Exploring The Role of Artificial Intelligence (AI) Chatbot Technologies on Secondary School Students' Mathematics Engagement

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ABSTRACT

Artificial Intelligence (AI) chatbot technologies have become increasingly relevant to secondary school mathematics learning. This study examines the role of AI chatbot technologies in students' mathematics engagement in Kuala Lumpur. Guided by Constructivist Learning Theory and Sociocultural Theory, the study examines chatbot use, chatbot features and quality of interaction, and students' behavioral, cognitive, and affective engagement, including perceived improvement in mathematics learning.

The study employed a quantitative, cross-sectional survey of 80 secondary school students who used AI chatbots, including ChatGPT, MathGPT, MathAI, and Gauth. Data were collected using an online questionnaire covering demographic characteristics, AI chatbot use, chatbot features and quality of interaction, student engagement, and perceived mathematics learning improvement. The findings indicate that students frequently use AI chatbots for mathematics learning, particularly for revision and examination preparation. Students generally perceived the chatbots as precise, responsive, easy to use, and helpful in simplifying difficult mathematical concepts. Positive perceptions were also reported for motivation, willingness to attempt challenging mathematics questions, and engagement with mathematics learning.

The reliability analysis showed acceptable to good internal consistency across the study constructs, with Cronbach's alpha values ranging from 0.782 to 0.839. Overall, the findings suggest positive associations between AI chatbot use, perceived chatbot quality, and students' engagement and perceived improvement in mathematics learning. Because the study relied on self-reported, cross-sectional data, the findings should be interpreted as students' perceptions and associations rather than evidence of objectively measured or causal improvements in mathematics achievement. The implications for mathematics educators and future research are discussed.

Keywords: AI, chatbot, mathematics, secondary student

INTRODUCTION

Currently Artificial Intelligence (AI) is one of the most prominent innovations that have transformed education into the digital transformation era. Rahman et al. (2023) found that companies, homes and many workplaces almost use information and communication technologies (ICT) including teachers, students and academicians. They are exploring how AI can be useful in making teaching and learning more effective. Students at secondary schools increasingly appreciate the opportunities of AI in the context of increasing the levels of engagement, motivations to study mathematics and their performance (Awang et al., 2025). Many students perceive mathematics to be challenging and difficult. Therefore, it may result in disinterest, anxiety and poor performance by the students. The traditional teaching methods, where teachers rely heavily on tend to ignore the differences surrounding individual learning methods and cannot maintain the motivation of students to

acquire mathematical knowledge. Consequently, the application of AI, especially of chatbot learning technologies, to the field of mathematics teaching can become one of the potentials developing a more personalized, interactive, and engaging learning experience (Maulida et al., 2024).

It is essential because the research addresses the existing issue of student lack of interest in mathematics that has become instrumental in the creation of logical thinking and problem-solving skills. According to Acheampong et al. (2025), the use of AI-based tools can assist students in becoming more interested and, at the same time, more engaged in the learning process. Similarly, Awang et al. (2025) also discovered that AI in mathematics learning plays an important role in students' personal needs and learning styles. AI tools enhance the level of cognitive attainment, foster positive attitudes toward mathematics, and make it easier and more student orientated. Students would be more ready to involve the chatbots which give feedback and suggestions immediately, so the student can be more open to trying to solve the challenging problems as well as feel less afraid about mistakes (Oliweh & Ugo, 2025).

This research topic was selected because mathematical understanding and motivation have remained an issue for several students in secondary schools. The inability of some students to engage during the lessons or the fear faced by students anytime mathematics is mentioned has ignited the need to seek out new methods of teaching mathematics that would revolutionize their minds to embrace the subject. Personalization and human-like interactions appear to be a promising way of boosting engagement and learning outcomes through AI chatbots, which combine both the human-like interaction and the use of data to develop more meaningful interaction. It has been mentioned in the previous research that students who are introduced to AI-assisted learning are better problem-solvers with increased confidence and interest in mathematics (Nguyen Van Doc et al., 2023; Chau et al., 2025). This research is considered more deeply how to apply such technology to the context of secondary schools and promote more severe engagement and inclusiveness in the learning process of mathematics.

Recent developments of AI, especially chatbot technologies like ChatGPT, have shown the ability to provide students with personalized, adaptive, and responsive feedback. Regional systematization reviews and education studies indicate the existing problem of mathematics disengagement as well as the lack of research distribution both on the educational levels and geographic locations (Egara et al., 2025; Oliweh & Ugo, 2024).

Previous studies found that AI tools can improve students' learning experiences in higher education (Amdan et al., 2024). Most of the available studies are about foreign or tertiary settings, rather than the secondary level in Malaysia. Moreover, although the findings in the world show that AI chatbots may have pedagogically beneficial effects, little is available concerning the impact of chatbots on engagement, and motivation in real-life classroom settings in Malaysia (Maulida et al., 2024; Oliweh & Ugo, 2024). The lack of studies in implementing AI chatbot technologies in secondary mathematics classrooms and the empirical evaluation of these technologies.

