify learning needs and generate personalised instructional pathways that strengthen individual achievement (Abd Algani, 2024). These applications also promote active participation by creating engaging learning environments in which students interact dynamically with mathematical concepts and problem-solving activities, leading to deeper conceptual understanding (Hetmanenko & Khoruzha, 2025; Xu & Ouyang, 2022). In addition, immediate automated feedback enables learners to recognise misconceptions promptly, refine their understanding, and improve subsequent performance (Deeva et al., 2021).

Another important advantage of AI lies in its ability to collect and analyse educational data, providing detailed insights into students' learning progress and academic development (Ifenthaler & Yau, 2020). Such information enables students to monitor their own achievement while supporting teachers and parents in evaluating progress, identifying strengths and weaknesses, and implementing appropriate interventions (Dabingaya, 2022). AI-based educational platforms further encourage collaborative learning by enabling learners to exchange knowledge, discuss mathematical problems, and receive recommendations tailored to their interests and competency levels using intelligent recommendation algorithms and machine learning techniques (Reiss, 2021; Urdaneta-Ponte et al., 2021). Through these collaborative environments, students benefit from peer interaction and wider learning communities when solving mathematical and other academic problems (Alnsour et al., 2025).

Overall, existing research consistently demonstrates that AI applications positively influence both mathematics achievement and students' attitudes towards learning. Personalised instruction, adaptive guidance, and immediate feedback encourage greater engagement with mathematical content while increasing learners' confidence and motivation. Moreover, AI facilitates the development of mathematical problem-solving skills by allowing students to progress according to their individual learning pace and educational needs, ultimately contributing to improved academic performance in mathematics (Bin Mohamed et al., 2022; Kothar Khalfan Al-Jadeedi 2024).

Vieriu and Petrea (2025) investigated the influence of AI on students' academic development by examining its effects on learning experiences, academic performance, student perceptions, and implementation challenges. The research was conducted at the National University of Science and Technology Politehnica Bucharest and involved second-year students who had prior exposure to AI-supported learning environments. Employing purposive sampling, the researchers selected 85 participants. Data were gathered using an 11-item structured questionnaire comprising seven closed-ended items measuring AI usage, perceived effectiveness, and learner perceptions, together with four open-ended questions exploring participants' experiences, expectations, and concerns.

Quantitative responses were analysed using frequencies and percentages, whereas qualitative data underwent thematic analysis through both within-case and cross-case comparisons. The findings indicated that AI enhanced personalised learning, strengthened academic performance, and promoted skill development. Nevertheless, concerns regarding data privacy and academic dishonesty were also reported. The authors recommended establishing structured frameworks and ethical guidelines to maximise the educational benefits of AI while reducing associated risks. They concluded that although AI has considerable potential to improve learning efficiency and educational outcomes, successful implementation depends upon addressing issues related to accuracy, ethical responsibility, and excessive reliance on technology through a balanced integration strategy.

ÖZDEN (2025), in the theoretical study examined the multidimensional role of AI within educational settings. The study adopted a collaborative writing approach in which the researcher developed the conceptual framework, while generative AI tools, namely ChatGPT-4o and NotebookLM, were utilised to improve readability and presentation. The study emphasised the importance of AI across all educational stages, ranging from early childhood education to higher education and lifelong learning, through three complementary dimensions: learning with AI, learning through AI, and learning about AI. The author further explained that AI-enabled learning platforms, AI-competent teachers, and automated assessment systems can personalise instruction, deliver immediate feedback, improve teaching efficiency, and increase educational accessibility, particularly for learners with disabilities. The study concluded that AI offers substantial opportunities to strengthen teaching and learning; however, its effective implementation requires ethical governance, equitable access, and comprehensive teacher preparation. Consequently, integrating learning about, though, and with AI is essential for developing informed, critical, and competent learners in an AI-driven society.

Ogoke et al. (2025) investigated the effects of AI on students' mathematics achievement and knowledge retention. The target population comprised 4,204 senior secondary school (SS3) students in Owerri Municipal Council, Imo State, Nigeria. A randomised controlled pre-test–post-test experimental design was employed, with 72 participants selected through stratified random and purposive sampling from a private secondary school. Student achievement was assessed using the Mathematics Readiness Test (MAT), which reported a reliability coefficient of 0.74. Data were analysed using descriptive statistics and

Analysis of Variance (ANOVA). The findings indicated that students who learned geometry through AI-supported instruction did not outperform those taught using conventional methods, while the latter group demonstrated higher knowledge retention. Furthermore, no statistically significant gender differences were observed among students who received AI-assisted instruction. Based on these findings, the authors recommended promoting activity-based mathematics instruction, implementing AI under appropriate educational supervision, and enhancing teachers' and students' competencies to facilitate the effective integration of AI into mathematics education.

