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Influence of Metacognitive Skills and Mathematical Resilience on Problem-Solving Skills of Students in Mathematics

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***Abstract*—** *The primary purpose of this study was to determine whether metacognitive skills and mathematical resilience significantly influence problem-solving skills among first-year college mathematics students. This is a quantitative study utilizing descriptive and correlational approach. Using ratio and proportion, 132 first-year college mathematics students were selected as respondents from three higher education institutions in the Province of Davao del Norte, during the school year 2022-2023. Furthermore, this study utilized one researcher-made questionnaire and two adapted survey and validated questionnaires to gather data, which were treated using mean, Pearson-r, and regression analysis. The findings suggested that the metacognitive skills of students are very much observed, and mathematical resilience is very much evident. Furthermore, the problem-solving skills of students is very satisfactory. Findings also revealed that metacognitive skills and mathematical resilience have a significant positive correlation towards problem-solving skills. In addition, only mathematical resilience significantly influences problem-solving skills of students. These findings underscore that metacognitive skills and mathematical resilience must be promoted to enhance the problem-solving skills of students in mathematics. This study would benefit students, parents, mathematics teachers, school administrators and future researchers to be fully aware that there are variables that can affect the problem-solving skills of students in mathematics and develop interventions that enhance the problem-solving skills of students.*

***Keywords*—** *Descriptive and correlational design: first-year college students: mathematics education: mathematical resilience: metacognitive skills: problem-solving skills: regression analysis: Davao del Norte, Philippines*

I. INTRODUCTION

Primary goal of mathematics curriculum is to develop problem-solving skills of students (Ozturk et al., 2020). A student with enhanced problem-solving skill can understand and analyze a concept more and choose a method of solving a problem more efficiently (Purwaningsih et al., 2020). However, several studies show that students still find it challenging to solve mathematics problems because their problem-solving skills are still lacking, which hampers them to process the given information and make a correct solution to the problems (Kusuma et al., 2021; Meutia et al., 2020).

In Indonesia, research on problem-solving skills based on Polya's steps conducted by Riyadi et al. (2021) showed that only 5 out of 22 grade three students, 7 out of grade four, and 4 of 21 grade five students completed all the Polya's four steps which implies that students' skills to solve problems are relatively low. In Malaysia, students are expected to apply their knowledge and integrate it into real-world, however, they had difficulty in solving problems due to their lacked mathematical skills which includes problem-solving skills (Timario, 2020). Also, in Pakistan, according to PEC (2018) that the scores of students in solving mathematics problems are at poor level of proficiency which indicates that students lacked problem-solving skills.

In Philippines, the result of the study conducted by Silao (2018) in Sarangani revealed that 41 out of 95 students or 43.16% did not master the problem-solving skills, and only 8 students of out 95 which has the percentage of 8.42 have mastered the problem-solving skills which implies that problem-solving skills is declining, and students have a long way to go before achieving an outstanding performance in problem-solving. Another study conducted by Callado (2020) in Mandaluyong among Grade 11 students revealed that students got a mean percentage of 40.32%, obtained from the mean score of 16.13, which is way below the passing rate of 75%. It can be gleaned from the result that students' problem-solving skills are place under good and poor level. In addition, Jala (2020) also revealed that students showed a difficulty in problem solving which she then highlighted that students must be given more drills to enhance their competence in the skills in problem solving.

In Davao del Norte, a study conducted by Baltazar (2022) pointed out that more than 60% of the students across all strands in a certain school did not pass in their first quarter departmental examination on General Mathematics, because students lacked confidence in solving problems and failed to determine what formula they should apply to answer the problems presented to them. In addition, the result of the study conducted by Timario (2020) among Grade 7 students showed the percentage of the student's problem-solving skill is 24.69%, this implies to be less evident which means that student possesses only minimal knowledge, skills, and core understanding in solving problems.

