Relationship Between Artificial Intelligence (AI) Application Skills and Mathematical Understanding among Malaysian Secondary School Students

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ABSTRACT

The rapid advancement of Artificial Intelligence (AI) has reshaped mathematics education by creating new opportunities for personalised, interactive, and self-directed learning. However, the growing accessibility of AI-powered applications has also raised concerns that students may become increasingly dependent on AI-generated solutions without developing a deep understanding of mathematical concepts or engaging in independent problem-solving. This emerging challenge highlights the need to understand not only students' use of AI, but also their competencies in applying AI effectively to support meaningful learning. Therefore, this study examined secondary school students' levels of mathematical understanding, AI application skills, and frequency of AI use in mathematics learning, as well as the relationship between AI application skills and mathematical understanding. A quantitative cross-sectional survey design was employed involving 59 Form Four and Form Five students from selected secondary schools in Selangor, Malaysia, recruited through purposive and convenience sampling. Data were collected using a structured online questionnaire and analysed using descriptive statistics and Pearson correlation analysis. The findings revealed positive AI application skills ($M = 3.65$), positive mathematical understanding ($M = 3.55$), and frequent AI application use ($M = 3.56$), while students also reported positive perceptions towards AI-supported mathematics learning ($M = 3.46$, $SD = 0.553$). Pearson correlation analysis further demonstrated a statistically significant moderate positive relationship between AI application skills and mathematical understanding ($r = .510$, $p < .001$), indicating that students who were more competent in using AI applications tended to report better mathematical understanding. Unlike previous studies that have primarily focused on AI adoption or students' acceptance of AI technologies, this study demonstrates that students' competencies in using AI constitute an important educational factor associated with mathematical understanding. The findings suggest that the educational value of AI lies not merely in the availability of intelligent technologies but in students' ability to use them critically, ethically, and purposefully. These findings provide practical evidence for educators and policymakers in Malaysia to strengthen AI literacy within mathematics education, particularly in developing students' prompt construction skills, critical evaluation of AI-generated information, and responsible AI practices to support future-ready learning.

Keywords: Artificial Intelligence (AI), AI literacy, Mathematics Education, Mathematical Understanding, AI-assisted Mathematics Learning, Secondary School Students.

INTRODUCTION

Artificial Intelligence (AI) has rapidly emerged as a transformative technology that is reshaping educational practices across various disciplines. The advancement of generative AI has enabled students to access personalised explanations, immediate feedback, and adaptive learning support that extend beyond the limitations of conventional classroom instruction (Gill et al., 2023; Yim & Su, 2024). In mathematics education, AI applications such as ChatGPT, intelligent tutoring systems, and AI-powered mathematics platforms have become increasingly popular because they provide students with multiple solution strategies, interactive learning experiences, and continuous learning support regardless of time and location (Wardat et al., 2023; Rane, 2023; Son, 2024).

The integration of AI into mathematics learning has demonstrated considerable educational potential. Previous studies have consistently reported that AI-assisted learning enhances students' conceptual understanding, mathematical reasoning, and confidence by providing personalised explanations and immediate feedback throughout the learning process (Canonigo, 2024; Torres-Peña et al., 2024). Similarly, intelligent tutoring systems equipped with adaptive feedback have been shown to improve students' mathematical achievement by diagnosing misconceptions and providing learning support tailored to individual needs (Shih et al., 2023; Marwiang et al., 2025; Villegas-Ch. et al., 2025). Recent systematic reviews and meta-analyses further concluded that AI has a significant positive effect on mathematics learning outcomes among school students when implemented as a pedagogical support tool rather than merely as an answer-generating application (Yi et al., 2025; Liu et al., 2026).

Despite these promising findings, the widespread adoption of AI in education has also generated growing concerns regarding students' cognitive engagement. Several studies reported that excessive reliance on AI may encourage students to obtain immediate answers without fully engaging in the reasoning and problem-solving processes necessary for meaningful mathematical learning (Bastani et al., 2025; Zhai et al., 2024). Such over-reliance may weaken critical thinking, analytical reasoning, and independent problem-solving abilities, particularly when students use AI primarily as a shortcut to complete mathematical tasks rather than as a learning support tool (Çela et al., 2024; Arifin et al., 2025). Consequently, the educational effectiveness of AI depends not only on the capabilities of the technology itself but also on how students interact with and utilise AI throughout the learning process.

In this context, AI literacy has become a fundamental competency for students in the digital era. AI literacy encompasses the knowledge, skills, and ethical awareness required to understand AI technologies, evaluate AI-generated information critically, construct effective prompts, and apply AI responsibly in learning activities (Ng et al., 2023; Walter, 2024).

Studies have shown that students with higher AI literacy demonstrate stronger prompt engineering skills, make better judgments regarding AI-generated responses, and use AI more productively to support learning (Knoth et al., 2024; Kim et al., 2025). Furthermore, AI literacy has been identified as an important predictor of students' acceptance of generative AI and their academic performance, suggesting that meaningful AI integration depends largely on students' competencies rather than technology availability alone (Salhab & Aboushi, 2025; Ahmed, 2026; Chee et al., 2025).

Although research on AI-assisted learning has expanded rapidly, several important gaps remain. Existing studies have predominantly focused on higher education students, AI acceptance, or general educational applications, while empirical evidence involving secondary school mathematics remains comparatively limited (Chung et al., 2026; Esiyok et al., 2025).

Moreover, previous studies have frequently examined AI literacy, self-regulated learning, technology acceptance, and mathematical learning outcomes as separate constructs, with limited attention given to the relationship between students' AI application skills and their mathematical understanding in secondary education (Ali et al., 2023; Lan & Zhou, 2025; Del Rosario Navas Bonilla et al., 2025). Understanding this relationship is increasingly important because effective AI integration in mathematics education requires not only frequent technology use but also the ability to utilise AI meaningfully, critically, and ethically.

