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The Influence of Interactive Learning Skills on Metacognitive Strategies Among College Students in Mathematics

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Abstract

Metacognitive strategies in mathematics remain a challenge for many college students, impacting their ability to apply concepts effectively. This study examined the influence of interactive learning skills on metacognitive strategies among college students in mathematics. Using a descriptive-correlational research design, data were collected from 100 randomly selected students through validated questionnaires. Results indicated that interactive learning skills significantly enhance metacognitive strategies. However, findings suggest that motivation, instructional design, and learning preferences also influence metacognitive development. These results affirm Vygotsky's Social Constructivist Theory (1978), emphasizing the role of collaboration in cognitive growth. Future research may explore additional factors affecting metacognitive strategies, and educators should integrate structured interactive learning techniques to strengthen students' problem-solving abilities

Keywords: *Interactive Learning, Metacognitive Strategies, Mathematics Education, Self-Regulation, Problem-Solving*

1. INTRODUCTION

Metacognitive strategies in mathematics remain a significant challenge for college students, as many struggle to regulate their learning processes effectively. Despite possessing content knowledge, students often fail to recognize when and how to apply specific mathematical concepts, leading to difficulties in problem-solving and self-monitoring (Laistner, 2016). Studies indicate that students who actively employ metacognitive strategies such as planning, monitoring, and evaluating demonstrate improved mathematical achievement (Ma, 2024). However, many college students exhibit inconsistent use of these strategies, with self-monitoring emerging as a particularly weak area (Anggo, et al, 2021). This lack of metacognitive regulation negatively impacts mathematical confidence and problem-solving efficiency (Li, 2024). Addressing these challenges requires a deeper exploration of how interactive learning skills can foster the development of metacognitive strategies among college students in mathematics.

Metacognitive challenges in mathematics education are prevalent across various countries, highlighting a global issue in students' ability to regulate their learning processes. In Turkey, research has found that students often fail to implement metacognitive strategies effectively in mathematical problem-solving, which negatively impacts their ability to analyze and apply problem-solving techniques (Erbas & Okur, 2012). Similarly, in Indonesia, despite early exposure to mathematics, students struggle with self-regulation in metacognitive strategies, contributing to their poor performance in international assessments like PISA and TIMMS (Cahayasti & Indrasari, 2018). In the United States, a study on STEM students emphasized the necessity of integrating metacognitive strategies to improve critical thinking and problem-solving abilities, as many college students lack the skills to evaluate their mathematical reasoning effectively (Mariano, et al, 2021).

The Philippines is no exception to this widespread problem, as many college students also face difficulties in utilizing metacognitive strategies effectively. A study conducted at Emilio Aguinaldo College-Cavite revealed that while students attempt to use self-motivation and self-monitoring techniques, distractions and weak regulation strategies significantly hinder their academic performance in mathematics (Reyes-Chua et al., 2023). In Mindanao, research on metacognitive and computation skills among college students found that despite these being essential for critical thinking in mathematics, students exhibit inconsistent application of these strategies, resulting in low mathematical achievement (Baraquia, 2024). Furthermore, a study in Aplaya National High School, Misamis Oriental, confirmed that students who were taught mathematics using traditional strategies performed significantly worse than those who engaged with metacognitive strategies, indicating a gap in instructional approaches that should be addressed (Gaylo & Dales, 2017). These findings underscore the urgent need to examine how interactive learning skills can support metacognitive strategy development to improve mathematical problem-solving and academic achievement among college students in the Philippines.

