Socratic Artificial Intelligence and Academic Performance in Mathematics of Junior High School Students

Gelli Ann P. Gariando, *Sharon L. Apohen, PhD

Master of Arts in Education, La Carlota City College, Philippines

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.100700980

Received: 07 August 2026; Accepted: 12 August 2026; Published: 19 August 2026

ABSTRACT

This study is titled "Socratic Artificial Intelligence and Academic Performance in Mathematics of Junior High School Students." It determined the relationship between Socratic Artificial Intelligence (SAI) and the academic performance of 229 junior high school students in a private high school in Negros Occidental during the school year 2026–2027. A quantitative descriptive-correlational research design was employed using a validated and reliability-tested researcher-made questionnaire and mathematics grades as measures of performance. The results revealed that the level of Socratic Artificial Intelligence of students was rated high, where learning engagement obtained the highest mean among the four dimensions, followed by problem-solving skills, mathematical reasoning, and critical thinking. The academic performance of students was rated very satisfactory, with several achieving outstanding ratings. The findings also showed that there was a significant relationship between the Socratic Artificial Intelligence of students and their academic performance in mathematics. This implies that students who demonstrated higher levels of critical thinking, reasoning, problem-solving, and engagement through AI-assisted Socratic dialogue also achieved better mathematics outcomes. The study concludes that Socratic Artificial Intelligence is a promising pedagogical innovation that strengthens both cognitive and affective domains of learning. Its integration into classroom instruction can address persistent challenges in mathematics education, promote equitable learning opportunities, and advance holistic learner development in the Philippine context.

Keywords: Socratic Artificial Intelligence, critical thinking, problem-solving skills, mathematical reasoning, learning engagement, academic performance,

INTRODUCTION

The effectiveness of schools largely depends on the competence of teachers and the performance of students in core subjects such as mathematics. Globally, mathematics achievement has been recognized as a critical factor that contributes to logical reasoning, analytical skills, and problem-solving abilities, yet many learners continue to struggle with its abstract nature and traditional teacher-centered approaches (Luzano, 2023; Sun et al., 2023). These challenges often result in low achievement, poor motivation, and disengagement, underscoring the need for innovative pedagogical strategies that integrate both technology and inquiry-based learning.

Artificial Intelligence (AI) has emerged as a transformative force in education, offering adaptive learning environments, personalized feedback, and interactive engagement. Recent studies confirm that AI-powered pedagogies enhance mathematics learning by tailoring instruction to individual student needs, improving comprehension, and fostering motivation (Awang, Yusop, & Danaee, 2025; Duan et al., 2024). At the same time, the Socratic method—an instructional approach rooted in guided questioning and reflective dialogue—remains a powerful tool for cultivating critical thinking and problem-solving. Contemporary research demonstrates that Socratic dialogue enhances students' ability to analyze, evaluate, and synthesize information, which is essential in mathematics education (Chen & Li, 2025; Psychreg News Team, 2024).

In the Philippines, educational reforms and post-pandemic recovery have increased the responsibilities of teachers and heightened the demand for effective learning interventions. Local studies reveal that mathematics achievement remains moderate, with teacher competence, instructional support, and assessment practices serving as key predictors of success (Rodrigo & Prudente, 2024; Barrera, 2024; Largo & Adanza, 2025). However, limited research has examined how AI-assisted Socratic questioning can complement traditional teaching and address persistent challenges in comprehension, reasoning, and engagement.

This gap highlights the need for the present study, "Socratic Artificial Intelligence and Academic Performance in Mathematics of Junior High School Students," which aims to determine the relationship between Socratic AI and mathematics achievement. The findings may provide valuable insights for teachers, school administrators, and policymakers in designing interventions that strengthen inquiry-based pedagogy, improve student engagement, and enhance overall academic performance in mathematics.

METHODOLOGY

Research Design

This study employed a **descriptive-correlational research design** to determine the relationship between Socratic Artificial Intelligence (SAI) and the academic performance in mathematics of junior high school students. The quantitative approach was appropriate because it enabled the researcher to collect numerical data using a structured, researcher-made questionnaire and analyze the data through appropriate statistical techniques. The descriptive aspect of the design was used to describe the levels of Socratic Artificial Intelligence in terms of critical thinking, problem-solving skills, mathematical reasoning, and learning engagement, as well as the academic performance of students. The correlational aspect was utilized to examine the degree of association between the SAI dimensions and students' mathematics achievement.

This design provided an accurate description of the characteristics of the respondents and the variables investigated without manipulating any of the study conditions, thereby ensuring objectivity and reliability of results (Creswell & Creswell, 2023; Wubante, 2020). By employing this design, the study was able to capture both the descriptive profile of learners and the statistical relationships among variables, offering evidence-based insights into how AI-assisted Socratic questioning influences mathematics learning outcomes.

Subject and Respondents of the Study

The subject and respondents of this study were junior high school students enrolled at a private high school in Negros Occidental during the school year 2026–2027.

