Metacognitive Strategy On Students' Mathematics Self-Efficacy And Critical Thinking Skills

Elmer A. Macabecha[1], Khaiser T. Tangcogo[2], Mariel Rose E. Sawit[3] and Jenyliza T. Ucang[4]

Science Education Department, Central Mindanao University, University Town, Musuan, Bukidnon, 8710 Philippines.

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Abstract: This study looks into the effects of employing metacognitive strategies on the self-efficacy towards Mathematics and critical thinking skills of Grade 10 students. The participants were grouped according to metacognitive and non-Metacognitive groups. The results demonstrated a significant improvement in the self-efficacy towards Mathematics among students in the metacognitive Group (mean=3.60) compared to the non-metacognitive Group (mean=3.11). The findings highlight the effectiveness of metacognitive strategies in fostering a more positive self-efficacy towards Mathematics. Despite the intervention, both groups exhibited similar levels of critical thinking skills, suggesting that metacognition might not directly influence this aspect. Nevertheless, a noteworthy distinction in self-efficacy towards Mathematics was observed between the two groups, indicating that students exposed to metacognitive approaches experience more favourable outcomes than those in the non-Metacognitive Group. Additionally, an Analysis of Covariance (ANCOVA) demonstrated a significant difference in critical thinking skills between the metacognitive and non-Metacognitive groups, with the former exhibiting superior necessary thinking abilities. These results underscore the importance of incorporating metacognitive techniques in educational settings to enhance both self-efficacy and critical thinking skills in Mathematics students.

Keywords: metacognitive strategy, self-efficacy, critical thinking skills

1. Introduction

Mathematics is essential to the K to 12 Basic Education Curriculum, transcending traditional classroom settings and permeating various aspects of life. Teachers provide strategies to improve understanding based on the curriculum to ensure comprehensive learning. The curriculum must emphasize developing critical thinking skills among Junior High School learners. Critical thinking entails self-guided, disciplined reasoning for high-quality, fair-minded problem-solving [1][2]. Notably, critical thinking is closely linked to self-efficacy [3], where individuals with higher self-efficacy are inclined to view challenging tasks as opportunities for mastery [4].

The Programme for International Student Assessment (PISA) results have shed light on the challenges faced by Filipino learners in applying their mathematical knowledge and critical thinking skills to real-life situations. Regrettably, the Philippines ranked second from the lowest among 79 participating countries in the 2018 PISA ranking [5]. Most Filipino learners struggle with solving problems requiring more than direct inference and using information from various sources. Similarly, the mathematics teachers at Langcataon National High School have encountered the reality that students' higher-order thinking skills, particularly critical thinking, remain underdeveloped, as evidenced by their recent National Achievement Test (NAT) performance. The school's mean percentage scores of 31.84%, 60.0%, and 73.91% for the consecutive school years 2012-2013, 2013-2014, and 2014-2015 were below the standard mean percentage score of 75%.

In light of these challenges, mathematics teachers, as facilitators of the teaching and learning process, are responsible for providing rigorous and high-quality mathematics instruction. Metacognitive strategies emerge as a valuable tool in this endeavour, enabling learners to monitor and control their learning, including cognitive strategies. As learning is an active process, students' engagement in a learning task is influenced by various motivational factors.

This research addresses these concerns, which aims to evaluate the impact of metacognitive strategies on the self-efficacy and critical thinking skills of Grade 10 students at Langcataon National High School during the School Year 2022-2023. By exploring the effects of metacognition on students' mathematical abilities and higher-order thinking, this study provides valuable insights for enhancing mathematics education and fostering critical thinking among learners.

2. Methods and Materials

This pretest-posttest quasi-experimental study aimed to assess the effectiveness of metacognitive strategy in enhancing self-efficacy and critical thinking skills in Mathematics among Grade 10 students at Langcataon National High School during the third quarter of the School Year 2022-2023. Two intact Grade 10 classes were selected through simple random sampling. The Experimental Group, the Metacognitive Group, received instruction using metacognitive strategies, while the control group, the non-metacognitive Group, received conventional instruction. Both groups were heterogeneous.