The persistence of weak metacognitive strategies among college students in mathematics has significant consequences, leading to poor academic performance, decreased problem-solving abilities, and low self-efficacy in mathematical tasks (Ma, 2024). Many students struggle with self-monitoring and regulation, resulting in difficulties in applying mathematical concepts effectively (Ingole & Pandya, 2016). Despite extensive research on metacognitive strategies, a gap remains in understanding how interactive learning skills can enhance these strategies among college students, as most studies focus on high school learners (Macabecha et al., 2024). Furthermore, current research does not fully explore the potential of interactive learning techniques in strengthening students' ability to plan, monitor, and evaluate their mathematical reasoning (Kaur & Kaur, 2011). Addressing this gap is urgent, as improving metacognitive strategy use through interactive learning interventions could significantly enhance students' mathematical performance and independent learning, preparing them for academic success and future careers in STEM fields.

2. RESEARCH METHOD

This study employed a non-experimental, quantitative research design using a descriptive-correlational method to examine the relationship between interactive learning skills and metacognitive strategies among college students in mathematics. In this approach, variables were not manipulated but observed to determine their relationships (Johnson, 2001; Rutberg & Bouikidis, 2018). Descriptive-correlational research is widely used in education to analyze and describe existing conditions while identifying possible relationships between variables (Koh & Owen, 2000). This design is particularly useful for assessing the influence of interactive learning skills on students' metacognitive strategies in mathematics.

The research was conducted at a local college in Region XI, Mindanao, Philippines, known for its commitment to innovative teaching practices and holistic education. This institution provides a diverse academic environment, making it a suitable setting for studying the relationship between interactive learning skills and metacognitive strategies in mathematics. The study sample consisted of 100 randomly selected students from a total of 320 enrolled students across four academic programs: Bachelor of Early Childhood Education (BECEd), Bachelor of Technical-Vocational Teacher Education (BTVTEd) Major in Computer Programming, BTVTEd Major in Heating, Ventilating, Air-Conditioning, and Refrigeration Technology (HVACRT), and Bachelor of Science in Entrepreneurship (BSE). Simple random sampling ensured all students had an equal chance of selection, reducing bias and increasing the generalizability of the findings (Noor et al., 2022).

Data were collected using a combination of researcher-developed and adapted questionnaires to assess both interactive learning skills and metacognitive strategies. The Interactive Learning Skills Questionnaire was developed based on Boaler (2022) and contained 25 items categorized into five indicators: teamwork, communication skills, problem-solving approach, helping each other, and learning from each other. The instrument underwent expert validation and a pilot test with 30 respondents, achieving a Cronbach’s alpha of .973, indicating high reliability (Ma, 2024). Responses were rated on a 5-point Likert scale, ranging from "very low" to "very high," to determine the frequency of observed interactive learning skills.

The Metacognitive Strategies Questionnaire, adapted from Schraw and Dennison (1994), contained 52 items categorized into eight indicators: declarative knowledge, procedural knowledge, conditional knowledge, planning, information management strategies, monitoring, debugging strategies, and evaluation. The instrument underwent expert validation and a pilot test with a similar sample size, achieving Cronbach’s alpha of .985, demonstrating high reliability (Reyes-Chua et al., 2023). Responses were measured using a 5-point Likert scale, categorizing metacognitive strategy use from "very low" to "very high."

The data collection process followed strict ethical guidelines. Formal approval was obtained from the OIC College President, and official authorization was secured before conducting the study. Experts reviewed the questionnaire to ensure validity and reliability, incorporating feedback for content improvement. Respondents were briefed on the study’s purpose, scope, and voluntary participation. Surveys were conducted via

Google Forms, ensuring secure online responses. To enhance data consistency and reliability, responses were collected within a single day.

Data analysis utilized both descriptive and inferential statistics. Mean scores were calculated to assess the levels of interactive learning skills and metacognitive strategies (Moore, McCabe, & Craig, 2013). Pearson Product-Moment Correlation Coefficient was used to measure the strength and direction of the relationship between interactive learning skills and metacognitive strategies (Hair et al., 2013). The correlation was categorized as follows: 0.00–0.40 (weak relationship), 0.41–0.60 (moderate relationship), and 0.61–1.00 (strong relationship). Additionally, multiple linear regression analysis was performed to examine the predictive influence of interactive learning skills on metacognitive strategies in mathematics, allowing for the identification of specific interactive learning components that significantly impact metacognitive strategy use (Ma, 2024).