Therefore, this study aims to examine secondary school students' level of mathematical understanding, AI application skills, frequency of AI use, and perceptions towards AI in mathematics learning. More importantly, this study investigates the relationship between AI application skills and students' mathematical understanding. The findings are expected to contribute empirical evidence to the growing literature on AI-assisted mathematics education while providing practical guidance for teachers, schools, and policymakers in promoting responsible and meaningful AI integration into mathematics teaching and learning.

LITERATURE REVIEW

AI in Mathematics Education

Artificial Intelligence (AI) has emerged as a transformative technology that is reshaping educational practices by providing more personalised, adaptive, and interactive learning experiences. In mathematics education, AI-powered applications such as generative AI, intelligent tutoring systems (ITS), and adaptive learning platforms have increasingly been integrated into teaching and learning to support students' conceptual understanding, mathematical reasoning, and problem-solving skills (Gill et al., 2023; Wardat et al., 2023; Walkington, 2025). These technologies enable students to receive immediate feedback, step-by-step explanations, and personalised instructional support based on their individual learning needs, thereby extending learning opportunities beyond the traditional classroom environment (Shih et al., 2023; Son, 2024; Marwiang et al., 2025).

Empirical evidence consistently demonstrates the positive contribution of AI to mathematics learning. Previous studies reported that AI-assisted learning improves students' conceptual understanding, confidence, and mathematical achievement by facilitating interactive learning experiences and adaptive feedback throughout the learning process (Canonigo, 2024; Torres-Peña et al., 2024). Similarly, AI-powered tutoring systems and teachable agents have been found to promote deeper engagement with mathematical concepts while encouraging students to actively participate in problem-solving activities (Xing et al., 2025; Pardos & Bhandari, 2024). Meta-analytic evidence further indicates that AI has a significant positive effect on students' mathematics learning outcomes when implemented as a pedagogical support tool rather than merely as a mechanism for generating answers (Yi et al., 2025; Liu et al., 2026). Nevertheless, researchers caution that the educational benefits of AI depend largely on how students utilise the technology, as excessive reliance on AI-generated responses may reduce opportunities for developing critical thinking and mathematical reasoning skills (Bastani et al., 2025; Zhai et al., 2024; Arifin et al., 2025).

Students' Mathematical Understanding

Mathematical understanding refers to students' ability to comprehend mathematical concepts, interpret solution procedures, and apply appropriate reasoning when solving problems. In AI-supported mathematics learning, students are no longer passive recipients of information but actively engage with AI-generated explanations, multiple solution strategies, and immediate feedback that facilitate conceptual development.

AI-powered learning environments enable students to visualise abstract mathematical concepts, identify misconceptions, and receive personalised instructional support according to their individual learning needs, thereby promoting meaningful learning experiences (Canonigo, 2024; Torres-Peña et al., 2024; Walkington, 2025). In addition, intelligent tutoring systems provide adaptive guidance that assists students in understanding mathematical procedures while encouraging continuous reflection throughout the learning process (Shih et al., 2023; Son, 2024).

Previous empirical studies consistently indicate that AI-assisted learning positively influences students' mathematical understanding and problem-solving performance. AI-powered tutoring systems, adaptive feedback, and teachable agents have been shown to improve conceptual understanding, mathematical reasoning, and learning confidence by encouraging students to explore different approaches rather than memorising procedures (Xing et al., 2025; Pardos & Bhandari, 2024; Marwiang et al., 2025). Similarly, meta-analytic evidence demonstrates that AI integration contributes significantly to mathematics learning outcomes across K–12 education, particularly when AI functions as a learning support tool that promotes active cognitive engagement instead of simply providing answers (Yi et al., 2025; Liu et al., 2026).

However, meaningful mathematical understanding can only be achieved when students actively evaluate, interpret, and apply AI-generated information rather than relying solely on AI-generated solutions, as excessive dependence may weaken conceptual learning and critical thinking (Bastani et al., 2025; Zhai et al., 2024).

AI Application Skills and AI Literacy

AI application skills and AI literacy have emerged as essential competencies that enable students to use AI effectively, critically, and responsibly in educational settings. AI literacy extends beyond the technical ability to operate AI applications and encompasses understanding AI concepts, evaluating AI-generated information, constructing effective prompts, and applying ethical considerations when interacting with AI technologies (Ng et al., 2023; Walter, 2024). As AI becomes increasingly integrated into mathematics education, students are expected not only to access AI-generated information but also to interpret, verify, and apply the information appropriately to support meaningful learning. Consequently, AI literacy has become a fundamental competency that influences students' readiness to utilise AI as a cognitive learning tool rather than merely as a source of instant answers (Chee et al., 2025; Salhab & Aboushi, 2025).

Recent studies have consistently demonstrated that students with higher AI literacy possess stronger AI application skills, enabling them to formulate more effective prompts, critically evaluate AI-generated responses, and integrate AI productively into their learning processes (Knoth et al., 2024; Kim et al., 2025). Similarly, digital literacy has been identified as a significant mediating factor between AI-based learning tools and students' academic performance, indicating that meaningful educational benefits are strongly influenced by students' competencies rather than technology availability alone (Ahmed, 2026). Conversely, inadequate AI literacy may encourage superficial learning behaviours, including overdependence on AI-generated responses and reduced engagement in higher-order thinking processes (Walter, 2024; Çela et al., 2024). Therefore, strengthening AI application skills and AI literacy is increasingly recognised as an important educational priority to ensure that AI supports students' mathematical reasoning, critical thinking, and independent learning rather than replacing them.

Frequency of AI Use in Mathematics Learning

The frequency of AI use has become an important indicator for understanding how students integrate AI into their learning activities. Recent studies have reported a substantial increase in students' use of generative AI across different educational levels. High school students are increasingly adopting AI to support school-related tasks, while university students frequently utilise AI for brainstorming, summarising information, editing academic work, and solving learning problems (Bueie et al., 2026; Chung et al., 2026). Within mathematics education, AI applications are commonly used to verify solutions, clarify mathematical concepts, and provide additional explanations when students encounter learning difficulties (Diaz et al., 2025). Nevertheless, the educational value of frequent AI use depends not only on how often students use the technology but also on the purpose and quality of its utilisation during the learning process.