The study demonstrates that the pedagogical use of AI chatbots can make learning interesting. Research indicates that chatbots can give feedback immediately and satisfy the needs that the students may need to learn, which motivates the students to be self-reliant and enhance personal learning (Egara et al., 2025; Chau et al., 2025; Oliweh and Ugo, 2024). Most of the studies have, however, been conducted outside Malaysian or tertiary environments. Therefore, the research is a source of novel knowledge because it becomes narrowed to a more specific field of secondary school mathematics in Kuala Lumpur, revealing the opportunities for AI chatbots to be successfully implemented into local classrooms.

There is also a theoretical implication in the study, which relies on the Constructivist Learning Theory (1972) proposed by Piaget and the Sociocultural Theory (1978) of Vygotsky. These frameworks describe how the student's mathematical knowledge can be scaffolded by AI chatbots by means of interactive dialogue, guided discovery and social interaction. The theoretical combination is how artificial intelligence chatbots internalize the principles of constructivism and make the abstract mathematical learning more concrete and interactive (Oliweh & Ugo, 2024; Egara et al., 2025).

It is devoted to the role of AI and chatbot technologies in increasing mathematics engagement and learning in Kuala Lumpur secondary school students. This study objective is to examine how AI chatbot technologies influence Kuala Lumpur secondary students' engagement in learning mathematics. Based on the identified gaps and challenges, this study is guided by the following research questions; How does the use of AI chatbot technologies make mathematics students engaged in Kuala Lumpur?

LITERATURE REVIEW

Artificial intelligence tools in mathematics can be grouped into solver centered systems and teacher centered systems (Awang et al., 2025). This review focuses on dialogic tutors, and it considers solver output only when it is embedded within guided conversation. In this study, chatbots are conversational agents that conduct real time dialogue and provide stepwise hints and prompts in response to learner input (Maulida et al., 2024). Prior work explains how tutoring moves are sequenced in mathematics and why these moves support problem solving and conceptual understanding (Luzano, 2024).

Engagement is considered behavioral, cognitive, and effective involved in the learning (Acheampong et al., 2025). Behavioral engagement encompasses persistence, help seeking, task completion, and time on task whereas cognitive engagement encompasses strategy use and self-explanations (Awang et al., 2025). Effective engagement is interesting and reduces anxiety on encountering challenging tasks. There are studies that combine self-report and observation and platform logs, but overreliance on self-report may undermine the mechanism of identification (Acheampong et al., 2025).

Chatbots are associated with willingness to work on non-routine activities, as well as faster help seeking in the school context (Egara et al., 2025). One of the most frequent explanations is that it occurs at an opportunity time when the feedback is timely and precise in the context of low threat conversation normalizing error and promoting effective risk taking (Oliweh and Ugo, 2025). The perceived usefulness and autonomy support may mediate the gains of engagement, whereas the results can be influenced by the previous achievement and language skill and device access (Awang et al., 2025). Initial successes may be blown out by small-scale tests and teacher motivation. Thus, classroom staging must be able to maintain progress after the novelty effect (Awang et al., 2025).

The analyzed literature demonstrates that a chatbot can promote student engagement and short-term problem-solving in mathematics even in case it is clear and timely, and it can prompt students to think and not to memories the answer. Adaptive task sequencing is also helpful in learning since it makes sure that the activities are not out of the current level of the students. Overall, this evidence shows that the improvements of behavioral, cognitive, and affective engagement are commonly related to the use of chatbots.

Most of the existing studies focus on short-term interventions that require an assessment of immediate accuracy, which means that long-term learning, the capacity to memories the concepts and transfer mathematical knowledge have not been studied adequately. Practical elements of the classroom, such as teacher workload, orchestration strategies, and equal access to digital tools have not been appropriately covered. In addition, most of the existing studies have been done either at the tertiary or international level, which limits their applicability to the Malaysian secondary mathematics classrooms, which undergo bilingual instruction, set lesson periods and inconsistent technological environments.

METHODOLOGY

The research adopted a quantitative, cross-sectional survey design to examine students' experiences with AI chatbot technologies in mathematics learning. The quantitative approach enabled the systematic measurement of students' AI chatbot use, perceptions of chatbot features and quality of interaction, and behavioral, cognitive, and affective engagement. The study also measured students' perceived improvement in mathematics learning rather than objectively measured mathematics achievement.

The questionnaire was developed based on the relevant literature and the conceptual framework. It comprised five subsections: demographic data; technology and learning profile; use of AI chatbot technologies; chatbot features and quality of interaction; and student engagement and perceived mathematical learning improvement. Items were measured using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A preliminary pre-test involving 10 students was conducted to assess the clarity and comprehensibility of the questionnaire items, and minor revisions were made based on the feedback received.