The primary data sources for this study were the students' scores on the Mathematics Self-efficacy Scale, the pretest, and the post-test. The Mathematics Self-Efficacy Scale, adapted from the work of Gafoor & Ashraf [6], consisted of forty statements. The scale was pilot-tested, and its reliability was established with a Cronbach's alpha coefficient of 0.802. Students responded using a five-point rating scale, ranging from 5 (strongly agree) to 1 (strongly disagree), with negative statements reverse-scored.

The pretest and post-test questionnaires were derived from the Learners' Module and Teacher's Guide the Department of Education provided. The questionnaire included ten mathematical problems for the students to solve. To evaluate students' critical thinking skills, the adapted Critical Thinking Guidelines with four indicators, based on the work of Zulkarnain, Kusumawati & Mawaddah [7], were employed to assess and score students' answers. The results were then interpreted using the K to 12 standards concerning DepEd Order No. 8, s. 2015, to determine the students' levels of critical thinking skills.[8]

The study design utilized a quasi-experimental approach due to the existing intact class structure. The data collected were subjected to statistical analysis to evaluate the impact of the metacognitive strategy on students' self-efficacy and critical thinking skills in Mathematics. Ethical considerations were considered, and informed consent was obtained from students and their parents or guardians. The study's limitations included the relatively small sample size and the limited scope of the study to a single school and grade level. Nevertheless, the findings are expected to provide valuable insights for enhancing teaching methods and fostering higher-order thinking skills in Mathematics education. The levels of students' self-efficacy towards Grade 10 Mathematics and critical thinking skills were analyzed using descriptive statistics, including measures such as mean, standard deviation, frequency, and percentage. In examining the differences between the pretest and post-test scores for critical thinking skills, the Analysis of Covariance (ANCOVA) was employed, using the pretest scores as a covariate to eliminate possible group effects.

Similarly, the Analysis of Covariance (ANCOVA) was used to determine the differences in students' self-efficacy towards Mathematics and critical thinking skills, considering the instructional treatments applied to the two groups.

3. Results and Discussions

This section presents the analysis and interpretation of data gathered from the participants. Tables were also presented to analyze the data.

3.1 Students' Self-Efficacy towards Mathematics Between the Metacognitive and Non-Metacognitive Group

The table 1 shows insights that both groups had shown evidence of experiencing positive changes in their self-efficacy, especially regarding their perceptions of teacher and peer support. This finding supports the idea that a supportive learning environment, with approachable teachers and helpful peers, can foster a sense of optimism and belief in their ability to handle challenging mathematical tasks.

Table 1: Students' Self-Efficacy towards Mathematics Between the Metacognitive and Non-Metacognitive Group