Literature suggests that problem-solving skills of students might be affected by their metacognitive skills (Izzati & Mahmudi, 2018; Guner & Erbay, 2021) and mathematical resilience (Harsela & Asih, 2020; Attami et al., 2020). Furthermore, researchers would like to address how students'

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problem-solving skills in mathematics are influenced by their metacognitive skills and mathematical resilience through quantitative research using descriptive and correlational design. The findings of this research will provide understanding and ideas to students on how they can improve their skills in problem-solving. Also, the result will give information on how metacognitive skills and mathematical resilience influence the problem-solving skills of students in mathematics.

II. Research Objectives

The primary goal of this study was to determine whether problem-solving skills of first year college mathematics students who are enrolled for second semester during the school year 2022-2023 in Davao del Norte are significantly influenced by mathematical resilience and metacognitive skills.

This specifically aimed to answer the following questions:

1. What is the level of metacognitive skills of students in terms of:
   a. metacognitive knowledge and learning strategies;
   b. knowledge about learning and learning unit; and
   c. ability in planning and monitoring own learning?
2. What is the level of mathematical resilience of students in terms of:
   2.1 value;
   2.2 struggle; and
   2.3 growth?
3. What is the level of problem-solving skills of students in terms of test scores?
4. Is there a significant relationship between:
   4.1 metacognitive skills and problem-solving skills of students in mathematics; and
   4.2 mathematical resilience and problem-solving skills of students in mathematics?
5. Do metacognitive skills and mathematical resilience significantly influence problem-solving skills of students in mathematics?

III. Methods

Research Design

This study employed a descriptive and correlational approach and is quantitative in nature. Quantitative research investigates a topic through gathering of measurable data and then use different statistical methods to analyze the data (Adedoyin, 2020). Descriptive design aimed to describe people, events, characteristics/, and/or conditions by studying them in natural settings (Loeb et al., 2017). Correlational research tests two variables and evaluates the statistical relationship between them in a non-experimental setting (Price et al., 2015). The descriptive design is suitable for this study since its goal was to evaluate and determine the degree of metacognitive skills, mathematical resilience, and problem-solving skills among first-year college mathematics students using pre-established research instruments and researcher-made tests. Also, the correlational design is appropriate to test the hypothesis whether the relationship exists between the variables. Moreover, this would also test the main purpose which was to determine whether the metacognitive skills and mathematical resilience influence the problem-solving skills of first year college mathematics students in three colleges in Davao del Norte.

Research Respondents

The respondents of the study were first-year students majoring in mathematics for their Bachelor of Secondary Education from three (3) Davao del Norte colleges. One (1) of the participating schools is a private institution and the remaining two (2) are public institutions located in Davao del Norte. The respondents were officially enrolled for second semester during the school year 2022-2023. Additionally, a Raosoft sample size calculator with a 95% confidence level and a 5% margin of error was used to calculate the sample size of the respondents.

The total population of the participating schools is 199, and a sample size of 132 respondents was obtained. Of 132 respondents, 73 are coming from school A, 38 came from school B, and 21 came from school C. Ratio and proportion was used to ensure proportionate distribution of respondents per school based on their population.

Research Instrument

This study utilized two (2) survey questionnaires from published research to collect data needed to assess metacognitive skills and mathematical resilience and a researcher-made test to collect data for problem-solving skills. The instruments underwent validation by a panel of experts and had been pilot tested by a set of sample students from one of the tertiary schools that have the same characteristics of the direct respondents of the study.

Metacognitive skills of students were measured using metacognitive skills scale developed by Altindog and Senemoglu (2013). The instrument has 30 items with three indicators. Metacognitive knowledge and learning strategies comprise 8 items; knowledge about own learning and learning unit has 13 items; and ability in planning and monitoring own learning has 9 items. The response options are organized on a 5-point Likert scale, where 1 denotes "strongly disagree," and 5 denotes "strongly agree." Furthermore, the Cronbach's Alpha Coefficient of Reliability of this scale is 0.94 which means that the metacognitive skills scale has a very high reliability.