Previous studies suggest that productive AI use is closely associated with self-regulated learning and students' ability to manage their own learning independently. AI can support various stages of self-regulated learning, including planning, monitoring, and self-reflection, by providing immediate feedback and personalised learning assistance (Chiu, 2024). Similarly, students who use AI critically by evaluating AI-generated responses and refining their prompts tend to demonstrate more meaningful learning behaviours than those who rely on AI merely to obtain answers (Javier & Moorhouse, 2024). Although frequent AI use may improve students' engagement and learning efficiency, existing evidence indicates that frequency alone does not necessarily lead to better academic performance. Instead, meaningful learning outcomes depend on students' ability to integrate AI purposefully and critically within their mathematics learning activities (Klarin et al., 2024; Diaz et al., 2025).

Students' Perceptions towards AI in Mathematics Learning

Students' perceptions towards AI play a significant role in influencing their willingness to integrate AI into mathematics learning. Positive perceptions are generally associated with greater acceptance of AI as a learning support tool, particularly when students perceive AI as useful, accessible, and capable of enhancing their learning experiences. Previous studies have reported that students view AI applications positively because they provide immediate feedback, personalised explanations, and flexible learning opportunities that increase confidence and learning motivation (Egara et al., 2025; Chudziak & Kostka, 2025). Similarly, AI-assisted learning has been found to promote independent learning by enabling students to explore mathematical concepts at their own pace while receiving continuous support throughout the learning process (Jančařík et al., 2023; Polydoros et al., 2025).

Nevertheless, students' perceptions of AI are not exclusively positive. Although many students recognise the educational benefits of AI, concerns remain regarding academic integrity, excessive dependence on AI-generated responses, and the potential reduction of critical thinking when AI is used inappropriately (Chen et al., 2026; Turós et al., 2025). Research also indicates that students are more likely to perceive AI positively when they possess adequate AI literacy and understand how to evaluate AI-generated information critically rather than accepting responses without verification (Infante et al., 2025; Grace Lau et al., 2025). Therefore, fostering positive perceptions towards AI should be accompanied by the development of responsible and ethical AI use to ensure that students employ AI as a meaningful learning support tool rather than merely as a source of ready-made answers.

Relationship Between AI Application Skills and Mathematical Understanding

The relationship between AI application skills and students' mathematical understanding has attracted increasing attention as AI becomes more integrated into educational settings. Existing studies suggest that students who possess stronger AI application skills are more capable of utilising AI as a meaningful learning tool rather than merely as a source of information. Such competencies enable students to formulate effective prompts, critically evaluate AI-generated responses, and apply the information to strengthen conceptual understanding and mathematical reasoning (Walter, 2024; Chee et al., 2025). Consequently, AI application skills are increasingly recognised as an important factor influencing students' ability to benefit from AI-assisted learning.

Empirical evidence further supports the positive association between AI competencies and mathematics learning outcomes. Ahmed (2026) reported that students' digital literacy mediates the relationship between AI-based learning tools and academic performance, highlighting that meaningful learning is influenced more by students' competencies than by technology itself. Similarly, Haguchi et al. (2026) found that AI-based learning significantly improved students' mathematical thinking in secondary education, while Wijaya et al. (2026) demonstrated that AI utilisation combined with digital literacy positively contributed to students' higher-order thinking in mathematics. Collectively, these findings suggest that students with stronger AI application skills are more likely to develop deeper mathematical understanding through effective interaction with AI technologies. Nevertheless, empirical evidence examining this relationship among secondary school students remains limited, particularly within the Malaysian educational context. Therefore, further investigation is necessary to provide empirical evidence regarding the relationship between AI application skills and mathematical understanding among secondary school students.

Research Gap

Despite the growing body of literature on AI-assisted learning, several important research gaps remain. Existing studies have primarily focused on AI acceptance, AI literacy, self-regulated learning, and students' perceptions of AI across various educational contexts (Ng et al., 2023; Walter, 2024; Chung et al., 2026). Although these studies have provided valuable insights into the educational potential of AI, relatively few have specifically examined how students' AI application skills are associated with their mathematical understanding in secondary school settings. Furthermore, much of the existing evidence has been conducted in higher education or has investigated AI use across general academic contexts rather than focusing specifically on mathematics learning among secondary school students (Esiyok et al., 2025; Lan & Zhou, 2025; Del Rosario Navas Bonilla et al., 2025).

Another limitation of previous studies is that AI-related constructs have often been examined independently. While prior research has investigated AI literacy, digital literacy, technology acceptance, or mathematics learning outcomes separately, limited empirical evidence has explored the direct relationship between AI application skills and students' mathematical understanding within a single research framework (Ahmed, 2026; Chee et al., 2025; Haguchi et al., 2026; Wijaya et al., 2026). Moreover, empirical evidence involving Malaysian secondary school students remains scarce, despite the increasing adoption of AI applications in teaching and learning. Addressing this gap is important to provide empirical evidence on whether students' competencies in using AI are associated with their level of mathematical understanding. Therefore, this study investigates the relationship between AI application skills and mathematical understanding among secondary school students, contributing to the growing literature on AI-assisted mathematics education while providing evidence that may inform future educational practice and policy.

RESEARCH OBJECTIVES, QUESTIONS & HYPOTHESES

Research Objectives

This study aims to investigate the use of Artificial Intelligence (AI) applications in supporting mathematics learning among secondary school students. Specifically, the study seeks to:

1. Examine the level of students' mathematical understanding towards the use of Artificial Intelligence (AI) applications in solving mathematics exercises.
2. Examine the level of students' Artificial Intelligence (AI) application skills in supporting mathematics learning.
3. Examine the frequency of Artificial Intelligence (AI) application use in mathematics learning among secondary school students.
4. Examine the relationship between Artificial Intelligence (AI) application skills and students' mathematical understanding.