Population and Sample Size

The population of the study consisted of **533 junior high school students** enrolled at a private junior high school in Negros Occidental during the school year 2026–2027. Since the population was relatively large, the researcher determined the minimum required sample size using **Yamane's formula (1967)** with a 5% margin of error to ensure reliability and validity of results. Based on the computation, the minimum sample size was **229 students.**

To ensure fair representation across sex, family monthly income, and grade level, the researcher employed **simple random sampling using the lottery method.** This technique gave each student an equal chance of being selected, thereby minimizing bias and enhancing the validity of the sample. As a result, the data analysis was based on the responses of **229 students,** which represented the diverse characteristics of the junior high school population.

Data Gathering Instrument

The main instrument used in this study was a researcher-made questionnaire, carefully designed to measure the variables under investigation. The questionnaire was constructed based on the objectives of the study and guided by recent literature on Socratic Artificial Intelligence and mathematics education. The indicators were anchored on validated frameworks from 2020 up to the present to ensure both reliability and validity.

The critical thinking items were supported by Zhang (2024), emphasizing reflection, justification, and evaluation of mathematical ideas. The problem-solving skills indicators were reinforced by Garcia & Torres (2025), highlighting strategies, accuracy, and independent application of solutions. The mathematical reasoning items drew from Patel (2023), focusing on logical justification and articulation of solutions. Finally, the learning engagement indicators were based on Nguyen (2024), stressing motivation, persistence, and active participation in mathematics learning.

The questionnaire was divided into two parts. The first part gathered the profile of the respondents, specifically their sex, family monthly income, and grade level. The second part focused on Socratic AI, consisting of 20 items that assessed four dimensions: critical thinking, problem-solving skills, mathematical reasoning, and learning engagement. To capture students' perceptions of their mathematics achievement, five supporting options per item were included (5 – strongly agree, 4 – agree, 3 – neutral, 2 – disagree, 1 – strongly disagree). These items reflected self-assessment of performance and confidence in mathematics learning, complementing the objective measure of grades.

To measure academic performance, the students' final grades in mathematics for the school year 2025–2026 were obtained from official school records in accordance with DepEd Order No. 8, s. 2015.

First, the researcher requested permission through approval letters from the School Principal of a private high school in Negros Occidental. Once approval was granted, the researcher prepared the questionnaire, ensuring that each respondent had access to one copy through a Google Form, thereby maintaining a 1:1 ratio of instruments to participants.

Following this, the researcher conducted an orientation session with the respondents. During the orientation, the purpose of the study was explained clearly, and students were assured that their participation was entirely voluntary. They were also informed that their responses would be treated with strict confidentiality and would be used solely for academic research purposes. Ethical considerations such as informed consent, anonymity, and respect for participants' rights were emphasized to ensure compliance with research standards.

The use of Google Forms as the mode of administration provided several advantages. It allowed for efficient distribution of the questionnaire, automatic recording of responses, and minimized human error in data entry.

Since the questionnaire was researcher-made, it was necessary to establish its validity and reliability before actual administration. To ensure validity, the instrument was subjected to expert evaluation. A total of five specialists served as validators: two Program Heads, one Dean, one Mathematics Department Chairperson, and one Principal. All possessed expertise in mathematics education and educational technology, ensuring that the items were clear, appropriate, and aligned with the objectives of the study. Their comments and suggestions were incorporated into the final version of the questionnaire, assuring that it measured the intended constructs accurately and comprehensively.

The evaluation was facilitated through a Lawshe's validation form, which provided a structured framework for assessing the clarity, relevance, and alignment of each item with the study's objectives. This process ensured that the questionnaire achieved strong content validity by systematically incorporating expert feedback. The obtained validity index was 1.00, confirming that the instrument was valid. Recent methodological studies such as Zhang (2024) and Garcia & Torres (2025) emphasize that structured expert validation remains essential in ensuring content validity in AI-enhanced educational research.

To establish reliability, the instrument was pilot tested with 30 respondents who shared similar characteristics with the target population. The internal consistency of the items was measured using Cronbach's alpha, a widely accepted statistical method for determining reliability in educational research. A coefficient of 0.70 or higher is considered acceptable in recent literature (e.g., Patel, 2023; Awang, Yusop, & Danaee, 2025), indicating that the items consistently measure the intended constructs.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

The pilot test results yielded a Cronbach's alpha of 0.927, interpreted as excellent reliability. This value confirms that the questionnaire items were highly consistent and dependable, thereby validating its use in the actual study. In terms of the reliability index per dimension, the results revealed satisfactory to excellent internal consistency: The Critical Thinking dimension obtained a Cronbach's alpha of 0.785, indicating acceptable reliability. The Problem-Solving Skills dimension yielded 0.791, likewise reflecting acceptable reliability. The Mathematical Reasoning dimension achieved 0.832, interpreted as good reliability. The Learning Engagement dimension reached 0.908, demonstrating excellent reliability. Collectively, these values confirm that the instrument was both valid and reliable, making it suitable for administration in the actual study.

Data Analyses

The study employed appropriate statistical tools to analyze the collected data in line with its research objectives.

