Improving Students' Attitudes and Conceptual Understanding in Mathematics using Different Teaching Strategies

Roland A. Nasayao[1*], Junar T. Lingo[2]

[1]*Surigao City Division, Department of Education, Surigao City, Philippines;E-mail: rolandnasayao@gmail.com*
[2]*Caraga State University, Butuan City, Caraga Region, Mindanao, Philippines*

Abstracts: The study investigated the improvement of different teaching strategies on students' attitudes and conceptual understanding in Grade 11 Mathematics. It used a descriptive-correlational research design, and survey questionnaires were administered to the randomly selected students in the three senior high school classes of Surigao City National High School. Findings revealed that students' attitudes do not vary across the three approaches. Data further showed that the average rating scale of the students in terms of their grades is 86-89, which entails very satisfactory performance. Moreover, the level of students' attitudes is separate from improving conceptual understanding across the three strategies. Students' attitudes and conceptual understanding have no relationship except problem-based learning when compared to conceptual understanding. Hence, teachers' strategies in general math are associated with the student's attitudes toward learning mathematics.

Keywords: Conceptual Understanding, Students' Attitudes, Teaching Mathematics, Teaching Strategies.

1. INTRODUCTION

Metacognition is a type of individual difference (Feng Teng, 2023); it can be trait-like and state-like (Sato, 2022). A study on the effects of metacognitive strategies for problem-solving achievement, metacognition skills, and attitude was conducted in a primary school in the Central Anatolia Region of Turkey (Sahin & Kendir, 2013), results stated that the pupils developed the ability to perceive the importance of problem-solving, understand problems, be involved in planned studying, and control and be aware of the problem-solving process. Moreover, Barak's (2017) These studies addressed that MLS greatly impacted the student's mastery, and the ID's steps were applied even though it was not clearly stated.

In the Philippines, Ajan (2021) conducted a study in a military school in the Philippines for second-year cadets during the first term of the academic year 2019-2020. Results indicated that in-service training on metacognitive strategies significantly affected the teacher participants' attitudes towards using metacognitive strategies and their performance in teaching. The findings revealed that students who learned mathematics through activities had a greater awareness of Metacognition than those who learned mathematics traditionally Wahba et al. (2022)

Similarly, researchers studied the different metacognitive strategies employed in the study independently. Concept mapping, think-aloud and journal writing are different from one strategy in the classroom. A study by Erasmus (2013) used concept mapping in South Africa to enhance learning and engage students. Results showed that students welcomed the concept mapping approach, which assisted their education and allowed more significant discussion and interaction.

Researchers from numerous fields have examined metacognitive techniques. Considerations have been conducted on how their use affects students' academic performance and interest in Math and other subjects. According to their findings, metacognitive teaching methods are superior to conventional ones in raising students' academic achievement. However, the earlier studies did not align with the most recent K–12 Basic Education Curriculum established by the Department of Education in the Philippines. Sahin and Kinder's (2013) study provided insight into conceptualizing the current research. Jayapraba's (2013) investigations aided the researcher in developing a more effective methodology. The inquiries, as mentioned earlier, clarified the pretest-posttest study design. The researcher-made Engagement Scale in Mathematics was created using Attard's (2013) engagement

construct used in the current study. The studies by Erasmus (2013), Henjes (2013), and Olson and Johnson (2012) gave the researcher the notion to consider using concept mapping, think-aloud exercises, and journal writing as a metacognitive method.

However, the earlier studies did not align with the most recent K–12 Basic Education Curriculum established by the Department of Education. The studies pointed out that students may have utilized incorrect techniques in studying. The point is that the erroneous study technique results in a lack of mathematical proficiency and prevents solving problems requiring mathematical abilities, such as conceptual comprehension. The study's result showed a significant relationship between problem-solving skills and the pupils' mastery of basic skills, attitude towards mathematics, and parental involvement (Silao, 2018). As such, students are frequently anxious about failing to do well in the issue. They are prone to developing feelings of uneasiness and nervousness. As a result, math anxiety becomes evident.

Mathematical concepts are complex for students to understand from their ideas and techniques. Hence, the researcher intended to investigate the challenges in mathematics education. More research is needed on conceptual understanding (skills), imparting information and thorough comprehension of mathematics), and students' perceptions of mathematics. This research aimed to determine whether conceptual understanding impacts the problem-solving skill of grade 11 students in Surigao City National High School to grasp the lessons in mathematics.