SELF-EFFICACY TOWARDS MATHEMATICS	METACOGNITIVE GROUP		NON-METACOGNITIVE GROUP	
	Mean	Qualitative Interpretation	Mean	Qualitative Interpretation
I can arrange the help of my teachers in learning Mathematics.	4.07	P	3.26	MP
I am assured that I have a few friends who would be helpful in my study	4.04	P	3.19	MP
During examinations, I can recollect what I have learnt.	4.00	P	3.37	MP
I cannot accomplish challenging tasks and problems in my study. *	3.96	P	3.04	MP
If taught, I can prepare my notes neatly.	3.93	P	3.26	MP
I failed to develop a healthy relationship with my teachers. *	3.89	P	3.07	MP
I cannot complete the homework without help from guidebooks, previous notes, and more. *	3.89	P	2.70	MP
If I try, I can become one of the good grade holders.	3.89	P	3.37	MP
I observe that I fail to prepare my assignments in time. *	3.85	P	2.70	MP
I can do my projects well.	3.81	P	3.04	MP
I can accomplish my aims in learning Mathematics.	3.74	P	3.30	MP
I cannot deal efficiently with the unexpected problems in my study. *	3.74	P	2.96	MP
I cannot keep things unforgotten. *	3.67	P	3.07	MP
I can handle disturbing situations in my study.	3.67	P	2.96	MP
I can answer it well if a sudden test is conducted for us without notice.	3.67	P	3.26	MP
I am weak in understanding the classes of my teachers. *	3.63	P	3.11	MP
I can develop the skills required to learn school Mathematics.	3.63	P	3.48	MP
If I miss some classes, I can compensate for the loss reasonably well.	3.63	P	3.11	MP
I can be calm during the exam as I am conscious of my learning ability.	3.63	P	3.26	MP
I cannot read and understand my textbooks well. *	3.59	P	3.30	MP
I am quick to pick the points from what I read.	3.59	P	3.04	MP
I cannot express ideas well while attending Mathematics examinations. *	3.59	P	2.89	MP
It is difficult for me to read and understand the textbooks in the English language. *	3.59	P	2.96	MP
I can score well in the short answer type questions.	3.59	P	3.11	MP
I may clarify doubts from my teachers while in class even if I reach higher classes.	3.48	MP	2.96	MP
I cannot arrange the resources for my study from my relatives, neighbours, and more. *	3.44	MP	3.26	MP
I can utilize the available library facility for my study.	3.44	MP	2.96	MP
I am confident that I can perform well in competitive examinations.	3.44	MP	3.19	MP
I fail to find out the necessary sources for my study. *	3.41	MP	3.11	MP
However, twisted the question is, I can answer them.	3.41	MP	3.04	MP
When I study a new concept, I cannot recall the related knowledge from the earlier classes. *	3.37	MP	2.93	MP
I can arrange help from my peers for my Mathematics learning whenever needed.	3.30	MP	3.52	MP
I find several solutions when I confront problems in my study.	3.30	MP	3.11	MP
Often, I fail to comprehend the actual meaning of what I study. *	3.30	MP	3.11	MP
I cannot answer the questions which teachers ask me. *	3.30	MP	2.78	MP
I cannot manage time efficiently for learning Mathematics. *	3.26	MP	3.07	MP
	3.26	MP	3.11	MP
	3.22	MP	2.93	MP
	3.19	MP	3.22	MP
	3.52	P	3.26	MP
	3.60	P	3.11	MP

I failed to set higher goals in my studies. * I fail to find time for learning amid sundry chores. * I cannot answer the mathematical problems well. * I am competent in learning Mathematics. Overall Mean				

*Negative indicators (scoring is reversed)

Scale	Range	Qualitative Description	Interpretation
5	4.50 – 5.00	Exactly True	Highly Positive (HP)
4	3.50 – 4.49	Nearly True	Positive(P)
3	2.50 – 3.49	Uncertain	Moderately positive (MP)
2	1.50 – 2.49	Nearly False	Negative (N)
1	1.00 – 1.49	Exactly False	Highly Negative (HN)

However, despite the overall positive development, specific differences between the two groups are worth noting. The Metacognitive group showed neutrality in setting higher goals in their studies, answering mathematics problems, recalling previous lessons, and expecting help from their peers. This result suggests that while they have improved their self-efficacy in some areas, they may still need additional guidance in setting higher aspirations and taking more initiative in their learning process.

On the other hand, the Non-Metacognitive Group displayed lower mean scores in several indicators, indicating uncertainty and hesitation in accomplishing mathematical tasks and learning goals. The fact that they are uncertain about finishing assignments on their own and recalling previous knowledge implies a lack of confidence in their retention abilities and independent problem-solving skills.

Moreover, the Non-Metacognitive Group's difficulty in focusing on tasks and being easily distracted highlights potential challenges in self-regulation and time management, which are essential skills for academic success.