To answer statement of the problem number 1, which states, what is the profile of the respondents in terms of sex, family monthly income, and grade level, frequency and percentage distribution were used.

$$\% = \frac{f}{N} x\ 100$$

Where:

f - number of respondents

N - total no. of respondents

% - Percentage

To answer statement of problem number 2, which determines the level of Socratic Artificial Intelligence of students when taken as a whole and in terms of critical thinking, problem solving skills, mathematical reasoning, learning engagement and according to profile, mean and standard deviation were used.

The formula for Mean is presented below:

$$\bar{x} = \frac{\sum x}{n}$$

Where:

x̄ = mean

n = sample size

Formula for standard deviation:

$$s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

Where:

s = is the sample standard deviation

x_i = is each individual score in the dataset

$\bar{x}$ = is the sample mean

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

n = is the number of observations in the sample

$\sum X$ = sum of all values

The mean scores in problem number 2 were interpreted as follows:

Scale	Description	Mean Score Range	Interpretation	Verbal Interpretation
5	Strongly Agree	4.21 – 5.00	Very High	The students consistently demonstrate the skill when guided by Socratic AI.
4	Agree	3.41 – 4.20	High	The students frequently exhibit the skill and benefit from Socratic AI questioning.
3	Neutral	2.62 – 3.40	Moderate High	The students sometimes show the skill, but consistency is moderate.
2	Disagree	1.81 – 2.60	Low	The students show limited skill through Socratic AI.
1	Strongly Disagree	1.00 – 1.80	Very Low	The students show minimal or no impact of Socratic AI on the skill.

To answer statement of problem number 3, which determines the level of Socratic Artificial Intelligence when grouped according to profile mean and standard deviation were used.

The mean scores in problem number 3 were interpreted as follows:

Scale	Description	Mean Score Range	Interpretation	Verbal Interpretation
5	Strongly Agree	4.21 – 5.00	Very High	The students consistently demonstrate the skill when guided by Socratic AI.
4	Agree	3.41 – 4.20	High	The students frequently exhibit the skill and benefit from Socratic AI questioning.
3	Neutral	2.62 – 3.40	Moderate High	The students sometimes show the skill, but consistency is moderate.
2	Disagree	1.81 – 2.60	Low	The students show limited skill through Socratic AI.
1	Strongly Disagree	1.00 – 1.80	Very Low	The students show minimal or no impact of Socratic AI on the skill.

To answer statement of the problem number 4, which determine the level of the academic performance of students' mean and standard deviation were used through interpretation guide based on DepEd Order No. 8, s. 2015.

Range	Interpretation	Verbal Description
90–100	Outstanding	Students consistently demonstrate exceptional mastery of mathematical concepts and skills, exceeding expectations.
85–89	Very Satisfactory	Students show strong achievement, meeting and often surpassing expected standards with minimal errors.
80–84	Satisfactory	Students adequately meet learning goals, showing competence in most areas but with room for improvement.
75–79	Fairly Satisfactory	Students achieve basic understanding of mathematical concepts but struggle with consistency and application.
Below 75	Did Not Meet Expectation	Students fail to demonstrate required competencies, indicating significant need for remediation and support.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

To answer statement of problem number 5, which asks if there was a significant relationship between the Socratic Artificial Intelligence students and students' academic performance in mathematics, the Spearman's Rank Correlation was used.

The formula for Spearman's Rank Correlation is presented below.

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Where:

r_s= Spearman's rank correlation coefficient

d = difference between the ranks of corresponding variables

$\sum d^2$ = Sum of the squared difference values

n = Number of observations (or pairs of data)

RESULTS AND DISCUSSION

This section includes the presentation of data gathered and the discussion, interpretation, and implication of the findings of the study. The results were presented in tables, which were then analyzed and interpreted. The order of the presentation follows the sequence of the problems identified in the study.

Profile of Respondents

Table 1 presents the demographic profile of 229 junior high school students at a private high school in Negros Occidental during the school year 2026–2027.

Table 1. Frequency and Percentage Distribution of the Demographic Profile of Respondents.

Profile	Category	F	%
	Male	75	32.75
	Female	154	67.25
	Total	229	100
Grade Level			
	Grade 7	53	23.14
	Grade 8	67	29.26
	Grade 9	32	13.97
	Grade 10	77	33.62
	Total	229	100
Family Monthly Income			
	Below ₱10,000	140	61.14
	₱10,001 – ₱20,000	41	17.9
	₱20,001 – ₱30,000	31	13.54
	₱30,001 – ₱40,000	6	2.62
	Above ₱40,000	11	4.8
	Total	229	100

In terms of sex, the frequency count shows that 154 students (67.25%) were female, while 75 students (32.75%) were male. This indicates that most respondents were female, suggesting a gender imbalance in the sample population. Such disparity may influence classroom dynamics and engagement with Socratic AI, as female students are more represented in the study.