Strict ethical considerations were maintained in compliance with the Data Privacy Act of 2012. Respondents were fully briefed on the study's purpose and assured of voluntary participation, with the option to withdraw at any time without consequences. Confidentiality was ensured by anonymizing personal information and responses, and all data were securely stored and accessible only to authorized personnel. The study was designed to avoid any physical or psychological harm to respondents, and transparency was upheld by accurately reporting findings with no conflicts of interest disclosed (Reyes-Chua et al., 2023).

3. RESULTS AND DISCUSSION

Table 1 presents descriptive statistics for two key areas: Interactive Learning Skills and Metacognitive Strategies, summarizing their Standard Deviation (SD), Mean scores, and Descriptive Levels. Overall, both categories exhibit high mean scores, indicating that students demonstrate intense interactive learning and metacognitive skills.

Table 1. Descriptive Levels

	SD	Mean	Descriptive Level
Interactive Learning Skills	**0.67**	**3.87**	**High**
Teamwork	0.78	4.00	High
Communication Skills	0.75	3.70	High
Problem-Solving Approach	0.70	3.72	High
Helping each other	0.74	3.84	High
Learning from each other	0.77	4.07	High
Metacognitive Strategies	**0.61**	**3.83**	**High**

Declarative Knowledge	0.72	3.69	High
Procedural Knowledge	0.73	3.80	High
Conditional Knowledge	0.75	3.83	High
Planning	0.70	3.84	High
Information Management Strategies	0.72	3.79	High
Monitoring	0.69	3.85	High
Debugging Strategies	0.74	3.97	High
Evaluation	0.71	3.88	High
Metacognitive Strategies	0.61	3.83	High

For Interactive Learning Skills, the overall mean score is 3.87, which falls under the high descriptive level. Among the subcategories, Learning from Each Other has the highest mean score (4.07), suggesting that students greatly benefit from peer collaboration. Conversely, Communication Skills has the lowest mean (3.70), which, while still high, indicates a potential area for improvement. The standard deviations (SDs) in this category range from 0.67 to 0.78, showing moderate variability in responses.

Similarly, for Metacognitive Strategies, the overall mean is 3.83, also classified as high. The subcategory Debugging Strategies scored the highest (3.97), indicating that students are effective in identifying and correcting their mistakes. Meanwhile, Declarative Knowledge has the lowest mean (3.69), suggesting that students may need additional support in understanding and recalling factual information. The standard deviations in this category range from 0.61 to 0.75, indicating relatively consistent responses among participants.

These findings suggest that students are proficient in both interactive learning and metacognitive strategies. However, communication skills and declarative knowledge could be further developed to enhance their overall learning experience. To address these areas, educators could incorporate more structured discussions, presentations, and interactive learning activities to improve communication skills. Additionally, reinforcing declarative knowledge through quizzes, concept mapping, and active recall exercises could help students retain factual information more effectively. Given that students already demonstrate strong debugging strategies, educators can leverage this skill in problem-solving activities to further enhance learning outcomes.

Several studies support these findings, reinforcing the notion that metacognitive skills and interactive learning play a crucial role in enhancing student learning and retention. For instance, Stanton et al. (2021) emphasize that metacognitive skills significantly improve learning outcomes by fostering better control over cognitive processes, monitoring learning strategies, and enhancing self-awareness in academic tasks. Similarly, Bahri (2017) found a strong positive correlation between metacognitive strategies and student retention, particularly in classrooms that integrated problem-based learning and questioning techniques. The study highlights that students with higher metacognitive awareness tend to retain and recall information more effectively. Further, Swanson et al. (2024) demonstrated that metacognition-based academic interventions significantly improved students' confidence, preparedness for exams, and overall performance, reinforcing the idea that structured metacognitive training enhances academic success.