Overall, the results suggest that the intervention positively impacted both groups, but the Metacognitive group showed more promising improvements in various areas of self-efficacy towards Mathematics. This finding aligns with previous research highlighting the effectiveness of metacognitive strategies in fostering self-efficacy and independent learning skills [9][10].

To further support the findings, qualitative data such as student interviews or focus groups could be collected to gain deeper insights into students' perceptions and experiences of the intervention and its effects on their self-efficacy and learning behaviours. Additionally, conducting longitudinal studies to assess the long-term sustainability of these positive changes in self-efficacy and learning outcomes would be beneficial in understanding the lasting impact of metacognitive interventions.

The overall mean scores of 3.60 for the Metacognitive group and 3.11 for the Non-Metacognitive Group signify that the intervention positively impacted the students' self-efficacy towards Mathematics, particularly for the Metacognitive Group. This positive shift suggests that implementing metacognitive strategies contributed to improving students' confidence and belief in their ability to tackle mathematical challenges.

Both the metacognitive and non-Metacognitive groups demonstrated improved self-efficacy after receiving the interventions, indicating the effectiveness of these instructional approaches in enhancing students' attitudes towards Mathematics. Exposure to metacognitive techniques leads to a more positive attitude and increased self-confidence among students [11][12].

The improvement in students' self-efficacy towards Mathematics after the intervention, particularly in the Metacognitive Group, underscores the importance of incorporating metacognitive strategies in educational practices and gives valuable insights for educators seeking to enhance students' self-efficacy and overall learning experience in Mathematics and other subjects.

Table 2: Level of critical thinking skill in Math10 students exposed to metacognitive and traditional instruction

Range	Post-test				Qualitative Description
	METACOGNITIVE GROUP		NON-METACOGNITIVE GROUP		
	f	%	F	%	
90% and above 85% - 89% 80% - 84% 75% - 79% 74% and below	2 0 3 2 20	7.41 0 11.11 7.41 74.07	1 0 0 1 29	3.23 0 0 3.23 93.55	Very Good Good Sufficient Less Very Less
	$\bar{x}$ = 66.0 (Did Not Meet Expectations)		$\bar{x}$ = 44.74 (Did Not Meet Expectations)		

Legend:

Descriptive Rating	Range	Interpretation
Outstanding	90% and above	Very Good
Very Satisfactory	85% - 89%	Good
Satisfactory	80% - 84%	Sufficient
Fairly Satisfactory	75% - 79	Less
Didn't meet Expectations	74% and below	Very Less

The results indicate that students in the Metacognitive Group achieved a higher mean score of 66 than the Non-Metacognitive Group's mean score of 44.74. This significant difference in mean scores suggests that the Metacognitive Group outperformed the Non-Metacognitive Group regarding critical thinking abilities.

The findings further reveal that most students in the Metacognitive group demonstrated improved critical thinking skills after the intervention. In contrast, most students in the Non-Metacognitive Group still exhibited lower levels of critical thinking abilities. This implies that the metacognitive instructional approach was more effective in developing students' critical thinking skills than traditional instruction.

Students who lack metacognitive skills may struggle academically [11]. In this context, students in the Non-Metacognitive Group might have faced challenges in moving towards higher levels of knowledge due to their limited development of metacognitive abilities. On the other hand, Aurah [14] supports the idea that students with strong metacognitive skills tend to be more successful in managing, monitoring, and evaluating their performance. They have higher confidence in their abilities to perform successfully. This could explain the superior performance of the Metacognitive Group, as they may have been more adept at applying metacognitive strategies to enhance their critical thinking abilities.

The results from Table 2 provide strong evidence in support of the effectiveness of metacognitive instruction in fostering critical thinking skills among students. These findings consistently highlight the positive impact of metacognitive skills on students' academic success and performance [11][14].