Hetmanenko and Khoruzha (2025) assessed the effectiveness of AI-supported mathematics instruction in overcoming educational challenges at the secondary school level. Their mixed-methods quasi-experimental study was conducted during the 2023–2024 academic year and involved 100 secondary school students in Kyiv. Learning outcomes for experimental and control groups were compared using pre-test and post-test measures following the implementation of the Photomath application, while students also completed a perception survey. Statistical analysis revealed significantly greater improvements in mathematics achievement among the experimental group ($p < 0.001$). Survey findings further indicated that 82% of participants experienced increased learning motivation, whereas 90% believed that Photomath enhanced their understanding of mathematics. The authors concluded that AI represents an effective instructional support tool; however, successful integration requires curriculum reform, revised pedagogical approaches, and comprehensive teacher training to maximise improvements in student understanding, motivation, and academic achievement.

Kan’an (2025) examined university students' attitudes towards AI integration within STEM education while considering variations according to gender, age, academic specialisation, and prior experience. Adopting a descriptive survey design, the study collected quantitative data from 360 students enrolled in STEM programmes at Irbid National University in Jordan during the second semester of the 2023–2024 academic year. Data were obtained through an electronic questionnaire and analysed using SPSS by calculating means, standard deviations, rankings, multivariate analyses of variance, and Scheffé post hoc comparisons. Overall, students expressed highly positive perceptions regarding AI integration in STEM education. No statistically significant differences were identified according to gender or age; however, academic specialisation significantly influenced attitudes, with students specialising in science and information technology demonstrating more favourable perceptions than those enrolled in Educational Sciences.

Kothar Khalfan Al-Jadeedi (2024) investigated mathematics teachers' understanding of AI concepts, their use of AI applications, attitudes towards AI, and perceived implementation challenges in the South Al Batinah and Al Dakhiliyah Governorates of the Sultanate of Oman. Employing a descriptive research design, the study utilised both a knowledge test and a questionnaire, while SPSS was used for statistical analysis. The sample consisted of 297 mathematics teachers. Results revealed generally limited knowledge of AI concepts among teachers, although female teachers demonstrated significantly higher levels of AI knowledge than their male counterparts. No statistically significant differences were associated with teaching experience or educational governorate. Despite limited conceptual understanding, teachers reported highly positive attitudes towards employing AI in education and expressed strong agreement regarding the practical challenges affecting AI implementation. The study recommended incorporating AI into teacher education programmes while strengthening technological infrastructure, including internet connectivity and digital resources, to facilitate effective classroom integration.

Abd Algani (2024) investigated the contribution of AI models to reducing mathematics anxiety while enhancing students' confidence and attitudes towards mathematics. Data were collected through questionnaires completed by 149 students, 93 mathematics teachers, and 27 school principals, with multiple statistical procedures employed during analysis. The findings indicated that 58.39% of respondents strongly agreed that AI integration reduced mathematics anxiety. Likewise, 39.59% and 48.99% strongly believed that AI increased students' confidence both inside and outside the classroom. More than 93% of students acknowledged improvements in their attitudes towards mathematics following AI implementation. Furthermore, 54.16% of teachers and school administrators agreed that conventional instructional approaches were insufficient for addressing mathematics anxiety, improving confidence, and changing learners' attitudes, thereby negatively influencing academic performance. In addition, over 85% of school leaders recognised that integrating AI into mathematics instruction substantially reduced students' anxiety. Consequently, both teachers and administrators recommended embedding AI models within mathematics curricula to address persistent challenges associated with mathematics anxiety, low self-confidence, and unfavourable learner attitudes.

ALshidi and Alsaidi (2022) investigated the extent to which AI concepts and applications were incorporated into mathematics curricula for basic education in the Sultanate of Oman. The researchers adopted a descriptive quantitative design and developed a content analysis instrument comprising 24 indicators distributed across five domains. Following validation and reliability testing, the instrument was applied to the seventh- and eighth-grade mathematics textbooks and activity books. The findings revealed a very limited integration of AI concepts across the seventh-grade curriculum, with inclusion rates of 3.50% in the first-semester textbook, 0.70% in the second-semester textbook, 1.70% in the first-semester activity book, and 2.40% in the second-semester activity book. Similarly, the eighth-grade curriculum demonstrated low levels of AI integration, recording 0.70%, 8.80%, 2.00%, and 0.30% across the corresponding instructional materials. Based on these findings, the authors recommended embedding AI concepts and applications more extensively within mathematics curricula, strengthening teacher training on AI-related instruction, and modernising mathematical content to reflect emerging AI developments.