Research Design

The research was carried out among the secondary school students in Kuala Lumpur. This location was chosen in the sense that it is a multicultural group of students with various academic backgrounds as well as access to digital and exposure to technology. The technological infrastructure of Kuala Lumpur is also highly developed, so it will be perfect to investigate the application of AI in mathematics learning.

The use of AI in instruction is in line with the Education Blueprint in Malaysia that supports digitalization in schools. The student diversity and the broad spectrum of the schools in Kuala Lumpur ensure that the findings are representative of the interaction in the city's secondary schools with AI chatbots. The survey targeted students in various schools within Kuala Lumpur which made it inclusive and representative.

Participants and Sampling

The study involved secondary school students in Kuala Lumpur. Stratified sampling was used to obtain representation across form level and gender. The target population comprised secondary school students in Kuala Lumpur, and the study aimed to include students from different form levels and both genders. The questionnaire was distributed online through Google Forms via student groups and social media channels. A total of 80 completed responses were included in the analysis after screening for completeness.

The final sample consisted of 80 students. This sample size was considered feasible for the descriptive and inferential analyses conducted in the study. The sampling approach was intended to reduce over-representation of particular form-level or gender groups within the study sample.

The sampling procedure focused on the two identified strata, namely form level and gender. Students were proportionally represented across these groups where possible. As the survey was distributed online through student groups and social media channels, the findings should be interpreted within the context of the study sample and should not be assumed to represent all secondary school students in Malaysia.

Ethical Considerations

Participation in the online questionnaire was voluntary. Respondents were provided with information about the purpose of the study and the use of the collected data for research purposes. The study was conducted in a school setting under the supervision of the respective teachers and in accordance with the applicable institutional requirements for research involving student participants. Confidentiality and anonymity were maintained throughout the study, and no personally identifying information was required for the analysis. The information collected was used solely for research purposes.

Instrument and Data Collection

The study used a structured 20-item questionnaire developed from relevant previous research and the conceptual framework. Following the preliminary pre-test, minor wording adjustments were made to improve clarity and comprehension. After data collection, responses were screened for completeness, coded, and analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize participant characteristics and questionnaire responses, while inferential analysis was used to examine relationships among AI chatbot use, chatbot features and quality of interaction, and student engagement and perceived mathematics learning improvement.

After data collection was done, responses were downloaded and filtered on completeness. Statistical Package of the Social Sciences (SPSS) was used to code and analyze the data. Demographic characteristics and perceptions of the students were summarized using descriptive statistics and the relations between the independent and dependent variables were analyzed using inferential statistics. This methodological procedure enabled the research study to establish the impact of AI chatbot technologies in engagement and learning performance of mathematics students.

The questionnaire consisted of two rating scales including the categories scale and the Likert scale. These scales were chosen because they offer an effective and standardized way of gathering quantitative data and the students could be asked to express how much they agree with a particular statement. The categories scale provides the respondent with a variety of choices, and the Likert scale allows the student to be a nonconformist when they wish, rather than to be compelled to give a straightforward either-or response.

Data Analysis

The questionnaire was developed to measure students' perceptions of AI chatbot use in mathematics learning, including chatbot features and quality of interaction, student engagement, and perceived improvement in mathematics learning. Content relevance was guided by the literature review and conceptual framework. A preliminary pre-test with 10 students was conducted to assess the clarity, wording, and comprehensibility of the items. Feedback from the pre-test was used to make minor revisions before the main data collection. The pre-test therefore provided preliminary evidence of item clarity; it should not be interpreted as formal expert validation of the instrument.

RESULTS

The descriptive analysis provides an overview of the participants' characteristics. Reporting the demographic profile helps readers understand the composition of the study sample and provides context for interpreting students' perceptions of AI chatbot use in mathematics learning. The available demographic information is presented below.

The gender distribution was relatively balanced, with representation from both male and female students. This provides a useful description of the sample; however, the distribution should not be interpreted as evidence that the sample is representative of all secondary school students in Kuala Lumpur or Malaysia.

Table 1: Gender distribution of participants

GENDER	FREQUENCY	PERCENTAGE (%)
MALE	38	47.5
FEMALE	42	52.5
TOTAL	80	100.0

The gender distribution was relatively balanced, with 47.5% male respondents and 52.5% female respondents. This indicates that both groups were represented in the sample and provides useful context for interpreting the reported perceptions and experiences. Although gender may be relevant when examining technology-related perceptions, the present study did not conduct a separate analysis of gender differences. Therefore, the gender distribution is reported descriptively rather than being used to claim that the findings are free from bias.