Research Questions

Based on the research objectives, this study addresses the following research questions:

1. What is the level of students' mathematical understanding towards the use of Artificial Intelligence (AI) applications in solving mathematics exercises?
2. What is the level of Artificial Intelligence (AI) application skills among secondary school students in supporting mathematics learning?
3. What is the frequency of Artificial Intelligence (AI) application use in mathematics learning among secondary school students?
4. What is the relationship between Artificial Intelligence (AI) application skills and students' mathematical understanding?

Research Hypotheses

To address the fourth research objective, the following hypotheses were formulated:

H_0: There is no significant relationship between Artificial Intelligence (AI) application skills and students' mathematical understanding among secondary school students.

H_a: There is a significant relationship between Artificial Intelligence (AI) application skills and students' mathematical understanding among secondary school students.

METHODOLOGY

Research Design and Sample Selection

This study employed a quantitative research approach using a cross-sectional survey design to investigate the relationship between Artificial Intelligence (AI) application skills and mathematical understanding among secondary school students. A quantitative approach was considered appropriate because it enables the systematic collection and statistical analysis of numerical data to examine patterns, describe variables, and determine relationships between constructs (Creswell, 2009). The cross-sectional survey design allows data to be collected from respondents at a single point in time, providing an efficient approach for examining students' mathematical understanding, AI application skills, and frequency of AI application use in mathematics learning.

The respondents consisted of 59 Form 4 and Form 5 secondary school students from selected secondary schools in Selangor, Malaysia**.** Purposive sampling was first employed to identify students who had prior experience using AI applications in mathematics learning, as this criterion was essential to address the research objectives. Subsequently, convenience sampling was used to recruit accessible participants who met the inclusion criterion and voluntarily agreed to participate in the study. A total of 59 completed questionnaires were returned and included in the final analysis. Although the sample was relatively small, all respondents fulfilled the predefined inclusion criterion of having prior experience using AI applications in mathematics learning, ensuring that the data collected were directly relevant to the objectives of the study.

The combination of purposive and convenience sampling techniques was considered appropriate because the study specifically targeted students with prior experience using AI applications rather than representing the entire population of secondary school students.

Research Instrument

Data were collected using a structured online questionnaire comprising four constructs: students' mathematical understanding, AI application skills, frequency of AI application use, and students' perceptions towards AI in mathematics learning. The questionnaire was adapted from validated instruments reported in previous studies to ensure the content was aligned with the theoretical constructs investigated. Specifically, the AI literacy items were adapted from Ng et al. (2023), whereas items related to AI use in mathematics learning and technology acceptance were adapted from Walter (2024), Xue et al. (2026), and Egara et al. (2025).

The questionnaire consisted of five sections. Section A gathered respondents' demographic information, while Sections B, C, D, and E measured students' mathematical understanding, AI application skills, frequency of AI application use, and students' perceptions towards AI in mathematics learning, respectively. Each construct comprised six items, resulting in a total of 24 items. All items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Pilot Study and Data Analysis

Prior to the main data collection, the questionnaire underwent a pilot study to evaluate its reliability and suitability for measuring the intended constructs. The internal consistency of the research instrument was assessed using Cronbach's alpha coefficient. The findings indicated that the reliability coefficients ranged from 0.778 to 0.823 across the four constructs, demonstrating acceptable to good internal consistency. The overall instrument achieved an excellent Cronbach's alpha coefficient of 0.927, indicating that the questionnaire possessed a high level of reliability and was appropriate for data collection. Following data collection, the responses were analysed using the Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were employed to describe respondents' demographic characteristics and determine the levels of students' mathematical understanding, AI application skills, frequency of AI application use, and students' perceptions towards AI in mathematics learning. Pearson's Product-Moment Correlation analysis was subsequently performed to examine the relationship between AI application skills and students' mathematical understanding. The interpretation of mean scores was based on the classification presented in Table 1.

Table 1. Interpretation of Mean Scores

Mean Score	Interpretation
1.00–2.33	Low

2.34–3.66	Moderate
3.67–5.00	High

Source: Developed by the researchers based on a five-point Likert scale.

Table 2. Internal Consistency Reliability of the Research Instrument

Construct	Items	Cronbach Alpha
Mathematical Understanding	6	0.81
AI Skills	6	0.80
Frequency	6	0.82
Perception	6	0.78
Overall Instrument	**24**	**0.93**

FINDINGS

Analysis of Respondents' Demographic Profile

A total of 59 secondary school students participated in this study. Table 3 presents the demographic characteristics of the respondents, including gender, grade level, previous experience using AI applications for mathematics learning, and the primary purpose of AI use. Overall, most respondents were female (72.9%) and were Form 5 students (79.7%). Nearly all respondents (98.3%) reported having prior experience using AI applications to support mathematics learning, indicating that AI-assisted learning has become widely adopted among the participating students.

Table 3. Demographic Distribution Profile of Respondents (*N*=59)

Demographic Category	Frequency (*f*)	Percentage (%)
Gender		
Male	16	27.1
Female	43	72.9
Grade Level		
Form 4	12	20.3
Form 5	47	79.7
Have used AI applications for Mathematics learning		
Yes	58	98.3
No	1	1.7

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Note. Collected demographic data for the entire sample size (*N*=59).

Regarding AI applications used, ChatGPT was the most frequently reported application, either as a standalone tool or in combination with other AI applications such as Gemini, Photomath, and Google Lens. Students primarily used these applications to support mathematics learning activities, including solving exercises, checking answers, and obtaining explanations for mathematical concepts. These findings suggest that generative AI tools have become common supplementary learning resources among secondary school students.

Analysis of the Level of Students' Mathematical Understanding

The level of students' mathematical understanding towards the use of Artificial Intelligence (AI) applications in solving mathematics exercises was examined using descriptive statistics. Table 4 presents the mean and standard deviation for each questionnaire item. Overall, students demonstrated positive mathematical understanding, with an overall mean score of 3.55 (SD = 0.539). This finding indicates that AI applications generally supported students in understanding mathematical concepts and solution procedures during mathematics learning.