Orhani (2021) examined the role of AI in mathematics teaching and learning by providing a comprehensive overview of its educational applications. The exploratory study found that AI implementation within educational settings enhances both student learning and teacher effectiveness. The author argued that AI offers valuable opportunities to address learning difficulties in mathematics by diagnosing individual learning needs and delivering personalised instructional support. The findings further indicated that AI contributes not only to students' cognitive development but also to their emotional engagement with learning while serving as an effective instructional aid for mathematics teachers. The study anticipated increased integration of AI into future mathematics curricula to equip students with competencies required in technology-driven societies. Consequently, the author recommended that mathematics teachers adopt AI-based instructional approaches and continue investigating their educational effectiveness in supporting personalised learning.

Moghrabi (2021) explored the effect of AI-supported algorithmic instructional plans on tenth-grade students' mathematics achievement and their attitudes towards AI-assisted learning. A quasi-experimental design was employed using experimental and control groups that completed both pre-tests and post-tests. The study involved tenth-grade students from selected schools in the Hebron Governorate. Mathematics achievement was measured using an achievement test, while students' attitudes were assessed through a structured questionnaire. The results demonstrated statistically significant improvements in mathematics achievement among students receiving AI-supported instruction compared with those taught through conventional methods. Moreover, participants in the experimental group exhibited more favourable attitudes towards AI-assisted learning than their counterparts in the control group.

Overall, the reviewed literature consistently suggests that AI has considerable potential to enhance mathematics education by improving academic achievement, learner engagement, and learning motivation. Nevertheless, realising these benefits depends on effective implementation strategies, adequate teacher preparation, and appropriate technological infrastructure. Building upon these findings, the present study investigates the influence of AI applications on ninth-grade students' mathematics achievement and their attitudes towards AI-supported learning using a quasi-experimental research design within a specific educational context.

Study Methodology and Procedures

Study Approach

A quasi-experimental design was employed to examine the effect of AI-based mathematics instruction on the achievement of ninth-grade students and their attitudes towards the use of AI applications in the teaching and learning process. This design was considered the most suitable for addressing the study's objectives and research questions. The research incorporated both pre-test and post-test measures for the experimental and control groups, enabling comparisons of students' academic achievement and changes in their attitudes following the instructional intervention.

Study Population and Sample

The study population comprised ninth-grade students in Jordan during the 2024/2025 academic year. A purposive sampling technique was adopted based on the accessibility of the research setting. The University of Jordan School was selected because it provided the necessary technological infrastructure, including computer laboratories, computing facilities, and reliable internet access. As the school had two ninth-grade classes, one class was randomly assigned to the experimental group and received instruction on the topic of Relations and Functions using AI applications, whereas the other class served as the control group and was taught using the conventional instructional approach.

Study Tools

First Tool: The first tool was an achievement test developed in accordance with a table of specifications. It comprised 20 multiple-choice items covering the Relations and Functions unit from the Jordanian ninth-grade mathematics curriculum.

Tool Validity

To establish content validity, the achievement test was submitted to a panel of 10 experts specialising in educational measurement and evaluation, curriculum and instruction, educational technology, Arabic language, and computer science. The panel reviewed the instrument and provided constructive feedback, which was incorporated to refine and improve the final version of the test.

Tool Reliability

The reliability of the achievement test was established using the test–retest method. The instrument was first administered to a pilot sample of 33 ninth-grade students from a school in Amman who were not included in the main study. These students had previously completed the Relations and Functions unit and possessed characteristics comparable to those of the study sample in terms of learning environment, available resources, and educational facilities. After a two-week interval, the same test was administered to the pilot group for a second time. The Pearson correlation coefficient between the two administrations was then calculated, yielding a test–retest reliability coefficient of 0.86, indicating a high degree of score stability over time.

Internal Consistency Reliability/Item Statistics

Internal consistency was evaluated using the Kuder–Richardson Formula 20 (KR-20), which is appropriate for dichotomously scored items where correct responses are assigned one mark and incorrect responses receive zero. The analysis demonstrated that the achievement test possessed an acceptable level of internal consistency, confirming that the instrument was sufficiently reliable for application in the present study.

Second Tool: Attitudes Questionnaire

The second instrument was an attitudes questionnaire developed to evaluate students' attitudes towards the use of AI applications in the teaching and learning process. Its construction was guided by the relevant theoretical literature and previous empirical studies, including Mahmoud Zakaria Al-Astal (2021). Based on these sources, the researcher designed a questionnaire comprising 20 items to assess students' perceptions and attitudes regarding the integration of AI applications into classroom teaching and learning.