However, not all research aligns with these findings, as some studies suggest limitations to the effectiveness of metacognitive strategies. While metacognitive strategies improved students' collaborative skills, they did not significantly impact academic achievement or subject-specific knowledge retention. This suggests that metacognitive interventions alone may not be sufficient to enhance student learning without additional instructional support (Susantini et al., 2018). Similarly, study on metacognitive strategies in digital learning environments found that while some strategies positively influenced students' perceived learning performance, others had a negative impact, indicating that metacognition is not universally effective across all educational settings (Anthonysamy et al., 2020). Additionally, while students developed metacognitive awareness during their studies, this awareness did not directly translate to improved academic performance unless it was actively applied to learning tasks. Their findings suggest that metacognitive knowledge alone is insufficient for academic success and must be coupled with structured learning strategies (Gundlach & Santangelo, 2021).

In conclusion, while the table suggests that students demonstrate strong interactive learning and metacognitive strategies, research presents both supporting and conflicting perspectives on their effectiveness. Some studies confirm that metacognition enhances retention, problem-solving, and academic achievement, while others highlight that its impact varies depending on how it is implemented. Thus, educators should ensure that metacognitive and interactive learning strategies are properly structured, context-specific, and reinforced through content-based instruction to maximize their effectiveness in student learning.

Table 2. Relationship Between Variables

	Metacognitive Strategies			
	r	p-value	Interpretation	Decision on H_o
Interactive Learning Skills	.806	.000	Reject	Significant

The table presents the correlation between Interactive Learning Skills and Metacognitive Strategies, showing a strong positive relationship with a Pearson correlation coefficient of 0.806 and a p-value of 0.000. This indicates that as students develop stronger interactive learning skills, their metacognitive strategies also improve. Since the p-value is below the standard significance level of 0.05, the null hypothesis (H_o) is rejected, confirming that the relationship between these variables is statistically significant and unlikely to be due to chance. The strong correlation suggests that students who actively engage in collaborative learning, problem-solving, and peer interactions are also more likely to exhibit higher-order cognitive skills, such as planning, monitoring, and evaluating their learning processes.

This finding aligns with existing research that highlights the interdependence of interactive learning and metacognition. Students engaged in problem-based learning and questioning techniques demonstrated higher metacognitive awareness and improved retention, emphasizing the role of interactive learning in metacognitive skill development (Bahri, 2017). Similarly, 54.9% of cognitive learning outcomes were attributed to metacognitive skills, highlighting the significance of structured, interactive learning strategies in enhancing metacognition (Kristiani, 2016). Additionally, a study found that a Vee Diagram-based learning approach effectively improved metacognitive engagement, enabling students to actively monitor and regulate their learning (Soesilawaty et al., 2019).

However, some studies challenge the universal effectiveness of metacognitive strategies, suggesting that their impact varies depending on context and learner characteristics. Gutiérrez de Blume & Montoya Londoño (2021) found that metacognitive skills are not universally applicable across disciplines, as students in different academic fields (e.g., psychology, education, and medicine) exhibited significant variations in metacognitive abilities. Al-Momani (2024) argued that external factors such as motivation, teaching strategies, and curriculum design influence the effectiveness of metacognition, suggesting that it does not always guarantee improved academic performance. Furthermore, Antoanzas (2017) found that students often overestimate their metacognitive abilities, leading to ineffective learning strategies despite engagement in interactive learning. These findings suggest that while interactive learning fosters metacognitive development, its effectiveness is influenced by multiple factors, requiring further exploration into how instructional design and learner characteristics shape metacognitive outcomes.