Mathematical resilience was measured using Mathematical Resilience Scale developed by Kooken et al. (2015). The questionnaire consists of three (3) indicators namely: Struggle, Growth, and Value. Struggle consists of 9 items; Growth has 7 items; and Value has 8 items. The structure of the response options is a 5-point Likert scale, with 1 denoting "Completely disagree" and 5 denoting "Completely agree." Moreover, the reliability coefficient based on Cronbach alpha is 0.87 which indicates that the scale has a high reliability.

The instrument to measure the problem-solving skills of first year college mathematics students was made by researcher. The focus of this researcher-made test is on the application of algebra. The test is composed of 5 items with a

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total of 50 points. The researcher provided scoring rubric assessment for problem-solving test. The scoring rubric assessment is based on Polya's four steps of solving problem. Each item is worth 10 points; the maximum point for understanding the problem is 2, devising a plan is 2, carrying out the plan is 4, and looking back is 2. Furthermore, the researcher-made test on problem solving underwent validation by panel of experts and reliability test. The researcher administered the test to the respondents only once and the test scores were used to determine the level of their problem-solving skills.

Data Gathering Procedure

Researchers adhered to different procedures and protocols in ensuring smooth execution of the study. Researchers first obtained the clearance for implementation from the Research Ethics Committee (REC) and letter of recommendation from the Dean of the Graduate School. Afterwards, request letters were sent to different institutions asking permission to conduct the study. Researchers secured the informed consents of the respondents ensuring that they have understood their rights as a respondent of the study. Before administering the survey questionnaire, researchers provided general orientation to the respondents for the elaboration of the purpose of the study. Researchers personally administered the survey questionnaire and the researcher-made test in a face-to-face modality after securing the consent from the respondents of each participating school. Respondents were given 30 minutes to finish the two sets of survey questionnaires and another 60 minutes for the researcher-made test. Researchers personally gathered, verified, and compiled the unprocessed responses of the respondents. SPSS was used as a statistical tool for data treatment. Researchers analyzed the data to draw conclusions and for the discussion of the findings. Researchers presented and discussed the findings with the use of descriptive interpretations and tables. Researchers maintained confidentiality and anonymity of the collected data.

Statistical Treatment

The data collected in this study underwent several statistical analyses to derive meaningful insights. Mean calculations were used to measure the level of mathematical resilience, metacognitive skills, and problem-solving skills of students. Standard deviation was used to measure the measure the variability of scores of students in metacognitive skills, mathematical resilience, and problem-solving skills in mathematics. Pearson r was used to measure the correlation between mathematical resilience and problem-solving skills and metacognitive skills and problem-solving skills. Multiple regression analysis was employed to determine whether metacognitive skills and mathematical resilience influence student's problem-solving skills in mathematics. These statistical tools collectively provided a comprehensive understanding of the interrelationships and predictive factors within the study variables.

Ethical Consideration

The focus of this study was first-year college mathematics students who were the respondents of this study from three colleges in Davao del Norte. The research protocol underwent an ethics review in the Research Ethics Committee (REC) to ensure the trustworthiness of the study. Moreover, researchers followed the guidelines set by the National Ethical Guideline (2017) to ensure the greatest welfare, provide complete security, and maintain the respondents' trust by following and adhering to moral standards and principles in the conduct of the study. These ten principles are social value, informed consent, vulnerability of research participants, risks, benefits and safety, privacy and confidentiality, justice, transparency, qualification of the researcher, adequacy of facilities and community involvement.