Table 2: Mean and Standard Deviation of Use of AI Chatbot Technologies

STATEMENT (ITEMS)	MEAN	STANDARD DEVIATION
I regularly use AI chatbots or virtual tutors to learn Mathematics	4.19	0.797
AI chatbots simplify and make Mathematics interesting to learn.	4.22	0.746

The application of AI chatbots can help me to solve challenging topics in Math	4.26	0.707
I use AI chatbots during Math quizzes or exams preparation	4.30	0.770

Table 2 presents the frequency and perceived usefulness of AI chatbot use among students. The mean scores for the four items ranged from 4.19 to 4.30, indicating generally high agreement with the statements. These results suggest that students reported frequent use of AI chatbots and positive perceptions of their usefulness in mathematics learning.

The item "I regularly use AI chatbots or virtual tutor to learn Mathematics" had a mean of 4.19, indicating that respondents reported regular use of AI chatbots for mathematics learning. This finding suggests that AI chatbots may have become a commonly used form of supplementary academic support among the participants.

The item "AI chatbots simplify and make Mathematics interesting to learn" had a mean of 4.22. This indicates that students generally perceived AI chatbots as making mathematical concepts more accessible and interesting. Such perceptions may be related to the ability of chatbots to provide explanations, examples, and simplified steps in response to students' questions.

The item "The application of AI chatbots can help me to solve challenging topics in Math" received a mean of 4.26. This indicates that respondents generally perceived AI chatbots as useful when dealing with difficult mathematics topics. The finding reflects students' reported experiences and does not establish that chatbot use objectively improved their problem-solving performance.

The item "I use AI chatbots during Math quizzes or exams preparation" had the highest mean of 4.30, indicating that respondents frequently reported using AI chatbots when preparing for mathematics assessments. This suggests that AI chatbots form part of the participants' revision and examination-preparation strategies.

Overall, the findings indicate that AI chatbots were frequently used by the participants for mathematics revision, examination preparation, and assistance with difficult concepts. These results reflect students' reported usage patterns and perceptions rather than objectively measured changes in mathematics achievement.

Table 3: Mean and Standard Deviation of Chatbot Features and Quality of Interaction

STATEMENT (ITEMS)	MEAN	STANDARD DEVIATION
The chatbot provides precise and useful responses to my questions in mathematics.	4.25	0.755
The chatbot can handle my queries even when I write them in different ways.	4.24	0.698
The chatbot is fast responding and friendly in interaction.	4.25	0.720
The chatbot uses examples to ease the understanding of concepts.	4.43	0.652

Table 3 presents students' perceptions of chatbot features and quality of interaction. Mean scores ranged from 4.24 to 4.43, indicating generally high agreement across the four items. The findings suggest that participants perceived the chatbots as useful, responsive, and capable of providing explanations and examples during mathematics learning.

The item "The chatbot provides precise and useful responses to my questions in mathematics" received a mean of 4.25. This indicates that students generally perceived the chatbot responses as useful and sufficiently clear for their mathematics questions. However, this result represents students' perceptions of response quality and should not be interpreted as an objective assessment of chatbot accuracy.

The item "The chatbot can handle my queries even when I write them in different ways" had a mean of 4.24, indicating that students generally perceived the chatbot as capable of responding to differently worded questions. This may be particularly useful for students with different levels of mathematical vocabulary or language proficiency.

The item "The chatbot is fast responding and friendly in interaction" had a mean of 4.25. This indicates that students generally perceived the chatbot as responsive and approachable. Immediate responses may support students' willingness to continue asking questions during revision and independent learning.

The item "The chatbot uses examples to ease the understanding of concepts" received the highest mean of 4.43. This indicates that examples were strongly valued by the respondents as a feature that may help them understand mathematical concepts. The result represents students' perceptions of the usefulness of examples provided by chatbots.

Overall, students reported positive perceptions of chatbot features and quality of interaction. The chatbots were perceived as precise, responsive, helpful, and easy to use. These findings suggest that such features may support students' engagement with mathematics learning; however, the cross-sectional perception-based design does not establish that these features caused improvements in mathematical achievement.

Table 4: Mean and Standard Deviation of Student Engagement and Improvement in Mathematical Learning.

STATEMENT (ITEMS)	MEAN	STANDARD DEVIATION
I feel motivated to study Mathematics with the help of AI chatbots.	3.85	0.982
I engage in more activities or spend more time exploring different AI tools studying Math.	3.80	0.973
I have been able to better understand and perform better in Mathematics since using AI chatbots.	3.88	1.048
I am willing to try more difficult math questions when using AI chatbots.	4.25	0.907

Table 4 presents students' reported motivation, engagement, and perceived improvement in mathematics learning. The mean scores for the four items ranged from 3.80 to 4.25, indicating generally positive responses. These results describe students' perceptions of their engagement and learning experiences when using AI chatbots.

The item "I feel motivated to study mathematics with the help of AI chatbots" scored a mean of 3.85. This indicates that respondents generally perceived AI chatbots as supporting their motivation to study mathematics. The finding concerns students' reported motivation and does not provide an objective measure of changes in achievement.

The item "I engage in more activities or spend more time exploring different AI tools studying Math" had a mean of 3.80. This suggests that respondents perceived themselves as engaging more actively with

mathematics-related AI tools. The finding reflects self-reported engagement rather than directly observed time-on-task or platform usage data.