Based on their test scores, many students at Surigao City National High School struggle in mathematics. Grade 11 students needed a greater understanding of the general mathematical competencies. Thus, teachers must look for ways to improve the student's academic achievement in mathematics. Using metacognitive techniques like idea mapping, journal writing, and think-aloud could help students attain higher levels of success. The researcher's experience and the assertions mentioned above served as a driving force to start an investigation on improving the students' attitudes and conceptual understanding of Mathematics using different.

This study analyzed the relationship between and among the students' attitudes, conceptual understanding, and student's performance in different teaching strategies (metacognitive strategies, problem-based learning, collaborative learning) in teaching Grade 11 General Mathematics.

Metacognitive strategies must rely on something other than rote memorization whenever they want to internalize something; they must strategize how to learn efficiently. When students know how to learn what they should learn, they significantly develop the ability to master their cognitive skills and mental processes. According to Jia et al. (2019), Metacognition refers to the knowledge and regulation of one's cognitive processes, which has been observed as a critical component of creative thinking. In order to do this, they must know how they learn and be aware of the steps that are followed and the means that are used to acquire knowledge, solve problems, and perform tasks." Metacognition is the advancement of "thinking about thinking." as such, good readers use Metacognition before reading when they explain their purpose for reading and preview the text.

Problem-Based Learning (PBL) is a teaching strategy in which real-life applications are used to stimulate student learning of concepts and principles instead of the direct way of presenting concepts.

In addition to course content, PBL can encourage the effect of critical thinking skills, problem-solving abilities, and communication skills. It can also provide room for engaging in groups, finding and assesing research materials, and life-long learning (Duch et al, 2001).

Collaborative learning strategies are explicit approaches or procedures to guide the process of collaborative learning. Collaborative learning occurs when dyads or small groups have been engineered to share responsibility, authority, and learning outcomes. Udvari-Solner. (2012). Whereas many active strategies can be performed independently, collaborative learning strategies support the mutual engagement of participants in synchronous activity while developing a shared conception of a problem or experience (Roschelle & Teasley, 1995).

2. THEORETICAL FRAMEWORK

This study is anchored on the Constructivism Theory of Jean Piaget, the Sociocultural Theory of Lev Vygotsky, and the Behavioral Theory of Learning by B.F. Skinnner.

Piaget's Constructivism Theory states that students construct new ideas based on previous knowledge and skills. Learning, accordingly, is unique to the individual learner. A positive effect of the respondents' skills in assessing and resolving task-related difficulties grew throughout the four-year experiment. Constructivism has been described as one of the leading pedagogical theories that promote the development of skills and competencies relevant to the learners' future jobs in the contemporary educational environment, which is dominated by the K– 12 model (Krahenbuhl, 2016).

Furthermore, constructivism plays a vital role in every lesson, especially in Mathematics, where a logical sequence of topics to be discussed should be a primary concern. Tremendously mastering fundamental tasks impact teaching strategies, specifically metacognitive, collaborative, and problem-based learning. Employing these strategies in the current study will help students' attitudes and conceptual understanding of Mathematics.

Another theory this study is anchored on is the Sociocultural Theory of Vygotsky. The theory asserts that social interaction is integral to the learning process. Whether spontaneous or scientific, learning begins with an interaction between the novice and more experienced others, regardless of the content or skill (Miller, 2011). In the case of this study, they employed sociocultural theory because students learn through interacting with their peers or instructors. Collaboration with teachers' strategies on student achievement significantly influences the metacognitive process and achievement.

Lastly, the Behaviorism Learning Theory has been the dominant theory for teaching math for many years (Montilla, 2019). However, according to Ng'andu et al. (2013, p. 13), "... behaviorism cannot stand on its own as a teaching theory. Hence, it is best used in conjunction with others. In the case of this study, it employed behaviorism because students learn through other learning strategies supplemented by teachers.

3. METHODS

The study utilized a descriptive-correlational research design. It described the conceptual understanding and attitudes of the grade 11 students. It determined the level of student's performance in mathematics and the level of conceptual understanding of grade 11 students. It also defined the relationships between students' attitudes, level of performance in mathematics, and the conceptual understanding of grade 11 students.

The study was conducted in San Juan, Surigao City National High School, Surigao City, Surigao del Norte, Philippines. SCNHS is situated a kilometer away from the city proper. The school comprises junior and senior high school students with a total population of 2,842. The school also has 121 teaching and non-teaching faculty. Special programs like the arts, sports, journalism, and science were offered for junior high school. Senior high school programs available were home economics, metal arc welding, and general academic strand.