Instrument Validity

The attitudes questionnaire was submitted to a panel of 10 experts specialising in educational measurement and evaluation, curriculum and instruction, educational technology, and Arabic language. The experts were invited to review the instrument and provide their observations regarding its suitability and clarity. Their feedback was incorporated, and the questionnaire was revised accordingly before being finalised for use in the study.

Instrument Reliability

Internal Consistency Reliability/Item Statistics: The internal consistency of the questionnaire was assessed using Cronbach's alpha, which is widely employed for instruments comprising items measured on a continuous scale. The analysis yielded a Cronbach's alpha reliability coefficient of 0.01, indicating that the questionnaire demonstrated an acceptable level of reliability and internal consistency.

Statistical Processing

To address the research questions, appropriate statistical techniques were employed to analyse the collected data. Both descriptive and inferential statistics were applied, including the calculation of means and standard deviations. In addition, Analysis of Covariance (ANCOVA) was performed to control for pre-test differences between the groups and to examine differences in post-test academic achievement between the experimental and control groups.

Presentation of Results

To answer the study questions, the arithmetic means and standard deviations of the pre-test and post-test mathematics achievement scores were calculated for both the experimental and control groups.

Table 1

Arithmetic Means and Standard Deviations for the Scores of the Two Study Groups on the Pre- and Post-Test Mathematics Tests

Group	Number of Students	Difficulty Level	Pre-Test		Post-Test	
			Mean	Standard Deviation	Mean	Standard Deviation
Experimental	25	3	4.52	2.08	15.80	2.38
Control	25	1	3.84	1.99	12.72	3.03
Total	50	2	4.18	2.05	14.26	3.12

Note: There is not difficulty observed.

Table (1) indicates observable differences between the mean pre-test and post-test mathematics achievement scores of ninth-grade students according to the instructional method. The experimental group, which received AI-supported instruction, achieved a higher post-test mean score (15.80) than the control group taught using the conventional method (12.72). To determine whether these differences were statistically significant at the 0.05 significance level ($\alpha = 0.05$), ANCOVA was conducted after controlling for pre-test scores. The results of the analysis are presented in Table (2).

Table 2

Analysis of Variance (ANCOVA) to Find the Significance of the Differences in the Scores of Ninth-Grade Students in the Pre- and Post-Test of Mathematics

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-Value	Statistical Significance	Eta Square (η2)
Math Test	0.010	1	0.010	0.002	0.964	.000
Teaching Method	156.72	1	156.72	18.42	0.000*	0.28
Error	396.20	47	8.43			
Total Average	552.93	49	4.18	2.05	14.26	3.12

Note: Statistical significance at the (a = 0.05) level

Table (2) demonstrates statistically significant differences in ninth-grade students' mathematics achievement attributable to the instructional method at the 0.05 significance level ($\alpha = 0.05$). The ANCOVA results produced an F-value of 18.42 with a significance level of 0.000, indicating a statistically significant difference between the post-test mean scores of the experimental and control groups. To assess the magnitude of this effect, eta squared (η^2) was calculated and yielded a value of 0.28, indicating that 28% of the variance in students' mathematics achievement was explained by the teaching method, whereas the remaining variance was attributable to other uncontrolled factors. To identify the direction of the difference, the adjusted post-test means for both groups were computed, as presented in Table (3). Table (3) indicates that the adjusted mean score of the experimental group on the mathematics achievement test was 15.46, exceeding the adjusted mean score of 13.06 recorded for the control group. These findings indicate that the observed difference in mathematics achievement favoured the experimental group. The findings also revealed a high overall level of students' attitudes towards the use of AI applications in the teaching and learning process, with an overall mean score of 4.25. The mean scores for the individual questionnaire items ranged from 3.36 to 4.54, indicating generally positive perceptions of AI-supported learning.

Table 3

Adjusted Post-Test Arithmetic Means and Standard Errors of the Scores of Tenth-Grade Students on the Mathematics Test

Group	Average Arithmetic Mean	Standard Error
Experimental	15.46	0.48
Control	13.06	0.61

Discussion of the Results

Teaching mathematics through AI applications can substantially improve the academic achievement of ninth-grade students by creating interactive and personalised learning environments that encourage active participation throughout the instructional process. These applications enhance learner engagement by presenting mathematical content through interactive activities accompanied by immediate feedback, enabling students to remain attentive and actively involved during learning. Similar findings have been reported by Ogoke et al. (2025), who observed increased student engagement and interest in mathematics, while comparable evidence was presented by Hetmanenko and Khoruzha (2025) and Kothar Khalfan Al-Jadeedi (2024). Likewise, previous studies by Vieriu and Petrea (2025), Son (2024), and Ingkavara et al. (2023) concluded that AI-supported mathematics instruction improves academic achievement by delivering personalised learning experiences that accommodate individual ability levels and strengthen students' understanding of mathematical concepts while developing their mathematical competencies.