Among the six items, the highest mean score was recorded for the statement, *"AI applications help me identify mistakes in mathematical solutions"* (M = 4.02, SD = 0.919). This suggests that students primarily utilised AI as a tool to verify and evaluate the accuracy of their mathematical solutions.

The second highest mean was obtained for the item related to understanding different solution methods through AI (M = 3.92, SD = 0.857), indicating that AI applications also facilitated students' exploration of alternative approaches to solving mathematical problems. In contrast, the negatively worded item, *"I still find it difficult to understand mathematical solutions even when using AI applications,"* recorded the lowest mean score (M = 2.44, SD = 1.193), suggesting that most respondents disagreed with this statement.

Overall, the descriptive findings indicate that students generally perceived AI applications as supportive learning tools that enhanced their mathematical understanding. The relatively higher mean scores for items related to identifying errors and exploring alternative solution methods further suggest that AI was commonly used to strengthen conceptual understanding rather than merely providing final answers.

Table 4. Descriptive Statistics of Students' Mathematical Understanding *(N*=59)

No.	Item	Mean	SD
1	AI applications help me understand mathematical solution steps more clearly.	3.78	0.872
2	I have a better understanding of mathematical concepts after using AI applications.	3.53	0.953
3	The explanations provided by AI applications are easy for me to understand.	3.59	0.812
4	AI applications help me identify mistakes in mathematical solutions.	4.02	0.919
5	AI applications help me understand different methods of solving mathematical problems.	3.92	0.857
6	I still find it difficult to understand mathematical solutions even when using AI applications. *(Reverse-coded item)*	2.44	1.193
	Overall Mean	**3.55**	**0.539**

Note. The mean score is measured based on a 5-point Likert scale.

Analysis of the Level of AI Application Skills

The level of students' AI application skills in supporting mathematics learning was examined using descriptive statistics. Table 5 presents the mean and standard deviation for each questionnaire item. Overall, students demonstrated positive AI application skills, with an overall mean score of 3.65 (SD = 0.565). This finding suggests that the respondents generally possessed adequate knowledge and skills to utilise AI applications effectively as learning support tools in mathematics.

Among the six items, the highest mean score was recorded for the statement, *"I know how to use AI as a learning tool rather than simply to obtain answers"* (M = 4.42, SD = 0.622). This indicates that most students recognised the educational role of AI beyond merely generating answers. The second highest mean score was obtained for the item, *"I know how to use AI applications to help solve mathematics exercises"* (M = 4.02, SD = 0.974), suggesting that respondents were generally confident in using AI applications to support mathematics learning. In contrast, the negatively worded item, *"I often encounter difficulties when using AI applications in mathematics learning,"* recorded the lowest mean score (M = 2.41, SD = 1.233), indicating that the majority of respondents did not perceive the use of AI applications as particularly difficult.

Overall, the descriptive findings indicate that students generally possessed the necessary AI application skills to support their mathematics learning. The relatively higher mean scores for items related to the educational use of AI and problem-solving further suggest that respondents were capable of utilising AI applications purposefully as learning support tools rather than relying on them solely for obtaining answers.

Table 5. Descriptive Statistics of AI Application Skills (*N*=59)

No.	Item	Mean	SD
1	I know how to use AI applications to help solve mathematics exercises.	4.02	0.974
2	I can provide appropriate prompts when using AI applications.	3.78	1.035
3	I can use various AI applications for mathematics learning.	3.66	1.092
4	I am able to evaluate the accuracy of answers generated by AI applications.	3.63	0.981
5	I know how to use AI as a learning tool rather than simply to obtain answers.	4.42	0.622
6	I often encounter difficulties when using AI applications in mathematics learning. *(Reverse-coded item)*	2.41	1.233
	Overall Mean	**3.65**	**0.565**

Note. The mean score is measured based on a 5-point Likert scale.

Analysis of the Frequency of AI Application Use in Mathematics Learning

The frequency of AI application use in mathematics learning was examined using descriptive statistics. Table 6 presents the mean and standard deviation for each questionnaire item. Overall, students frequently used AI applications in mathematics learning with an overall mean score of 3.56 (SD = 0.596). This finding indicates that AI applications were frequently utilised to support various mathematics learning activities among the respondents.

Among the six items, the highest mean score was recorded for the statement, *"I use AI applications to check my mathematics answers"* (M = 4.03, SD = 0.928), indicating that students primarily used AI as a verification tool

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after completing mathematics exercises. This was followed by the item, *"I use AI applications when I do not understand a mathematics topic"* (M = 3.92, SD = 0.915), suggesting that students also relied on AI to obtain additional explanations when encountering learning difficulties. In contrast, the item, *"I use AI applications while doing mathematics exercises,"* recorded the lowest mean score among the positively worded items (M = 3.34, SD = 1.154). The negatively worded item, *"I rarely use AI applications in mathematics learning,"* recorded a mean score of 2.68 (SD = 1.238), indicating that most respondents disagreed with the statement.

Overall, the descriptive findings suggest that AI applications were commonly incorporated into students' mathematics learning activities. The relatively higher mean scores for checking answers and clarifying mathematical concepts indicate that students tended to use AI as a supplementary learning resource to support understanding and self-evaluation throughout the learning process.

Table 6. Descriptive Statistics of the Frequency of AI Application Use in Mathematics Learning (*N*=59)

No.	Item	Mean	SD
1	I use AI applications while doing mathematics exercises.	3.34	1.154
2	I use AI applications to check my mathematics answers.	4.03	0.928
3	I use AI applications when I do not understand a mathematics topic.	3.92	0.915
4	I use AI applications as an additional learning resource besides teachers and textbooks.	3.73	1.096
5	I use AI applications during mathematics revision at home.	3.66	1.077
6	I rarely use AI applications in mathematics learning. *(Reverse-coded item)*	2.68	1.238
	Overall Mean	**3.56**	**0.596**

Note. The mean score is measured based on a 5-point Likert scale.