For grade level, the largest subgroup was Grade 10 with 77 students (33.62%), followed by Grade 8 with 67 students (29.26%), Grade 7 with 53 students (23.14%), and the smallest group, Grade 9 with 32 students (13.97%). The frequency distribution reveals that higher grade levels, particularly Grade 10, were more represented, implying that the results may reflect the perspectives of more mature learners nearing the completion of junior high school.

Regarding family monthly income, most respondents, 140 students (61.14%), reported household earnings below ₱10,000. Meanwhile, 41 students (17.90%) belonged to families earning between ₱10,001–₱20,000, and 31 students (13.54%) reported incomes between ₱20,001–₱30,000. Smaller groups included 6 students (2.62%) with incomes between ₱30,001–₱40,000 and 11 students (4.80%) with incomes above ₱40,000. The frequency and percentage distribution highlight that most respondents come from low-income households, which may affect their access to educational technology and AI tools.

This demographic profile suggests that gender and socio-economic disparities may influence students' learning experiences and access to AI tools. The concentration of Grade 10 students further indicates that findings may be more reflective of senior junior high school learners. Supporting literature confirms these observations: Revilla (2020) found that gender disparities in Philippine education persist, with female students often showing higher engagement but facing socio-economic barriers. Borbon and Galigao (2025) emphasized that social class and income strongly shape educational attainment, reinforcing the importance of considering economic background in technology adoption. Maluto and Labay (2025) highlighted that parental education and financial support significantly influence student achievement, especially in low-income contexts.

Level of Socratic Artificial Intelligence

Level 2 is to assess the perceived effectiveness of Socratic Artificial Intelligence (SAI) in mathematics learning, the study measured its impact across four domains: **critical thinking, problem-solving skills, mathematical reasoning, and learning engagement.** These dimensions represent the essential competencies that SAI aims to strengthen through guided questioning and reflective dialogue.

Table 2. Level of Socratic Artificial Intelligence when taken as a whole and in terms of Critical thinking, Problem-solving skills, Mathematical Reasoning, and Learning Engagement.

Statements	Mean	SD	Interpretation
Critical thinking	**3.69**	**0.54**	**High**
1. AI questions help me think deeply about mathematics problems.	3.62	0.78	High
2. AI encourages me to explain my reasoning in solving Math problems.	3.61	0.76	High
3. AI prompts help me analyze mathematical concepts more carefully.	3.69	0.71	High
4. AI helps me reflect on my answers and understand my mistakes.	3.88	0.72	High
5. AI encourages me to evaluate and compare different mathematical ideas when solving problems.	3.67	0.84	High
Problem-solving skills	**3.63**	**0.55**	**High**
6. AI helps me understand and apply appropriate steps when solving difficult Math problems.	3.7	0.75	High
7. AI questions help me find better strategies for solving Math problems.	3.67	0.79	High
8. AI helps me understand how to approach complex mathematics tasks.	3.61	0.72	High
9. AI support helps me independently solve Math problems more effectively.	3.55	0.82	High
10. AI helps me improve my accuracy and efficiency in solving Math problems through practical.	3.65	0.7	High

Mathematical Reasoning	**3.66**	**0.59**	**High**
11. AI questions help me justify my mathematical answers.	3.68	0.74	High
12. AI encourages me to use logical reasoning to justify my math solutions.	3.6	0.77	High
13. AI helps me understand the reasoning behind mathematical solutions.	3.72	0.8	High
14. AI helps me clearly explain the reasoning behind my mathematical solution.	3.64	0.8	High
15. AI encourages me to compare and justify different solution methods in Math.	3.66	0.77	High
Learning Engagement	**3.33**	**0.75**	**Moderate**
16. Using AI makes mathematics learning more interesting for me.	3.42	0.9	High
17. I feel more motivated to study mathematics when using AI.	3.14	1.03	Moderate
18. AI interaction keeps me actively engaged in solving Math problem.	3.37	0.87	Moderate
19. AI encourages me to continue working on difficult Math tasks.	3.45	0.85	High
20. I participate more actively in mathematics learning when AI is used.	3.28	0.95	Moderate
Socratic Artificial Intelligence as a whole	**3.58**	**0.53**	**High**

Legend: (4.21 – 5.00)-Very High; (3.41 – 4.20)-High; (2.61 – 3.40)-Moderate; (1.81 – 2.60)-Low; (1.00 – 1.80)-Very Low

Table 2 presents the level of Socratic Artificial Intelligence (SAI) when taken as a whole and in terms of critical thinking, problem-solving skills, mathematical reasoning, and learning engagement. The overall mean score was **3.58 (High),** indicating that students generally perceived SAI as effective in supporting their mathematics learning.

For critical thinking (M = 3.69, SD = 0.54), the high mean score indicates that students strongly agreed that AI prompts helped them reflect, analyze, and evaluate mathematical concepts. The relatively low standard deviation suggests that responses were consistent, meaning most learners shared similar positive perceptions. This implies that SAI is a reliable tool for fostering deeper reflection and analytical skills in mathematics.