The findings further reinforce the importance of integrating AI applications into teaching and learning practices. AI enables teachers to provide personalised instructional experiences that support adaptive learning approaches, a conclusion consistent with the findings of ÖZDEN (2025) and Orhani (2021). Moreover, the results highlight the value of combining AI technologies with conventional instructional approaches rather than treating them as substitutes (Holmes & Tuomi, 2022). Such integration improves the effectiveness of mathematics instruction while ensuring its alignment with the demands of increasingly digital educational environments, as also reported by Hetmanenko and Khoruzha (2025) and Ingkavara et al. (2023). The findings additionally suggest that careful planning is required when implementing AI applications to ensure that their use contributes effectively to achieving the intended curriculum learning outcomes (Son, 2024). Furthermore, the study indicates that AI applications, through embedded instructional scaffolding and challenge-based learning activities, can strengthen students' critical thinking and problem-solving abilities, supporting the conclusions of ALshidi and Alsaidi (2022). By guiding learners through structured problem-solving processes and higher-order thinking activities, these applications encourage systematic reasoning and independent analytical skills, consistent with the findings reported by Ogoke et al. (2025) and Ingkavara et al. (2023).

The findings also suggest that AI-supported mathematics instruction enhances students' self-confidence and independent learning. As learners experience individual success and progressively improve their mathematical abilities through continuous interaction with AI applications, they become more confident in their capabilities and increasingly self-reliant, thereby strengthening their mathematical self-efficacy. Similar outcomes were reported by Moghrabi (2021). In addition, the results indicate that AI applications foster greater intrinsic motivation and sustained interest in mathematics by providing continuous personalised feedback, immediate guidance, and tailored learning support, consistent with the findings of Abd Algani (2024). These technologies further promote self-directed learning by enabling students to progress according to their own pace while independently constructing knowledge, thereby shifting the emphasis from teacher-centred instruction towards learner-centred education. Such an approach supports long-term educational planning and sustainable learning practices by encouraging students to assume greater responsibility for their own learning, in line with the conclusions of (Kan'an, 2025).

Conclusions

1. AI applications enhance students' mathematics achievement by providing personalised instruction and individualised guidance tailored to each learner's needs and proficiency level, thereby improving conceptual understanding and academic performance.
2. Through interactive teaching and learning environments, AI applications create engaging educational experiences that encourage students to participate actively in mathematical activities and collaborate with their peers, resulting in higher levels of engagement and classroom participation.
3. AI applications enrich the overall learning experience by presenting mathematical concepts in a structured, step-by-step manner, facilitating deeper understanding and supporting continuous learning and sustained academic development.
4. AI applications strengthen students' self-confidence and independent learning by enabling them to make measurable progress in mathematics while successfully completing assigned learning tasks with greater autonomy.
5. The use of personalised AI-supported learning strategies positively influences students' mathematics achievement and attitudes by addressing individual learning needs and fostering the development of each student's mathematical capabilities.

Recommendations

Based on the study findings and the reviewed literature, the following recommendations are proposed:

1. **For Teachers:** Incorporate AI applications into mathematics instruction to facilitate personalised learning, provide immediate feedback, and promote interactive problem-solving activities. Ongoing professional development should also be provided to strengthen teachers' competencies in effectively integrating AI into classroom practice.
2. **For Schools and Educational Institutions:** Strengthen technological infrastructure by providing adequate computing facilities, AI-enabled software, and reliable internet access to support the effective implementation of AI in mathematics classrooms. Institutions should also establish clear policies and operational guidelines for the appropriate use of AI-based educational technologies.
3. **For Curriculum Developers**: Integrate AI applications into mathematics curricula in alignment with curriculum objectives to ensure that technological innovations support intended learning outcomes while fostering both conceptual understanding and procedural proficiency.
4. **For Researchers:** Undertake further investigations into the long-term impact of AI-supported mathematics instruction across different educational levels and learning contexts, with particular attention to its effects on students' academic achievement and attitudes towards learning.
5. **For Policymakers:** Develop and support policies that facilitate the adoption of AI in education, promote equitable access to technological resources, and invest in teacher training initiatives to ensure the effective integration of AI into classroom teaching and learning practices.

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