The significant difference in post-test means scores and the improved critical thinking abilities observed in the Metacognitive Group emphasizes the advantages of employing metacognitive strategies in Mathematics instruction. The supportive evidence from previous research further strengthens the argument that metacognitive skills are crucial to students' academic achievements. Thus, integrating metacognitive approaches into educational practices can empower students to become more effective critical thinkers and problem solvers.

Table 3: Comparison of students' self-efficacy towards Mathematics between groups

GROUP	N		Mean	Std. Deviation	
Metacognitive Group Non-Metacognitive Group TOTAL	27 31 58		3.61 3.10 3.33	0.25376 0.18507 0.33402	
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
GROUP Error Total Corrected Total	3.815 2.524 650.015 6.359	1 55 58 57	3.815 0.046	83.134	.000

Table 3 provides valuable insights into the levels of self-efficacy in both the Metacognitive and Non-Metacognitive groups. The mean score of 3.60 with a standard deviation of 0.25 for the Metacognitive group and the mean score of 3.10 with a standard deviation of 0.19 for the Non-Metacognitive Group indicate that both groups experienced improvements in their self-efficacy towards Mathematics after the interventions.

The F-value of 83.134 and the probability value of 0.000 ($p<0.01$) suggest a significant difference in the levels of self-efficacy between the two groups, with the Metacognitive Group showing higher levels of self-efficacy compared to the Non-Metacognitive Group. This significant difference in self-efficacy levels implies that the metacognitive instructional approach positively impacted students' beliefs in their ability to succeed in Mathematics.

The rejection of the null hypothesis further supports the conclusion that the Metacognitive Group experienced a more significant increase in self-efficacy than the Non-Metacognitive Group. This result aligns with the findings from previous studies that have demonstrated the positive impact of metacognitive strategies on students' self-efficacy [11][12]. These studies have shown that metacognitive techniques can lead to a more positive attitude and increased self-confidence among students, contributing to their overall academic performance.

The Metacognitive group's development of positive self-efficacy, while the Non-Metacognitive Group remained neutral after the interventions, further highlights the effectiveness of metacognitive strategies in building students' confidence and belief in their mathematical abilities. This positive response by the Metacognitive Group to the self-efficacy indicators underscores the importance of incorporating metacognitive approaches in educational practices to enhance students' perceptions of their capabilities.

The results from Table 7 demonstrate that the Metacognitive group displayed a higher mean score and a more positive self-efficacy towards Mathematics than the Non-Metacognitive Group. This finding, supported by the significant difference between the two groups' self-efficacy levels, emphasizes the effectiveness of metacognitive instructional strategies in fostering a stronger belief in students' ability to succeed in Mathematics. These findings add to the body of evidence supporting the positive impact of metacognitive techniques on students' self-efficacy, reinforcing the argument for incorporating such strategies in Mathematics education.

Students who were taught to solve problems through metacognition performed better, became more successful, developed a more positive attitude, increased self-confidence and were observed to have developed their reflective skills [11]. Moreover, metacognitive scaffolding and metacognitive promoted significant differences in students' academic self-efficacy [12].

Table 4: Analysis of Post-test Results Between Treatments

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
pretest score	978.685	1	978.685	4.739	
groups	6314.379	1	6314.379	30.573	.034
Error	11359.251	55	206.532		
Total	192007.00	58			.000
Corrected Total	18859.397	57			

The F-value of 30.573 with a probability value of 0.000 ($p<0.01$) indicates a highly significant difference between the two groups regarding their post-test critical thinking skills. This significant difference is supported by the rejection of the null hypothesis, which implies that the use of metacognitive strategies substantially impacted students' critical thinking abilities compared to traditional instruction.

GROUP	N	Mean	Std. Deviation
Metacognitive Group	27	66.0	15.596
Non-Metacognitive Group			
TOTAL	31	44.74	14.159
	58	54.64	18.190

The probability value further confirms that students in both the Metacognitive and Non-Metacognitive groups significantly differed in their critical thinking skills during the post-test assessment. This result underscores the effectiveness of metacognitive strategies in fostering better critical thinking abilities among students, as supported by previous research [11][12].