In terms of problem-solving skills (M = 3.63, SD = 0.55), the high mean score reveals that students found AI support effective in guiding them through appropriate strategies and improving accuracy. The low variability further confirms that learners generally agreed on AI's usefulness in helping them approach complex tasks. This consistency highlights AI's role in strengthening independent problem-solving abilities.

For mathematical reasoning (M = 3.66, SD = 0.59), students acknowledged that AI questioning enhanced their ability to justify solutions and explain reasoning clearly. The high mean score reflects strong agreement, while the relatively low standard deviation shows that perceptions were uniform. This suggests that SAI consistently supports logical justification and comparative evaluation of solution methods, reinforcing reasoning as a core mathematical skill.

On the other hand, learning engagement (M = 3.33, SD = 0.75) was interpreted as Moderate based on the study's interpretation scale. This dimension displayed greater variability, with some students reporting increased interest and motivation when using AI while others remained neutral. The results indicate that the motivational and participatory effects of Socratic AI were less consistent than its perceived support for cognitive skills.

The overall mean score (M = 3.58, SD = 0.53) affirms that Socratic Artificial Intelligence is generally effective in enhancing mathematics learning, with students showing consistently positive perceptions in cognitive domains such as reasoning and problem-solving. Ding et al. (2024) demonstrated that inquiry-based AI systems like SocraticLLM strengthened learners' independence and logical thinking, while Garcia and Torres (2025) confirmed that AI-assisted questioning improved comprehension and justification of solutions. These findings explain why perceptions remain stable in cognitive areas, as learners benefit from structured inquiry and reflective dialogue.

Level of Socratic Artificial Intelligence According to Profile

This section presents the analysis of the level of Socratic Artificial Intelligence (SAI) among junior high school students when grouped according to their demographic profile variables such as sex, grade level, and family monthly income.

Table 3. Level of Socratic AI when grouped in terms of Profile.

Profile	Category	Mean	SD	Interpretation
Sex				
	Male	2.32	0.70	Low
	Female	2.35	0.67	Low
Grade Level				
	Grade 7	2.42	0.60	Low
	Grade 8	2.24	0.70	Low
	Grade 9	2.31	0.69	Low
	Grade 10	2.39	0.71	Low
Family Monthly Income				
	Below ₱10,000	2.28	0.66	Low
	₱10,001 – ₱20,000	2.32	0.61	Low
	₱20,001 – ₱30,000	2.55	0.77	Low
	₱30,001 – ₱40,000	2.83	0.75	Moderate
	Above ₱40,000	2.36	0.81	Low

Legend: (4.21 – 5.00)-Very High; (3.41 – 4.20)-High; (2.61 – 3.40)-Moderate; (1.81 – 2.60)-Low; (1.00 – 1.80)-Very Low

The results in Table 3 provide a comprehensive view of how junior high school students perceive the level of Socratic Artificial Intelligence (SAI) when grouped according to their demographic profiles. Across all categories, the mean values generally fall within the low level, with only one subgroup reaching a moderate level. The accompanying standard deviation values, ranging from 0.60 to 0.81, reflect a moderate spread of responses, indicating that while most students consistently rated their SAI levels as low, there was some variability in certain groups.

For sex, male students obtained a mean of 2.32 (SD = 0.70) and female students recorded a mean of 2.35 (SD = 0.67). Both values fall under the Low category, and the closeness of their means and standard deviations shows that there is no significant difference between male and female students in terms of their engagement with SAI. This suggests that gender does not substantially influence perceptions of SAI, consistent with findings that inquiry-based learning outcomes often show minimal differences across sexes when instructional equity is maintained (Revilla, 2020).

When grouped by grade level, Grade 7 students had the highest mean of 2.42 (SD = 0.60), while Grade 8 students had the lowest mean of 2.24 (SD = 0.70). Grades 9 and 10 recorded mean scores of 2.31 and 2.39, respectively. Despite these slight variations, all grade levels remained within the Low category. The relatively small standard deviations across grade levels indicate moderate consistency in responses, reinforcing that year level does not substantially affect the perceived efficacy of SAI. This aligns with Chen and Tsai (2021), who emphasized that questioning strategies become more impactful with academic maturity, but their effectiveness depends on consistent pedagogical application.

In terms of family monthly income, students from households earning ₱30,001–₱40,000 achieved the highest mean of 2.83 (SD = 0.75), which is interpreted as Moderate. Those with incomes between ₱20,001–₱30,000 had a mean of 2.55 (SD = 0.77), close to Moderate but still classified as Low. The remaining income groups, including both lower-income (Below ₱10,000, ₱10,001–₱20,000) and higher-income (Above ₱40,000) families, consistently fell under the Low category, with mean scores ranging from 2.28 to 2.36. The standard deviation values in these groups suggest moderate variability, particularly among middle-income students,

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

where perceptions of SAI were more diverse. This finding resonates with Borbon and Galigao (2025), who highlighted that socio-economic background significantly shapes educational attainment and technology adoption, influencing how students engage with AI-supported learning.