The item "I have been able to better understand and perform better in mathematics since using AI chatbots" had a mean of 3.88. This indicates that students perceived an improvement in their understanding and performance after using AI chatbots. Importantly, this is a self-reported perception and should not be interpreted as evidence of objectively measured improvement in mathematics achievement.

The item "I am willing to try more difficult math questions when using AI chatbots" had the highest mean of 4.25. This suggests that respondents generally perceived AI chatbots as supporting their willingness to attempt more challenging mathematics questions. The result is consistent with a positive perception of confidence and engagement but does not establish a causal effect of chatbot use.

Overall, the findings suggest positive self-reported engagement, motivation, and perceived improvement in mathematics learning among the participants. Because the study used a cross-sectional questionnaire, these findings should be interpreted as perceived experiences and associations rather than as evidence that AI chatbots significantly improved students' actual mathematics achievement.

Reliability Analysis

Reliability analysis was conducted to examine the internal consistency of the questionnaire items for each study construct. Cronbach's alpha was used to assess whether items within each construct showed an acceptable level of consistency. The analysis was based on the responses of the 80 participants.

Cronbach's alpha values of 0.70 or above are commonly considered acceptable, with higher values indicating stronger internal consistency. In the present study, Cronbach's alpha values were calculated for the three main constructs to assess the consistency of their respective questionnaire items.

Table 5: Rule of Thumb Measures for Cronbach's alpha

Cronbach's alpha	Internal consistency
Alpha ≥ 0.9	Excellent reliability
0.8≤ Alpha<0.9	Good reliability
0.7≤Alpha <0.8	Acceptable reliability
0.6≤Alpha <0.7	Questionable reliability
0.5≤Alpha <0.6	Poor reliability
Alpha<0.5	Unacceptable reliability

The results indicate acceptable to good internal consistency across the three constructs, supporting the use of the questionnaire items for the subsequent statistical analyses.

Table 5: Reliability Analysis

Variables	Cronbach's Alpha	Number of Items
Use of AI Chatbot Technologies	0.782	4
Chatbot features and the quality of interaction	0.800	4

Student engagement and improvement in mathematical learning	0.839	4

The Use of AI Chatbot Technologies construct had a Cronbach's alpha of 0.782 across four items, indicating acceptable internal consistency. This suggests that the items used to assess students' reported use of AI chatbot technologies were sufficiently consistent for the purposes of the present study.

The Chatbot Features and Quality of Interaction construct had a Cronbach's alpha of 0.800 across four items, indicating good internal consistency. The items concerning response usefulness, handling of differently worded questions, response speed and friendliness, and the use of examples were therefore sufficiently consistent as a scale.

The Student Engagement and Improvement in Mathematical Learning construct had a Cronbach's alpha of 0.839 across four items, indicating good internal consistency. The result suggests that the items measuring motivation, engagement, perceived understanding and performance, and willingness to attempt challenging questions were internally consistent. This reliability evidence supports the consistency of the scale, but it does not by itself establish construct validity or causal effectiveness.

Normality Test

The interest of testing normality is that it establishes whether to use a parametric or non-parametric statistical test on the subsequent tests. The Kolmogorov-Smirnov test and the Shapiro-Wilk test were applied in this research. Generally, the Shapiro-Wilk test is said to be more trustworthy to use in small samples of less than 200 respondents although the Kolmogorov-Smirnov test serves as an added reference. The significance value of 0.05 and above in both tests is the sign of normal distribution and below is non-normality.

Table 6: Normality Statistics

Variables		Kolmogorov-Smirnov Sign.	Shapiro-Wilk Sign.
Use of Ai Chatbot Technologies		<.001	<.001
Chatbot Features and Quality of Interaction		0.005	<.001
Student Engagement and Improvement in Mathematical Learning.	0.010	<.001	