Table 3. Predictive Strengths of Independent Variable

	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
(Constant)	0.978	0.214		4.561	.000
Interactive Learning Skills	0.738	0.055	0.806	13.499	.000

R =.806, R2 = .650, F-ratio = 182.236, p-value = .000

The table presents the regression analysis results, demonstrating the predictive strength of Interactive Learning Skills on Metacognitive Strategies. The unstandardized regression coefficient (B = 0.738, p = 0.000) indicates that for every unit increase in Interactive Learning Skills, Metacognitive Strategies improve by 0.738 units. The standardized Beta coefficient (β = 0.806) confirms a strong positive relationship between the two variables. Additionally, the t-value (13.499, p = 0.000) suggests that Interactive Learning Skills are a highly significant predictor of Metacognitive Strategies. The constant (B = 0.978, p = 0.000) represents the expected value of Metacognitive Strategies when Interactive Learning Skills are at zero. The model's overall significance (p = 0.000) and the high F-ratio (182.236) further indicate that the regression equation effectively explains variations in the dependent variable.

The coefficient of determination ($R^2 = 0.650$) suggests that Interactive Learning Skills can explain 65% of the variance in Metacognitive Strategies, while the remaining 35% is attributed to other factors such as motivation, instructional approaches, or individual learning styles. This strong predictive ability suggests that students who engage more in interactive learning, such as group discussions, peer collaborations, and active problem-solving, are likely to develop more effective self-regulation, planning, and evaluation strategies in their learning processes. Given that a substantial portion of metacognitive strategy development remains unexplained by this model, future research should explore additional influences such as student motivation, self-efficacy, and instructional design to understand better the full range of factors contributing to metacognitive growth. These findings highlight the importance of integrating structured interactive learning techniques to foster metacognitive skills and enhance student learning outcomes.

This aligns with previous research emphasizing the positive role of interactive learning in developing metacognitive skills. Kristiani (2016) found a significant correlation between metacognitive skills and cognitive learning outcomes, where scientific learning strategies accounted for 54.9% of the variance in metacognitive abilities, reinforcing the idea that interactive learning fosters self-regulation. Similarly, Bahri (2017) demonstrated that students who engaged in problem-based learning (PBL) and reading-questioning-answering (RQA) strategies developed significantly stronger metacognitive skills and retention rates. Furthermore, Kusuma & Busyairi (2024) found a very high correlation ($r = 0.945$) between metacognitive skills and cognitive outcomes, indicating that structured interactive learning significantly enhances self-regulated learning. These findings collectively support the strong predictive power of Interactive Learning Skills in developing metacognitive abilities.

However, some research challenges the extent to which interactive learning directly influences metacognition, suggesting that other external factors play a crucial role. Vettori et al. (2018) found that only self-assessment, among several metacognitive skills, had a direct positive effect on academic performance, suggesting that not all metacognitive strategies are equally effective. Additionally, Siburian & Mardiyanti

(2023) found that metacognition explained only 20% of students’ meta-skills development, indicating that factors like motivation, learning styles, and self-efficacy significantly contribute to learning outcomes. Moreover, Wang et al. (2021) argued that self-control and interest in learning play a more crucial role in academic engagement than metacognitive strategies alone, challenging the assumption that interactive learning directly enhances metacognitive development. These contrasting findings suggest that while Interactive Learning Skills strongly predict Metacognitive Strategies, the relationship is not absolute, and educators must consider other variables, such as student motivation, interest, and instructional design, to maximize metacognitive growth

4. CONCLUSION

Based on the findings of this study, it is concluded that interactive learning skills have a significant influence on metacognitive strategies among college students in mathematics. Students who engage in collaborative learning, problem-solving, and peer discussions demonstrate improved self-regulation, planning, and evaluation in their mathematical learning processes. This conclusion affirms Vygotsky’s Social Constructivist Theory (1978), which highlights the role of social interaction in cognitive development. The findings support the idea that learning is enhanced through guided collaboration and meaningful discourse with peers. However, while interactive learning positively contributes to metacognitive strategy development, other factors such as motivation, instructional design, and individual preferences also play a role. This suggests that while Social Constructivism provides a strong theoretical foundation for understanding learning processes, a more comprehensive approach incorporating cognitive and motivational elements could further enhance students' ability to regulate their learning in mathematics

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