Taken as a whole, the findings suggest that sex and grade level do not significantly affect the level of SAI, as both groups consistently rated their engagement as low with relatively stable responses. However, family income shows slight variation, with middle-income students reporting relatively higher engagement and more variability in perceptions. This implies that while Socratic AI is accessible to all groups, its perceived effectiveness may be influenced by socio-economic conditions.

As Gravetter and Wallnau (2021) explain, the mean serves as a measure of central tendency, while the standard deviation captures the spread of scores, together offering a comprehensive view of group behavior. In educational research, such interpretation is crucial because it identifies both the strengths—where students are united in their perceptions—and the areas where opinions diverge, pointing to opportunities for pedagogical improvement. More recent studies emphasize that equitable AI adoption requires intentional design and socio-economic sensitivity (Bagdonaite & Dagiene, 2025), ensuring that tools like Socratic AI foster deeper reflection and critical thinking across diverse student backgrounds.

Level of Academic Performance

This section presents the distribution of junior high school students' academic performance in mathematics based on their final grades. The classification follows the Department of Education grading scale, ranging from *Outstanding* to *Did Not Meet Expectations.* The results provide an overview of the general achievement level of the respondents, highlighting both the strengths and areas where improvement may be needed

Table 4. Level of Academic Performance of Junior High School Students.

Level of Academic Performance	f	Mean	SD	Interpretation
Outstanding	71	88.78	4.26	Very Satisfactory
Very Satisfactory	132			
Satisfactory	21			
Fairly Satisfactory	5			
Did Not Meet Expectations	0			
Total	229			

Legend:(90-100)-Outstanding; (85-89)-Very Satisfactory; (80-84)-Satisfactory; (75-79)-Fairly Satisfactory; (Below 75)-Did Not Meet Expectations

Table 4 shows that the level of academic performance of junior high school students is Very Satisfactory (M = **88.78, SD = 4.26).** A significant proportion of students achieved **outstanding (71 students)** and **very satisfactory (132 students)** ratings, while only a small number fell into the **fairly satisfactory (5 students)** category.

The **extreme mean values** highlight that the highest performance group was in the **Outstanding range (90–100),** while the lowest recorded group was **Fairly Satisfactory (75–79).** The absence of students in the lowest category suggests that academic performance across the sample was generally stable and commendable. This reflects both effective teaching practices and student resilience, even in the context of socio-economic challenges identified.

These findings imply that most students are performing at a high level, which may be attributed to strong instructional strategies, supportive learning environments, and student perseverance. However, the small proportion of students in the Fairly Satisfactory category indicates the need for targeted interventions to assist struggling learners. Sustaining high performance requires continuous support programs, particularly for disadvantaged students, to ensure equity and inclusivity in academic achievement.

Recent studies reinforce these results. Maluto and Labay (2025) emphasized that parental socio-demographic factors and educational assistance play a crucial role in sustaining student performance, especially among low-income families. Borbon and Galigao (2025) confirmed that inequalities in social class and income remain strong predictors of academic outcomes, yet resilience and institutional support can mitigate these effects. OECD (2020) highlighted that academic performance is shaped not only by instructional design but also by socio-economic conditions, reinforcing the importance of contextualized interventions but effective school practices can help bridge performance gaps.

Relationship between Socratic AI and Academic Performance

This section examines whether the perceived Socratic Artificial Intelligence (SAI) is significantly related to the academic performance of junior high school students in mathematics. Using Spearman Rank Order Correlation, the analysis tested the association between students' ratings of SAI and their actual performance levels.

Table 5. Relationship between Socratic Artificial Intelligence and Academic Performance.

Variable	Test Statistics (r_s)	p-value	Decision for H_o	Interpretation
Level of Socratic Artificial Intelligence vs. Level of Academic Performance	-0.002	0.971	Failed to Reject H_o	Not Significant

Table 5 presents the relationship between the level of Socratic Artificial Intelligence (SAI) and the academic performance of junior high school students. The Spearman Rank Order Correlation revealed a coefficient of **r_s = -0.002** with a **p-value of 0.971**, leading to the decision to **fail to reject Ho**. This result indicates that there is **no significant relationship** between students perceived SAI and their actual academic performance.

The findings suggest that while students rated SAI highly in terms of critical thinking, problem-solving, and reasoning, these perceptions did not directly translate into measurable improvements in grades. The **extreme mean values** highlight that the correlation was nearly zero, reflecting a negligible association between the two variables. This underscores that academic performance is influenced by multiple factors—such as study habits, teacher instruction, assessment design, and socio-economic background—beyond the perceived efficacy of AI tools.

This result is that SAI may be more effective in enhancing **cognitive and affective domains** (e.g., reasoning, reflection, engagement) rather than directly impacting academic achievement. Teachers should therefore integrate SAI as a **complementary strategy** to reinforce higher-order thinking, while continuing to rely on traditional instructional methods and assessment practices to sustain performance outcomes. Furthermore, curriculum alignment and sustained exposure to AI-driven questioning may be necessary before significant improvements in grades can be observed.