Analysis of Students' Perceptions towards AI in Mathematics Learning

Students' perceptions towards the use of Artificial Intelligence (AI) applications in mathematics learning were examined using descriptive statistics. Table 7 presents the mean and standard deviation for each questionnaire item. Overall, students demonstrated positive perceptions towards the use of AI applications in mathematics learning, with an overall mean score of 3.46 (SD = 0.553). This finding indicates that respondents generally viewed AI applications as beneficial tools that could support their mathematics learning experiences.

Among the six items, the highest mean score was recorded for the statement, *"I am willing to use AI applications ethically in mathematics learning"* (M = 3.95, SD = 0.936), suggesting that students recognised the importance of responsible AI use in educational settings. This was closely followed by the statement, *"AI applications are useful supporting tools in mathematics learning"* (M = 3.93, SD = 0.828), indicating that respondents generally acknowledged the educational value of AI applications. In contrast, the negatively worded item, *"The use of AI applications does not provide many benefits in helping me solve mathematics exercises,"* recorded the lowest mean score (M = 2.20, SD = 1.079), suggesting that most students disagreed with this statement.

Overall, the descriptive findings indicate that students generally held favourable perceptions towards the integration of AI applications into mathematics learning. The relatively higher agreement with items related to ethical AI use and the usefulness of AI applications suggests that respondents perceived AI as a supportive learning resource that complements, rather than replaces, the mathematics learning process.

Table 7. Descriptive Statistics of Students' Perceptions towards AI in Mathematics Learning (*N*=59)

No.	Item	Mean	SD
1	The use of AI applications makes mathematics learning more interesting.	3.36	0.866
2	AI applications help me learn mathematics independently.	3.73	1.014
3	The use of AI applications increases my confidence in solving mathematics exercises.	3.59	1.019
4	AI applications are useful supporting tools in mathematics learning.	3.93	0.828
5	The use of AI applications does not provide many benefits in helping me solve mathematics exercises. *(Reverse-coded item)*	2.20	1.079
6	I am willing to use AI applications ethically in mathematics learning.	3.95	0.936
	Overall Mean	**3.46**	**0.553**

Note. The mean score is measured based on a 5-point Likert scale.

Analysis of the Relationship between AI Application Skills and Students' Mathematical Understanding

The relationship between AI application skills and students' mathematical understanding was examined using Pearson's Product-Moment Correlation analysis. Pearson correlation was employed to determine the strength and significance of the relationship between the two variables. The results of the analysis are presented in Table 8.

Table 8. Relationship between AI Application Skills and Students' Mathematical Understanding (*N*=59)

Variables	Pearson Correlation *(r)*	*p*-value	Interpretation
AI Application Skills and Students' Mathematical Understanding	0.510	< 0.001	Moderate positive relationship

Note. Correlation is significant at the 0.001 level (2-tailed).

The findings revealed a moderate positive and statistically significant relationship between AI application skills and students' mathematical understanding ($r = 0.510$, $p < 0.001$). Based on Cohen's (1988) guidelines, a correlation coefficient of 0.510 indicates a moderate positive relationship, suggesting that students with higher AI application skills tended to report higher levels of mathematical understanding. Since the significance value was less than 0.001, the null hypothesis (H_0) was rejected. Therefore, the findings indicate that there is a significant relationship between AI application skills and students' mathematical understanding among secondary school students.

Since the p-value was less than 0.001, the null hypothesis (H_0) was rejected. Therefore, the findings indicate a significant relationship between AI application skills and students' mathematical understanding among secondary school students.

The coefficient of determination further indicated that AI application skills accounted for approximately 26.0% of the variation observed in students' mathematical understanding ($R^2 = 0.260$). This suggests that while AI application skills were significantly associated with students' mathematical understanding, approximately 74.0% of the variation may be attributed to other factors beyond the scope of the present study.

Overall, the findings presented in this section successfully addressed all four research objectives by providing empirical evidence on students' mathematical understanding, AI application skills, frequency of AI application use, and the relationship between AI application skills and mathematical understanding. The discussion of these findings in relation to previous studies and theoretical perspectives is presented in the following section.

DISCUSSION

The present study examined secondary school students' mathematical understanding, AI application skills, frequency of AI application use, and the relationship between AI application skills and mathematical understanding. Overall, the findings indicate that students demonstrated positive mathematical understanding, adequate AI application skills, frequent AI use and positive perceptions towards AI-supported mathematics learning. These findings suggest that AI applications have become increasingly integrated into students' learning practices and are commonly utilised as supplementary learning tools to facilitate mathematics learning. More importantly, the significant relationship identified between AI application skills and mathematical understanding indicates that students' ability to use AI effectively is associated with their level of conceptual understanding in mathematics.

Discussion of Students' Mathematical Understanding

The findings revealed that students demonstrated positive mathematical understanding when using AI applications in mathematics learning. Specifically, students reported that AI applications helped them understand solution procedures more clearly, identify errors in mathematical solutions, and explore different problem-solving approaches. These findings suggest that AI applications were perceived as valuable learning support tools that facilitated students' understanding of mathematical concepts rather than merely providing final answers.

The present findings are consistent with Torres-Peña et al. (2024), who reported that AI-assisted learning environments enhanced students' conceptual understanding by providing systematic explanations and immediate feedback during problem-solving activities. Similarly, Canonigo (2024) found that AI-supported learning environments improved students' conceptual understanding and confidence through personalised explanations tailored to learners' individual needs. Comparable findings were also reported by Pardos and Bhandari (2024), who demonstrated that AI-generated instructional support produced mathematics learning gains comparable to those achieved through assistance provided by human tutors. Collectively, these studies suggest that AI has considerable potential to support conceptual learning when integrated appropriately into mathematics instruction.

Although students generally demonstrated positive levels of mathematical understanding, the relatively lower mean score for the item related to conceptual understanding after using AI indicates that some students may still require additional instructional support to fully comprehend mathematical concepts. This finding suggests that AI should be viewed as a complementary instructional resource rather than a substitute for teacher guidance. Effective mathematics learning continues to depend on students' active cognitive engagement in interpreting explanations, evaluating alternative solution strategies, and applying mathematical reasoning to different problem contexts.