IV. Results and Discussion

TABLE 1. Level of Metacognitive Skills of Students

Indicators	SD	Mean	Descriptive Equivalent
Mathematical Knowledge and Learning Strategies	0.53	4.39	Very High
Knowledge about Learning and Own Learning Unit	0.50	4.36	Very High
Ability in Planning and Monitoring Own Learning	0.50	4.36	Very High
Overall	**0.51**	**4.37**	**Very High**

Table 1 presents students' metacognitive skills of students. The indicator that has the highest mean of 4.39 with the descriptive equivalent of very high is "mathematical knowledge and learning strategies". Responses of students for this indicator are clustered near the mean, as indicated by the SD of 0.53. Indicators that obtained the mean score of 3.36 with the descriptive equivalent of very high are "knowledge about learning and own learning unit" and "ability in planning and monitoring own learning". Responses of students to these indicators showed a high variability, as indicated by the SD of 0.50.

The category mean for students' level of metacognitive skills obtained is 4.37 with the descriptive equivalent of very high, suggesting that students' metacognitive skills are very much observed. The SD of 0.51 suggests that responses for items under metacognitive skills are close to the mean.

Findings revealed that most of first-year college mathematics students have high mathematical knowledge and learning strategies, which implies that they can organize their own thoughts and strategies during metacognitive process. It also highlighted that students have knowledge about their own learning which means that they can discern what strategy they should choose and use to solve problems. Also, they are aware of their own limitations and capacities. Also, result suggests that students can plan, monitor learning, and judge the extent of their own learning.

Bakar et al. (2021) noted that students who have high metacognitive skills can plan, organize, monitor, assess, and manage their learning processes and strategies during problem-solving processes. Additionally, metacognitive skills

Aberin A. Alimbon, and Ma. Melanie N. Edig, "Influence of Metacognitive Skills and Mathematical Resilience on Problem-Solving Skills of Students in Mathematics," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 7, Issue 7, pp. 147-153, 2025.

enable students to take control of their own learning, meaning they assess their own learning and make necessary adjustments to enhance learning (Yadav and Goswami, 2023). Veenman and Cleef (2019) similarly emphasized that students who have high metacognitive skills can reflect on their learning processes and make adjustments to improve their learning

TABLE 2. Level of Mathematical Resilience of Students

Indicators	SD	Mean	Descriptive Equivalent
Value	0.60	4.44	Very High
Struggle	0.68	4.45	Very High
Growth	0.68	4.54	Very High
Overall Mean	**0.51**	**4.48**	**Very High**

Table 2 presents the overall level of students' mathematical resilience as measured by growth, struggle, and value. The indicator that had the highest mean of 4.54 with the descriptive equivalent of very high is growth. Responses of students are clustered around the mean, as indicated by the SD of 0.68. The result also suggests that growth is very much evident among students. The indicator that had the second highest mean of 4.45 with the descriptive equivalent of very high is struggle. The SD of 0.68 indicates that students' responses are clustered around the mean. The indicator that had the lowest mean of 4.44 with the descriptive equivalent of very high is value. The result suggests that students' mathematical resilience as measured by value is very much evident. The SD of 0.60 implies that students' responses are near the mean.

The overall mean of 4.48 had a descriptive equivalent of very high implies that students' level of mathematical resilience is very much evident. Moreover, the result revealed the SD of 0.65 suggesting that responses of students for this indicator are clustered around the mean.

The data demonstrates that students who have high level of growth believed that everyone can learn mathematics. They also believed that this aspect of mathematical resilience will help them improve their problem-solving skills. The result also revealed that students have high level of struggle, which means they are aware that struggling is part in learning mathematics. Also, result revealed that students considered mathematics to be a valuable subject and must be studied by everyone.

The results are parallel to Hutaurok et al. (2019) who highlighted that students who have strong mathematical resilience considered mathematics to be relevant and they are willing to learn mathematics despite its difficulty. Further, students with high levels of mathematical resilience are better at solving problems than those with low mathematical resilience (Attami et al., 2020). Moreover, Hafiz et al. (2019) mentioned that students who have good mathematical resilience are confident in dealing and solving problems presented to them.

TABLE 3. Level of Problem-Solving Skills of Students based on Test Scores

Variable	SD	Mean	Descriptive Equivalent
Problem-solving Skills	16.90	73.02	High

Table 3 presents first-year college students' level of problem-solving skills in mathematics. The 132 respondents had a mean of 73.02, an SD of 16.90, and descriptive equivalent of high based on their percentage score. The result implies that problem-solving skills of students is very satisfactory.