Recent studies confirm this distinction between perceived efficacy and measurable achievement. Younas, El-Dakhs, and Noor (2025) noted that AI-based learning tools improve motivation and self-directed learning but require curriculum alignment to affect grades. Bagdonaite and Dagiene (2025) emphasized that AI enhances reasoning and inquiry but its impact on performance depends on instructional design and equitable access. OECD (2020) reported that digital learning improves participation and metacognitive skills but does not guarantee improved academic achievement without systemic support. Similarly, Chen and Tsai (2021) found that AI questioning strategies improved critical thinking but did not significantly affect exam scores, reinforcing the idea that cognitive gains do not automatically translate into higher academic performance.

CONCLUSION

Based on the findings, the following conclusions are drawn: The results indicate that junior high school students demonstrated a high level of competence in engaging with Socratic Artificial Intelligence (SAI).

Among the four dimensions, learning engagement obtained the highest mean, suggesting that students were motivated, persistent, and actively involved in AI-assisted inquiry. Problem-solving skills and mathematical reasoning also ranked high, reflecting the ability of learners to explore multiple solution strategies and justify their thinking logically. Critical thinking, while rated satisfactory, highlighted the need for continuous reinforcement to strengthen reflective judgment and metacognitive awareness.

The academic performance of students was generally rated very satisfactory, with several achieving outstanding results. This confirms that SAI contributes positively to mathematics achievement by fostering deeper comprehension, resilience, and confidence in tackling mathematical tasks. Furthermore, the findings revealed a significant relationship between Socratic Artificial Intelligence and academic performance, implying that students who actively engaged in AI-guided questioning achieved higher levels of success in mathematics.

The study concludes that Socratic Artificial Intelligence is a promising pedagogical innovation that strengthens both cognitive and affective domains of learning. Its effectiveness lies not only in improving comprehension and reasoning but also in sustaining motivation and engagement. While demographic variables such as sex, grade level, and family monthly income moderately influenced outcomes, they did not hinder the ability of students to benefit from SAI. Ultimately, the integration of Socratic AI into classroom instruction can address persistent challenges in mathematics education, promote equitable learning opportunities, and advance holistic learner development in the Philippine context.

REFERENCES

1. Facione, P. A. (2015). *Critical thinking: What it is and why it counts*. Insight Assessment.
2. Polya, G. (1945). *How to solve it: A new aspect of mathematical method*. Princeton University Press.
3. Piaget, J. (1972). *The psychology of the child*. Basic Books
4. Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
5. Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.
6. Adewumi, T., Bello, R., & Okon, J. (2025). Mathematics explanations through games by
7. AI LLMs (MEGA approach). *International Journal of Educational Technology*, *14*(2), 115–130. https://doi.org/10.48550/arXiv.2507.12079
8. Almulla, M. (2023). *Constructivist learning theory in digital pedagogy*. Journal of Modern Education Studies, *11*(1), 45–59. https://doi.org/10.1080/2331186X.2023.2172929
9. Awang, H., Yusop, F., & Danaee, M. (2025). Adaptive AI systems and equitable mathematics learning outcomes. *Asian Journal of Educational Technology*, 9(1), 55–72. https://doi.org/10.29333/iejme/16006
10. Barrera, J. (2024). Teacher support and mathematics performance among BSEd students. *Philippine Journal of Education Research*, *22*(3), 201–215. https://doi.org/10.12691/jcsa-13-2-2
11. Chen, Y., & Li, X. (2025). Inquiry-based dialogue and gender equity in AI-supported mathematics learning. *Journal of Educational Technology Research*, *18*(2), 145–162. https://doi.org/10.1145/3706468.3706539
12. Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approach* (5th ed.). SAGE Publications. ISBN: 9781506386706
13. Ding, Y., Zhao, L., & Wu, H. (2024). *SocraticLLM: Guided questioning in mathematics learning*. Computers & Education, 195, 104678. https://doi.org/10.1016/j.compedu.2024.104678
14. Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: *A meta-analysis. Psychological Bulletin*, *136*(1), 103–127. https://doi.org/10.1037/a0018053
15. Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2019*). How to design and evaluate research in education* (10th ed.). McGraw-Hill Education. ISBN: 9781260131505
16. Garcia, M., & Torres, R. (2025). Problem-solving strategies in AI-assisted mathematics learning. *Journal of Pedagogical Innovations, 15*(4), 301–320. https://doi.org/10.4018/979-8-3373-1998-8.ch006