Discussion of AI Application Skills

Among all the constructs examined in this study, AI application skills recorded the highest overall mean score, indicating that students generally possessed adequate competencies to utilise AI applications for mathematics learning. The findings showed that students were confident in using AI applications to solve mathematical problems, formulate appropriate prompts, evaluate AI-generated responses, and utilise AI as a learning support

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tool rather than merely obtaining answers. These findings suggest that students have begun to develop practical competencies that enable them to engage meaningfully with AI technologies during mathematics learning.

The findings support the growing emphasis on AI literacy as an essential competency for learners in the digital era. Salhab and Aboushi (2025) argued that AI literacy extends beyond technical knowledge and encompasses learners' ability to evaluate, interpret, and apply AI-generated information responsibly in educational contexts. Similarly, Walter (2024) highlighted that AI literacy, prompt engineering, and critical thinking have become increasingly important competencies for students as generative AI technologies continue to reshape educational practices. Knoth et al. (2024) further emphasised that effective prompt engineering enables learners to obtain more accurate, relevant, and contextually appropriate AI-generated responses, thereby enhancing the overall quality of learning. These perspectives support the present findings that students' competence in operating AI applications plays an important role in facilitating meaningful learning experiences.

Nevertheless, possessing AI application skills should not be interpreted solely as technical proficiency. The relatively high level of AI application skills observed in this study suggests that students were generally capable of using AI to support mathematics learning; however, effective educational use also requires critical judgement, ethical awareness, and the ability to evaluate the reliability of AI-generated information. Therefore, strengthening AI literacy should focus not only on improving students' technical competencies but also on cultivating responsible and reflective AI use to maximise its educational benefits while minimising potential misuse. These findings imply that AI competency should be viewed as an educational competency rather than merely a technological competency.

Discussion of the Frequency of AI Application Use in Mathematics Learning

The findings indicated that students frequently used AI applications in mathematics learning. The descriptive analysis further revealed that students most frequently used AI applications to verify their mathematics answers and to obtain explanations when they encountered difficulties in understanding mathematical concepts. In contrast, the use of AI applications during the initial stages of solving mathematics exercises was comparatively lower. This pattern suggests that students primarily utilised AI as a supplementary learning resource to support understanding and self-evaluation rather than relying on AI throughout the entire problem-solving process.

This finding is consistent with Chiu (2024), who proposed that generative AI can effectively support self-regulated learning by assisting students in monitoring, evaluating, and reflecting on their own learning processes. Similarly, Chung et al. (2026) found that students generally perceived generative AI as a complementary learning companion that enhanced learning efficiency without replacing their own learning efforts. Comparable findings were also reported by Egara et al. (2025), who observed that secondary school students commonly used AI applications to obtain additional explanations, verify solutions, and strengthen conceptual understanding in mathematics learning. Collectively, these studies support the present findings that AI applications are increasingly being incorporated into students' everyday learning practices as supportive educational tools.

Although students reported frequent use of AI applications, the findings do not indicate excessive dependence on AI. Instead, the relatively higher use of AI for answer verification and conceptual clarification suggests that students remained actively engaged in their own learning while using AI to support reflection and reinforce understanding. This observation highlights the importance of encouraging balanced AI integration in mathematics education, where technology complements rather than replaces students' independent problem-solving and critical thinking processes.

Discussion of the Relationship between AI Application Skills and Students' Mathematical Understanding

The most significant finding of this study was the identification of a statistically significant moderate positive relationship between AI application skills and students' mathematical understanding. The Pearson correlation analysis demonstrated that students with higher AI application skills tended to report higher levels of mathematical understanding. This finding suggests that students' ability to operate AI applications effectively may contribute to more meaningful engagement with mathematics learning by enabling them to obtain relevant explanations, evaluate AI-generated responses, and apply the information appropriately during problem-solving activities.

The present findings are consistent with Ahmed (2026), who reported that digital literacy played an important mediating role in the relationship between AI-assisted learning tools and students' academic performance. Similarly, Chee et al. (2025) argued that AI competency enables learners to critically evaluate AI-generated information and apply it productively within educational contexts. Ng et al. (2023) further emphasised that AI literacy should be systematically developed from secondary education to prepare students for responsible and effective AI use. Together, these studies reinforce the present findings by suggesting that the educational benefits of AI are closely associated with learners' competencies in using AI rather than the technology itself.

The findings also imply that AI application skills extend beyond operational knowledge. Students who possess stronger AI competencies are more likely to formulate appropriate prompts, interpret AI-generated explanations critically, and utilise AI to strengthen conceptual understanding instead of merely obtaining solutions. Consequently, the educational effectiveness of AI depends not only on students' access to AI technologies but also on their ability to engage with these technologies critically, ethically, and purposefully. Nevertheless, the relationship identified in this study should not be interpreted as evidence of causality because the cross-sectional correlational design only establishes statistical associations between variables. Further longitudinal and experimental studies are therefore required to determine whether improvements in AI application skills directly contribute to enhanced mathematical understanding over time.

Overall, the findings of this study demonstrate that AI applications have become valuable learning support tools in secondary school mathematics education. Students generally possessed adequate AI application skills, reported positive learning experiences, and frequently used AI applications to support conceptual understanding and solution verification. More importantly, the significant relationship between AI application skills and mathematical understanding suggests that the educational benefits of AI depend largely on students' competencies in using AI effectively rather than on the availability of the technology itself. These findings reinforce the importance of promoting AI literacy as an essential educational competency that enables students to engage with AI critically, responsibly, and meaningfully in mathematics learning.

Although a significant positive relationship was identified between AI application skills and students' mathematical understanding, the findings should be interpreted within the context of the study design. As this study employed a cross-sectional correlational approach, the results demonstrate statistical associations rather than causal relationships. Therefore, while students with higher AI application skills tended to report better mathematical understanding, further longitudinal and experimental studies are required to determine whether improvements in AI application skills directly contribute to enhanced mathematics learning outcomes.