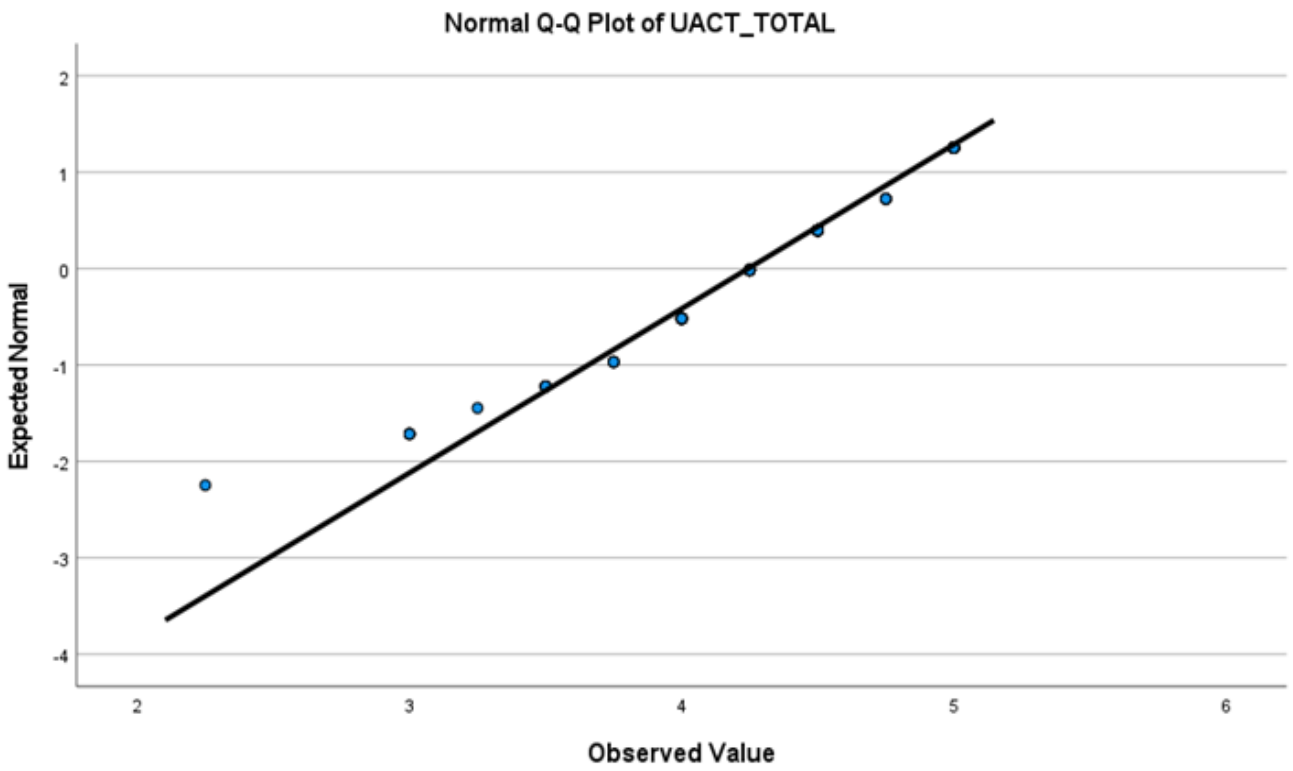
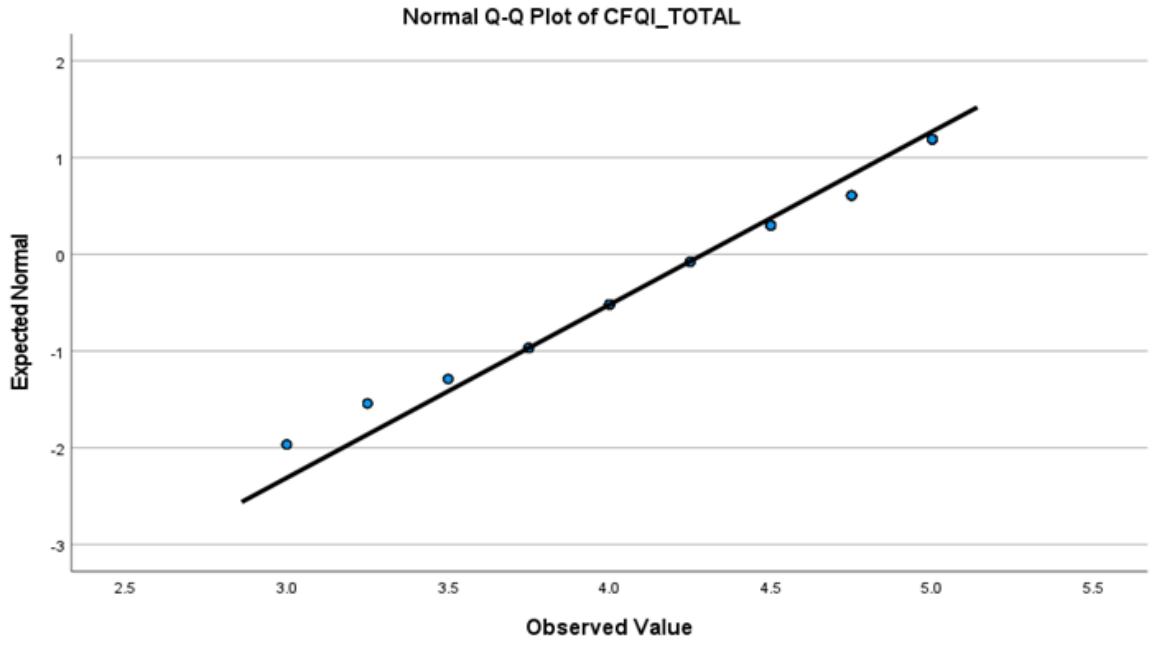


Figure 1: Q-Q Plot of Use of AI Chatbot Technologies

The Kolmogorov-Smirnov test resulted in a significance of less than 0.001, less than 0.05. However, the Shapiro-Wilk test has a value lower than 0.001. Since a Shapiro-Wilk test is more precise in cases of smaller samples, this proves that UACT_TOTAL is not normally distributed. This pattern is also indicated in the Q-Q plot where the plotted values are not closely matched with the normal distribution line.