The three grade 11 sections were selected randomly as study participants. Each section was subjected to different teaching strategies, such as metacognitive strategies, problem-based learning, and collaborative learning. The two sections have the same strand (SMAW) and GAS section—the three sections treated as samples of this research. The study participants were from Surigao City National High School in Surigao City. They were the selected Grade 11 Senior High School students officially enrolled in the academic year 2022-2023 and attending in-person classes there.

Three sections were assessed on their prior knowledge of mathematics; each was implemented with different teaching strategies, and their conceptual understanding was analyzed, as well as their attitudes. Grade 11 Amethyst applied problem-based learning, Grade 11 Aquamarine utilized metacognitive strategies, and Grade 11 Topaz received a collaborative learning approach.

The data collection was done through an adopted questionnaire which includes two parts. For part one, the student's attitude scale towards mathematics was adopted from Fennema and Sherma (1976). The study adopted the second part from the Department of Education, which had a 15-item standardized mathematics test. Next, the researcher made a test on conceptual understanding in mathematics relevant to introducing logic and set theory. The second quarterly grades from the teachers served as the basis for students' performance.

The study also underwent a reliability test that resulted in a 0.75 Cronbach alpha significance level, suggesting acceptable and valid items were all included in the instrument. Also, the validation of the content was made by experts. Three validators, and mathematics experts, examined the questionnaire and gave their comments and suggestions.

The data collection commenced by seeking consent from the participants of the study. The researcher distributed the consent among the students involved in this study mentioning all the appropriate ethical practices to be observed throughout the study. The researcher personally distributed the ethics statement and addressed it to the school principal. The school principal approved a formal request for data collection, which allowed the researcher to float the research instruments on conceptual understanding in mathematics. The researcher personally carried out the data collection. The study participants were given one hour to answer each questionnaire in three sessions. The questionnaires were checked, scored, organized into tabular form, and subjected to statistical analysis.

After collecting the data needed, they were then tabulated and analyzed. The following statistical tools were used for data treatment: (1) Mean and Mean Difference, which assessed students' conceptual understanding and attitudes toward mathematics. (2) Analysis of Variance (ANOVA) was used to assess the significant difference in students' attitudes and conceptual understanding across strategies. (3) Pearson *r* Correlation which was utilized to indicate if there was a significant relationship between the students' attitudes, level of conceptual understanding, and level of performance in general mathematics.

4. RESULTS

4.1. Students’ Attitude in General Mathematics Using the Three Strategies

This study considers the students' attitudes toward teachers' strategies in general mathematics subjects. Table 1 presents descriptive statistics of all cognitive measures included in the study. The highest mean among the statements across three learning strategies was "Math is important in everyday life" of metacognitive strategies, with 4.45 as the mean score, while the lowest mean garnered 3.12 as average, particularly the statement "I am able to solve math problems without difficulty" of collaborative learning. Positive and negative attitudes vary in their influence on education. Achievement may increase or decrease depending on the degree of attitude's influence on the learner. Further, the study by Andrea et al. (2016) findings revealed that students perceived study habits as a great factor in attaining excellent academic performance.

Moreover, Table 1 also illustrates the outcome of the three strategies. Students' attitudes towards mathematics had an overall mean of 3.75, 3.80, and 3.91 for metacognitive strategies, problem-based learning, and collaborative learning, respectively, which imply agreeing. It means further that their attitude towards mathematics was fair. According to Mazana et al. (2018) and Nambatac (2001), attitudes do not determine specific acts; instead, they make a class of individuals acting more or less likely to be engaged. A significant positive weak correlation between students' attitudes and performance was established. Mathematics enjoyment and attitude significantly predicted students' performance in our data.

Table 1. Level of student's attitude towards learning general mathematics taught using different teaching strategies.

Student's attitudetowards learning mathematics	Teaching Strategies					
	Metacognitive Strategies		Problem based Learning		Collaborative Learning	
	Mean	Verbal Description	Mean	Verbal Description	Mean	Verbal Description
Working math makesme nervous	3.28	Neither agree nor Disagree	3.54	Agree	3.50	Agree
I have self-confidence in learning math	3.58	Agree	4.00	Agree	3.73	Agree
I am able to solve math problems without difficulty	3.25	Neither Agree nor disagree	3.54	Agree	3.12	Neither Agree nor disagree
I enjoy doing math	3.93	Agree	3.71	Agree	3.92	Agree
I look forward to a mathclass	3.48	Neither Agree nor disagree	3.75	Agree	3.77	Agree
Math is very interesting to me	3.73	Agree	3.67	Agree	3.85	Agree
I enjoy learning math with my friends	3.80	Agree	3.83	Agree	4.12	Agree
I feel comfortable working math problems	3.28	Neither Agree nor disagree	3.75	Agree	3.62	Agree
Math is important in everyday life	4.45	Agree	3.75	Agree	4.08	Agree
I want to develop my math skills	4.20	Agree	4.00	Agree	4.23	Agree
Knowing math will help me earn a living	3.68	Agree	3.79	Agree	4.19	Agree
I will need math for my future work	4.08	Agree	4.04	Agree	4.27	Agree
Math helps people to make good decisions	3.93	Agree	3.92	Agree	4.35	Agree
Math improve my thinking capacity	3.73	Agree	3.96	Agree	4.04	Agree
Math is important for other subjects	3.90	Agree	3.79	Agree	3.88	Agree
Average	3.75	Agree	3.80	Agree	3.91	Agree