The post-test means scores provide additional support for the superiority of the Metacognitive Group in terms of critical thinking skills. The Metacognitive Group achieved a mean score of 66.0, substantially higher than the mean score of 44.74 obtained by the non-Metacognitive Group. This significant difference in mean scores reinforces the notion that students exposed to metacognitive strategies performed better in their critical thinking abilities.

The most successful students are those with strong metacognitive skills who manage, monitor, and evaluate their performance and have confidence in their abilities to perform successfully," resonates with the higher post-test mean score obtained by the Metacognitive Group in this research [14]. This suggests that students with metacognitive abilities are likelier to excel in their critical thinking skills and overall academic performance.

Moreover, a study finding further reinforces the effectiveness of metacognitive strategies in enhancing critical thinking skills. Their research supports that metacognitive knowledge strategy and discovery learning positively impact students' critical thinking abilities [15]. The alignment between their study and the current research adds robustness to the conclusion that metacognitive approaches contribute significantly to students' development of critical thinking skills.

The results affirms that metacognitive strategies are more effective in building and enhancing students' critical thinking skills [14]. This research underscores the significance of incorporating metacognitive techniques into instructional practices to empower students with the essential cognitive tools necessary for academic success and lifelong learning.

Conclusions and Recommendations

The levels of self-efficacy for both the Metacognitive and Non-Metacognitive groups were initially deficient, indicating that students did not meet the expectations the Department of Education set. However, after exposure to metacognitive instruction, the Metacognitive Group achieved a positive self-efficacy level, while the Non-Metacognitive Group remained neutral.

Both the Metacognitive and Non-Metacognitive groups showed a very low level of critical thinking skills before the intervention, indicating a significant need for improvement. After the intervention, there was a substantial difference in the levels of self-efficacy towards Mathematics between the Metacognitive and Non-Metacognitive groups. Students in the Metacognitive Group developed a more positive self-efficacy towards Mathematics compared to those in the Non-Metacognitive Group.

The intervention also resulted in a significant difference in students' critical thinking skills in Mathematics. The Metacognitive group demonstrated better critical thinking skills in the post-test compared to the Non-Metacognitive Group.

Thus, this study demonstrates the positive impact of metacognitive strategies on students' self-efficacy and critical thinking skills in Mathematics. The conclusions drawn from the findings highlight the importance of empowering students with metacognitive tools and effective instructional practices to foster a more positive outlook towards learning and enhance their critical thinking abilities. By implementing the recommended strategies and conducting further research, educators can contribute to their students' holistic development and academic success.

Recommendations:

Teachers are encouraged to assess students' self-efficacy towards Mathematics before instruction and implement effective strategies to address the low levels of self-efficacy. Metacognitive approaches should be maximized to help students achieve and sustain a highly positive self-efficacy level.

To enhance students' critical thinking skills, teachers should employ various effective strategies, including metacognitive techniques, in their teaching practices. Regular diagnostic tests can aid in identifying specific areas of weakness and guide targeted interventions.

Mathematics teachers are encouraged to continuously investigate students' self-efficacy levels towards Mathematics by conducting self-efficacy tests before and after interventions to assess the effects of metacognitive instruction. In addition to metacognitive strategies, teachers may explore other practical approaches to boost students' self-efficacy in the subject.

Teachers should provide feedback to students at the beginning and end of each school year to foster ongoing improvement in critical thinking skills. This feedback will allow students to track their progress and enable the next teacher to identify the starting point for instruction.

Future researchers should consider conducting studies that evaluate the effects of metacognitive instruction on students' self-efficacy and critical thinking skills in Mathematics and across various disciplines and grade levels. This broader exploration will contribute valuable insights into the potential benefits of metacognitive strategies in diverse educational contexts.

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