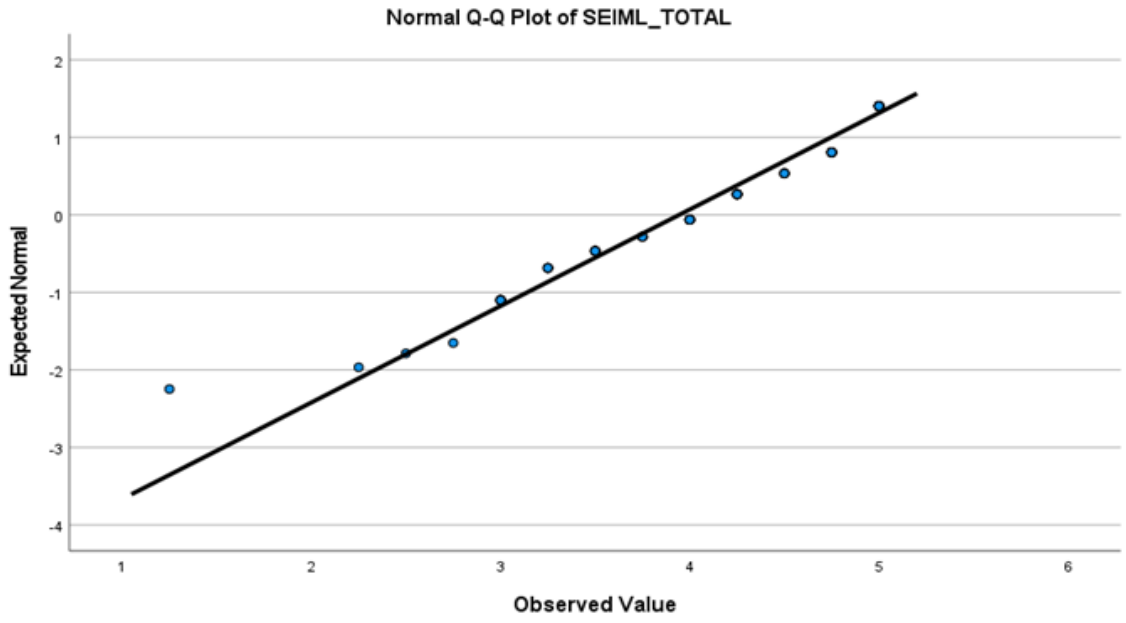
Figure 2: Q-Q Plot of Chatbox Features and Quality of Interaction



In the case of the CFQI_TOTAL variable, the Kolmogorov-Smirnov test yielded a significance value of 0.005, and the Shapiro-Wilk test yielded a value of less than 0.001. Both values are below the 0.05 value, which

proves that CFQI TOTAL is not normally distributed. This is also demonstrated in the Q-Q plot by the apparent outliers of the diagonal reference line.

Figure 3: Q-Q Plot of Student Engagement and Improvement in Mathematics Learning



In the case of the variable SEIML_TOTAL, the Kolmogorov-Smirnov test value stands at 0.010, and the Shapiro-Wilk is at 0.001. Both results are less than the required value, which implies that there is no normal distribution of SEIML_TOTAL. This observation is supported by the Q-Q plot, because some of the data points do not follow the reference line, the diagonal.

According to the findings of the Kolmogorov-Smirnov and Shapiro-Wilk tests alongside the visual observations made on the Q-Q graphs, all three variables which are SEIML_TOTAL, UACT_TOTAL, and CFQI_TOTAL had significant departures from normal distribution. This is not an exceptional occurrence with behavioral and survey-based research, where the respondents tend to give similarly high or low ratings, resulting in skewed or clustered response distributions instead of a flawless bell-shaped distribution. These tendencies of response are particularly widespread when Likert-scale instruments are used, which inherently restrict variability and can create non-normal distributions despite sufficiently large sample sizes.

The assumption of normality failed. Hence, the study uses non-parametric statistical methods, which do not assume that data offers a normal distribution. These are statistically suitable, strong and generally suggested in circumstances of ordinal data and non-normally distributed data. The use of non-parametric methods avoids assumption violations and makes the analysis of the given findings accurate, reliable and sound methodologically. Thus, the choice in favor of non-parametric tests does not only comply with the best statistical practice but also contributes to the validity of the overall results of the study.

Correlation Analysis

Correlation analysis was conducted to examine the relationships among the three primary variables. The results showed positive and statistically significant associations among the variables at the 0.01 level ($p < .001$). Because the study is cross-sectional, the correlations indicate relationships among the variables and should not be interpreted as evidence of causation.