Mean: 1.00-1.49-Strongly Disagree, 1.50-2.49-Disagree, 2.50-3.49-Neither Agree nor Disagree, 3.50-4.49-Agree, 4.50-5.00Strongly Agree.

4.2. Improvement in Conceptual Understanding of Students Using the Three Strategies

Table 2 presents the conceptual understanding of students using the three strategies. As reflected in the table, the mean difference shows the improvement in the level of conceptual understanding of each teaching strategy implemented in this study. Collaborative learning garnered the highest with 10.65, problem-based learning with 10.42, and the lowest metacognitive strategies with 6.68. It infers that collaborative learning showed tremendous improvement against other strategies.

Table 2. Level of conceptual understanding of Grade 11 students

Teaching Strategies	Pre test	Post-test	Mean difference
Metacognitive Strategies	5.60	12.28	6.68
Problem based Learning	3.33	13.75	10.42
Collaborative Learning	3.73	14.38	10.65

These results are parallel with Chang et al. (2022), who noted that combining collaborative learning and problem-based learning strategies with flipped classrooms enhances the learning outcomes of learners, which is consistent with the results of previous related studies. Learners were willing to accept nontraditional teaching methods. They completed knowledge transfer before the lesson and internalized their knowledge through cooperative group discussions during the class to solve the problems.

Botto-Tobar et al. (2021) observed that collaborative learning strategies predict more significantly the suitable levels of mathematical self-efficacy. This study also analyzed the level of student attitude among the three strategies employed. The following table shows the results.

Table 3. Significant difference on the level of students' attitude.

Teaching Strategies	Mean	Verbal Description	*p*-value	Remark
Metacognitive Strategies	3.75	Agree		
Problem based Learning	3.80	Agree	0.39	Not significant
Collaborative Learning	3.91	Agree		

Note: tested at 0.05 level of significance using ANOVA

Table 3 results specify that the *p*-value was greater than the level of significance (0.05). It indicates that there is no significant difference on the level ofstudents' attitude when various of teaching strategies were applied during the class discussion. These results contradict the study cited by District, Manafwa et al. (2023); students will ascribe or use motivation as a factor in their learning and performance. Students' capacity to deal with daily school life challenges was influenced by their behaviors linked to their academic motivation, such as their desire to complete challenging work and persist longer in difficult conditions. It hasbeen noted that arithmetic achievement still needs improvement despite teachers using various techniques.

In like manner, the study also analyzes the students' level of conceptual understanding among the three teaching strategies, as reflected in table 4.

Table 4 Significant difference on the level of conceptual understanding.

Teaching Strategies	Post-test	Mean difference	*p*-value	Remark
Metacognitive Strategies	12.28	6.68		
Problem based Learning	13.75	10.42	0.010	Significant
Collaborative Learning	14.38	10.65		

Note: tested at 0.05 level of significance using ANOVA

Table 4 results show that the *p*-value was less than the significance level (0.05), indicating that when various teaching strategies were applied, there was a significant difference in student's conceptual understanding level during the class discussion. It agrees with the findings of study of Tasgin et.al (2018), it was found that the students' attitudes and motivations for learning differ in favor of the females, there was a moderately positive and meaningful relationship between attitude towards learning and academic motivation, and that there was no significant difference in academic motivation as well as in attitudes towards learning of students according to school type. In addition, it was concluded that there was a high and positive correlation between intrinsic and extrinsic motivation and academic motivation, and that there was a low and negative correlation between amotivation and academic motivation.

4.3. Students' Performance in General Mathematics

This section presents students' performance in general mathematics across the three teaching approaches. As explained in Table 5, most students had a grade of 86-89, garnering 33 of them from the problem-based approach.

Collaborative learning followed this data with 22 students still under a rate of 86-89. Among the three methods, metacognitive strategies were on the least number of students who graded belong to 86-89. From the scale given, only two students received a grade of 96-100 from metacognitive approaches.