IMPLICATIONS

The findings of this study provide several important implications for mathematics education, particularly regarding the integration of Artificial Intelligence (AI) applications into secondary school learning. From a theoretical perspective, this study contributes to the growing body of literature on AI-supported learning by providing empirical evidence that AI application skills are significantly associated with students' mathematical understanding. The findings support the fundamental assumptions of the Technology Acceptance Model (TAM), which emphasises that learners are more likely to benefit from technology when they possess the necessary competencies to utilise it effectively (Li, 2023; Xue et al., 2026). In addition, the findings are consistent with the principles of Self-Regulated Learning (SRL), suggesting that students use AI applications not only to obtain information but also to monitor, evaluate, and reinforce their own learning processes (Chiu, 2024; Ali et al., 2023). Collectively, these findings contribute to the understanding of how AI application skills can support meaningful mathematics learning in secondary education.

From a practical perspective, the findings suggest that mathematics teachers should encourage students to use AI applications as complementary learning tools rather than as substitutes for independent thinking. The relatively high levels of AI application skills and mathematical understanding observed in this study indicate that AI can effectively support conceptual learning when students possess adequate competencies to evaluate and apply AI-generated information. Therefore, classroom practices should focus on developing students' abilities to formulate effective prompts, critically evaluate AI-generated responses, and apply mathematical reasoning when using AI applications. Such practices may encourage students to use AI responsibly while strengthening conceptual understanding and problem-solving skills (Walter, 2024; Knoth et al., 2024).

The findings also have implications for schools and educational policymakers. As AI applications become increasingly integrated into teaching and learning, schools should consider incorporating AI literacy into the secondary school curriculum through structured learning activities that emphasise ethical AI use, critical evaluation of AI-generated information, and responsible digital practices. Such initiatives would help ensure that students are equipped with the competencies required to utilise AI effectively while minimising the risks associated with inappropriate or uncritical use of AI technologies (Ng et al., 2023; Salhab & Aboushi, 2025).

LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. First, the study involved a relatively small sample of 59 secondary school students from selected schools in Selangor using purposive and convenience sampling techniques. Consequently, the findings should be interpreted with caution and may not be generalised to the broader population of Malaysian secondary school students. Second, the study employed a cross-sectional correlational design, which identifies statistical associations between AI application skills and mathematical understanding but does not establish causal relationships between the variables. Third, the findings were derived from self-reported questionnaire responses, which may not fully reflect students' actual AI application practices or their objective mathematical abilities. Nevertheless, these findings provide valuable preliminary evidence regarding the relationship between AI application skills and mathematical understanding, offering useful insights for future research and educational practice in mathematics education.

RECOMMENDATIONS

Future research is encouraged to involve larger and more diverse samples from different Malaysian states to improve the generalisability of the findings. In addition to questionnaire-based measures, future studies should incorporate objective assessments of mathematical understanding, such as mathematics achievement tests, classroom-based assessments, or problem-solving tasks, to provide a more comprehensive evaluation of students' learning outcomes. Furthermore, longitudinal and experimental research designs are recommended to examine whether AI application skills and structured AI literacy interventions contribute to sustained improvements in students' mathematical understanding over time. Future research may also investigate additional variables, including AI literacy, self-regulated learning, learning motivation, digital competency, and teacher support, to develop a broader understanding of the factors influencing the effective integration of AI in mathematics education.

CONCLUSION

This study successfully achieved all the research objectives by examining students' mathematical understanding, AI application skills, frequency of AI application use, and the relationship between AI application skills and mathematical understanding among secondary school students. Overall, the findings demonstrated that students demonstrated positive mathematical understanding, AI application skills, and frequency of AI use, accompanied by positive perceptions towards AI-supported mathematics learning. More importantly, a statistically significant moderate positive relationship was identified between AI application skills and students' mathematical understanding, suggesting that students who were more competent in using AI applications tended to demonstrate better mathematical understanding.

The findings contribute to the growing body of knowledge on Artificial Intelligence in mathematics education by highlighting that the educational value of AI extends beyond the availability of intelligent technologies. Rather, meaningful learning depends on students' ability to utilise AI critically, ethically, and purposefully to support conceptual understanding and mathematical problem-solving. Unlike many previous studies that primarily focused on students' acceptance or general use of AI, this study provides empirical evidence that AI application skills constitute an important educational competency associated with mathematical understanding among Malaysian secondary school students**.** This perspective broadens current discussions on AI integration in education by emphasising students' competencies in using AI effectively rather than technology adoption alone.

From the Malaysian educational perspective, the findings offer timely evidence to support ongoing initiatives in strengthening digital education and the responsible integration of Artificial Intelligence in schools. The study suggests that AI literacy should become an integral component of mathematics education through the development of students' abilities to formulate effective prompts, critically evaluate AI-generated information, and apply AI ethically during learning activities. Such competencies are increasingly important in preparing students for an education system that is progressively shaped by digital technologies and AI-driven learning environments.

In conclusion, Artificial Intelligence should not be regarded merely as a tool for generating answers but as a meaningful learning partner that complements students' mathematical reasoning, independent learning, and critical thinking. By strengthening AI application skills and promoting responsible AI literacy, Malaysian schools will be better positioned to prepare future learners who are capable of using emerging technologies effectively while maintaining sound mathematical reasoning and academic integrity.

Overall, this study provides empirical evidence that AI application skills represent an important educational competency associated with students' mathematical understanding in secondary mathematics education. While the findings should be interpreted within the limitations of the research design, they contribute to the growing body of knowledge on AI-supported learning and offer practical implications for mathematics educators and policymakers. As Artificial Intelligence continues to transform educational practices, strengthening students' ability to use AI critically, ethically, and purposefully will be essential in preparing digitally competent learners who are capable of engaging meaningfully with emerging technologies while maintaining independent mathematical reasoning.

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