Table 7: Correlation Analysis

Variables	Pearson Correlation	Sig. (2-tailed)	Relationship

	(Sig.)		
Use of Ai Chatbot Technologies	0.637	<.001	Significant positive relationship
Chatbot Features and Quality of Interaction	0.469	<.001	Significant positive relationship
Student Engagement and Improvement in Mathematical Learning.	0.662	<.001	Significant positive relationship

Use of AI Chatbot Technologies (UACT) and Chatbot Features and Quality of Interaction (CFQI) showed a positive correlation ($r = 0.637$, $p < .001$). This indicates that students who reported more frequent use of AI chatbots also tended to report more favorable perceptions of chatbot accuracy, speed, usefulness, and interaction quality.

The correlation between Use of AI Chatbot Technologies (UACT) and Student Engagement and Improvement in Learning (SEIML) was positive ($r = 0.469$, $p < .001$). This indicates that greater reported use of AI chatbots was associated with higher reported engagement and perceived mathematics learning improvement.

Chatbot Features and Quality of Interaction (CFQI) and Student Engagement and Improvement in Learning (SEIML) showed the strongest positive correlation ($r = 0.662$, $p < .001$). This indicates that students who perceived the chatbot as useful, responsive, and supportive also tended to report higher engagement and perceived improvement in mathematics learning.

Overall, the findings indicate positive associations between chatbot use, perceived chatbot quality, and student engagement and perceived mathematics learning improvement. These relationships should not be described as causal effects or objective learning outcomes because the study did not include a control group, pre- and post-assessment, or an objective mathematics achievement measure.

DISCUSSION

The reliability analysis showed acceptable to good internal consistency across the three constructs, with Cronbach's alpha values ranging from 0.782 to 0.839. The correlation analysis also showed positive and statistically significant relationships among AI chatbot use, chatbot features and quality of interaction, and student engagement and perceived mathematics learning improvement. These findings suggest that students who reported more frequent chatbot use and more favorable perceptions of chatbot interaction also tended to report higher engagement and perceived learning improvement. However, the cross-sectional design does not permit causal conclusions, and the learning improvement measure was perception-based rather than an objective achievement measure.

The study has several limitations. First, the sample was limited to 80 secondary school students in Kuala Lumpur, which restricts the generalizability of the findings to other Malaysian secondary school populations. Second, the study relied on self-reported questionnaire data, which may be affected by response and social-desirability bias. Third, the cross-sectional design does not allow changes in mathematics achievement to be measured over time or causal effects of AI chatbot use to be established. Finally, the study did not compare different chatbot types, levels of prior mathematical ability, or other student characteristics in relation to the observed relationships.

Future research should therefore incorporate more objective measures of mathematics achievement alongside perception-based measures. Pre- and post-assessments could be used to examine changes in mathematics achievement, while experimental or quasi-experimental designs could compare students using AI chatbots with an appropriate control or conventional-learning group. Future studies could also examine whether chatbot

type, frequency of use, prior mathematical ability, and student characteristics influence engagement and mathematics learning outcomes.

CONCLUSION

This study examined the role of AI chatbot technologies in mathematics engagement among secondary school students in Kuala Lumpur. The findings indicate that students generally reported frequent use of AI chatbots for mathematics revision, examination preparation, and assistance with challenging concepts. Participants also reported positive perceptions of chatbot responsiveness, usefulness, and the provision of examples. These findings suggest that AI chatbots may serve as a supplementary learning resource that students perceive as useful during mathematics learning.

The findings also indicate positive self-reported engagement and perceived improvement in mathematics learning. Students reported motivation to study mathematics, engagement with AI tools, perceived improvement in understanding and performance, and willingness to attempt more difficult mathematics questions. However, these findings represent students' perceptions and associations identified from a cross-sectional survey. They should therefore not be interpreted as evidence that AI chatbot use objectively improved mathematics achievement or caused the reported changes.

The study is subject to several limitations. The sample was relatively small and geographically limited to Kuala Lumpur, which limits generalization to the wider Malaysian secondary school population. In addition, the reliance on self-reported data may introduce response bias, and the cross-sectional design prevents causal conclusions. The study also did not include objective pre- and post-assessments of mathematics achievement or a comparison group.

Future research should use larger and more diverse samples across different geographical areas, school categories, and socioeconomic backgrounds. Experimental or quasi-experimental studies comparing AI chatbot-supported learning with conventional learning or an appropriate control group would provide stronger evidence of effectiveness. Pre- and post-assessments of mathematics achievement could complement perception-based measures and allow researchers to distinguish perceived improvement from objectively measured learning gains.

Future studies could also investigate whether chatbot type, frequency of use, prior mathematical ability, and student characteristics influence the observed relationships. Such research would provide a more detailed understanding of when and for whom AI chatbot technologies may be most beneficial in secondary mathematics learning.

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