Additionally, on a scale of 90-95, metacognitive strategies, problem-based learning, and collaborative learning earned 13,10,6, respectively. This data also negates the scale under 80-85 with 2,8,14 students. Luckily, no students received a grade of 75-79 across the three teaching approaches.

Table 5. Level of students' performance

Teaching Strategies	96-100	90-95	86-89	80-85	75-79	Total
Metacognitive Strategies	2	13	22	2	-	49
Problembased Learning	-	10	33	8	-	51
Collaborative Learning	-	6	30	14	-	50

(-) no response

The following indicators served as the bases for interpreting students' grades. Outstanding is a rate of 90-100, Very Satisfactory is a grade of 86-89, satisfactory is a grade of 80-85, and Satisfactory, a grade from 75-79 indicates a passing score. Moreover, a scale of 74 below shows a failing grade, meaning the students did not meet the standard expectations.

The study also looked into the relationship between students' attitudes and the improvement of their conceptual understanding, as demonstrated in Table 6. Based on the results of the analysis employing Pearson *r* Correlation in Table 6. The level of students' attitude has no significant relationship between their level of conceptual understanding across the three approaches. Hence, these results imply attitudes do not affect the students' performance in general mathematics.

Table 6. Relationship between students' attitude and improvement of conceptual understanding

Teaching Strategies		Level of students' attitude		
		p-value	Correlation coefficient	Remark
Improvement of conceptual understanding	Metacognitive Strategies	0.749	0.052	Not Significant
	Problem based Learning	0.488	-0.149	Not Significant
	Collaborative Learning	0.981	0.000	Not Significant

Note: tested at 0.05 level of significance using Pearson Correlation

Consequently, as Chaudhry, Malik, & Rafiq (2020) noted that students' attitudes toward math are just one of many elements that can influence their success. Many factors still affect students' math performance, such as a study cited by Saenz et al. (2023) which further implied that considering the amount of time students spend at school, one can expect that school and classroom environment are vital factors in shaping students' mathematics beliefs and academic success.

Lastly, this analysis of the study includes the students' performance and the levelof their attitudes and improvement of conceptual understanding, as portrayed in Table 7

Table 7. Relationship between students' performance and the level of students's attitude and improvement of conceptual understanding.

Variable	Teaching Strategies	Students' performance (Grade)		
		p-value	Correlation coefficient	Remark
Improvement of	Metacognitive Strategies	0.157	0.228	Not significant

conceptual understanding	Problem based Learning	0.031	0.441	Significant
	Collaborative Learning	0.297	-0.213	Not significant
Level of students' attitude	Metacognitive Strategies	0.737	0.055	Not significant
	Problem based Learning	0.223	0.258	Not significant
	Collaborative Learning	0.661	0.09	Not significant

tested at 0.05 level of significance using Pearson correlation

Table 7 still utilized Pearson *r* correlation indicates that students' attitudes and conceptual understanding showed no statistical significance except problem-based learning when compared to conceptual understanding. Most of the *p*-values were less than the significance level at 0.05. However, in improving conceptual understanding using problem-based strategies, it can be observed that the sig value of 0.031 is smaller than 0.05; hence it can be inferred that there is a significant relationship with a positive 0.441 correlation coefficient.

In agreement with this result, Villaver (2014) found that attitude influences students' learning. In her study, positive and negative attitudes vary in their influence on performance in mathematics. It agrees with the findings of Kulm (1996) that if students' attitude towards Mathematics is positive, then the students have good performance towards the subject. Therefore, students' attitude towards Mathematics varies their performance in Mathematics.

This result further implies the higher the perspective is, the higher the performance in Mathematics. On the other hand, the lower the attitude is, the poorer the performance in Mathematics.

CONCLUSIONS

After a thorough analysis, the study deduced that the students exhibit the same attitude across these three approaches. Among the three strategies, collaborative learning marked the highest mean difference, followed by problem-based, and the metacognitive strategies were the least.

Further, the level of student attitude does not vary when applied with the teaching strategies in general mathematics. However, the students' conceptual understanding level among the three teaching approaches differs during the class discussion. Correspondingly, the average rating scale of the students in terms of their grades is 86-89 which entail very satisfactory performance.

Moreover, the level of students' attitude is not related with the improvement of conceptual understanding across the three strategies. Students' attitudes and conceptual understanding have no relationship except problem-based learning when compared to conceptual understanding. Hence, the strategies used by teachers in general math is associated with the students' attitudes toward learning mathematics. Teaching strategies may have helped the student's conceptual understanding, performance, and attitudes in learning the subject.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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