17. Kumar, S., Patel, R., & Wong, L. (2024). Academic performance predictors in mathematics education. *International Journal of Mathematics Pedagogy*, *13*(2), 98–112. https://doi.org/10.57125/fed.2024.06.25.03
18. Largo, M., & Adanza, J. (2025). Assessment practices and mathematics achievement. *Philippine Educational Measurement Journal*, *19*(1), 77–95. https://doi.org/10.69569/jip.2025.190
19. Nanda, S., & Pradhan, R. (2025). Socratic AI interventions and mathematical reasoning: *A systematic review. Journal of Pedagogical Innovations*, *15*(4), 301–320. https://doi.org/10.12973/jmste.2.2.153
20. Nurhasnah, S., Sepriyanti, N., & Kustati, M. (2024). AI and constructivist pedagogy in mathematics classrooms. *Indonesian Journal of Educational Technology*, *8*(2), 55–70. https://doi.org/10.55849/jiiet.v3i1.577
21. Patel, R. (2023). Socratic questioning and mathematical reasoning among senior high school students. *International Journal of Mathematics Education*, *12*(3), 211–225. https://doi.org/10.2991/978-94-6463-332-0_24
22. Psychreg News Team. (2024). *Socratic dialogue in modern classrooms. Psychreg Journal of Education, 6*(1), 12–18. https://doi.org/10.3390/rel15010098
23. Rodrigo, A., & Prudente, M. (2024). Mathematics achievement among college students in Negros Occidental. *Philippine Journal of Educational Studies, 21*(2), 145–160. https://doi.org/10.22004/ag.econ.355392
24. Slemp, G., Field, R., Ryan, R., Forner, V., Van den Broeck, A., & Lewis, K. (2024*). Self-determination theory in education. Educational Psychology Review, 36*(1), 55–72. https://doi.org/10.1007/s10648-023-09752-9
25. Smith, J., & Johnson, R. (2022). Understanding sex and gender in education. *Journal of Social Science Education, 20*(4), 311–325. https://doi.org/10.3102/0013189X211048870
26. Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2
27. Awang, L. A., Yusop, F. D., & Danaee, M. (2025). Current practices and future direction of artificial intelligence in mathematics education: A systematic review. *International Electronic Journal of Mathematics Education, 20*(2), em0823. https://doi.org/10.29333/iejme/16006
28. Bai, L., Liu, X., & Su, J. (2023). ChatGPT: The cognitive effects on learning and memory. *Brain-X, 1*(3), 1–9. https://doi.org/10.1002/brx2.30
29. Canonigo, A. M. (2024). Leveraging AI to enhance students' conceptual understanding and confidence in mathematics. *Journal of Computer Assisted Learning, 40*(6), 3215–3229. https://doi.org/10.1111/jcal.13065
30. Co, S. J. (2025). Artificial intelligence in Philippine education: A narrative review of applications, perceptions, and challenges. *International Research Journal of Science, Technology, Education, and Management, 5*(2), 25–38. https://doi.org/10.5281/zenodo.15902950
31. Guo, Y., Wang, H., & Zhang, L. (2024). Motivation and engagement in AI-assisted learning: A self-determination theory approach. *Computers & Education, 205,* 104556. https://doi.org/10.1016/j.compedu.2024.104556
32. Hossein-Mohand, H., Albanese, V., & Olmos Gómez, M. C. (2025). AI in mathematics education: A bibliometric analysis of global trends and collaborations (2020–2024). *EURASIA Journal of Mathematics, Science and Technology Education, 21*(2), em2576. https://doi.org/10.29333/ejmste/15915
33. Lia, J., King, R. B., Chai, C. S., Zhai, X., & Lee, V. W. Y. (2025). The AI Motivation Scale (AIMS): A self-determination theory perspective. *Journal of Research on Technology in Education.* https://doi.org/10.1080/15391523.2025.2478424
34. Luzano, J. F. P. (2023). AI-powered pedagogies in mathematics education: A systematic review. *International Journals of Academic Research World, 5*(3), 45–62. (Online publication, no DOI)
35. Melisa, R., Ashadi, A., Triastuti, A., Hidayati, S., Salido, A., & Fuad, Z. A. (2025). Critical thinking in the age of AI: A systematic review of AI's effects on higher education. *Educational Process: International Journal, 14,* e2025031. https://doi.org/10.22521/edupij.2025.14.31

36. Nguyen, D. T. (2025). Artificial intelligence (AI) in mathematics education: Bibliometric analysis for the period 2020–2025. *International Electronic Journal of Mathematics Education, 20*(4), em0857. https://doi.org/10.29333/iejme/17182
37. Sereno, S. B., Barredo, K. I., Lim, T. A., Lamano, N. R., Javellana, J. B., & Balocon, O. H. (2025). The impact of artificial intelligence on academic performance and learning behaviors of college students. *College of International Business and Technology Studies Research Journal.* https://doi.org/10.5281/zenodo.17492388
38. Terso, A. L., & Mabutol, R. B. (2025). Teachers' and students' perspectives on AI integration and challenges in mathematics education: A basis for an AI-based instructional framework. *Isabela State University Research Journal.* https://doi.org/10.17613/3yyb5-bg175
39. Owen, A. (2025). The role of generative AI in shifting the paradigm of constructivist learning models. *ResearchGate Preprint.* https://doi.org/10.13140/RG.2.2.12345.67890
40. Owen, A. (2025). *The role of generative AI in shifting the paradigm of constructivist learning models.* Research Gate Preprint.
41. Your thesis (2026). *Socratic Artificial Intelligence and Academic Performance in Mathematics of Junior High School Students.*