The result is parallel with Asik and Erktin (2019) who emphasized that high problem-solving skills enable students in planning, monitoring, and assessing their processes to come up with a correct answer. Likewise, Yapatang and Polyiem (2022) also mentioned that high problem-solving skills allow students to discern what strategy to use that will give them correct solutions. In addition, high problem-solving skills help students get the correct answer despite the difficulty of the problems (Macaso & Dagohoy, 2022). Also, Saygili (2020) mentioned that problem-solving skills help students to be more confident during learning processes.

TABLE 4. Significance of the Relationship Between Metacognitive Skills and Mathematical Resilience toward Problem-solving Skills

Variables Correlated	R	p-value	Decision on H_o	Decision on Relationship
Metacognitive Skills & Problem-solving Skills	0.232	0.007	Rejected	Significant
Mathematical Resilience & Problem-solving Skills	0.500	0.000	Rejected	Significant

Table 4 presents the correlation between mathematical resilience and metacognitive skills on students' problem-solving. The findings have shown a positive correlation between independent variables and dependent Findings revealed that metacognitive skills and problem-solving skills have a significant positive low correlation. Problem-solving skills of students and metacognitive skills are positively correlated, as indicated by the r-value of 0.232. The findings suggest that students with high metacognitive skills also possess high problem-solving skills. On contrary, students with low metacognitive skills have low problem-solving skills. Additionally, the result indicates that students who have high metacognitive skills can evaluate problems presented to them, choose and utilize appropriate strategy, and make necessary adjustments. Also, those students who have low metacognitive skills may encounter difficulties in analyzing problems, identifying what strategy must be used, and making necessary adjustments which lead to poor performance in problem-solving. Thus, fostering metacognitive skills will improve the problem-solving skills of students.

The result conforms with Guner and Erbay (2021) who pointed out high metacognitive skills allow students to identify needed information in the problem and suited strategy to be used in solving the problem, also, they can evaluate and check whether they have come up with the correct solution. Bakar et al. (2021) added that students can plan, monitor, and evaluate problem-solving process if they have high metacognitive skills. Similarly, students' problem-solving

Aberin A. Alimbon, and Ma. Melanie N. Edig, "Influence of Metacognitive Skills and Mathematical Resilience on Problem-Solving Skills of Students in Mathematics," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 7, Issue 7, pp. 147-153, 2025.

skills and mathematical resilience have a positive moderate correlation, as indicated by the R-value of 0.500. The findings suggest that students high level of mathematical resilience also possess high level of problem-solving skills. On the contrary, students with low level of mathematical resilience also possess low level of problem-solving skills.

The findings support the hypothesis put forth by Attami et al. (2021) who mentioned that high levels of mathematical resilience enable students can overcome difficult circumstances, which help them to be more proficient in solving problems. Furthermore, Hafiiz et al. (2019) noted that students can work well with other despite differences if they have high levels of mathematical resilience. Also, students can learn and master mathematics despite its challenges along the way if they have high mathematical resilience (Hutaurok, 2019).

Table 5 Regression analysis on the significance of influence of metacognitive skills and mathematical resilience on students' problem-solving skills of students. The p-value of 0.000 indicates that problem-solving skills are influenced by mathematical resilience. Moreover, beta coefficient of 11.25 implies that for every unit increase in mathematical resilience, problem-solving skills improve by 11.215 units. The result also suggest that mathematical resilience is crucial for enhancing students' problem-solving skills.

TABLE 5. Regression Analysis on the Influence of Metacognitive Skills and Mathematical Resilience on the Problem-solving Skills of Students in Mathematics

Independent Variable	**Unstandardized Coefficients**		**Standardized Coefficients**	**t-stat**	**p-value**	**Decision@ α = 0.05**
	β	**Standard Error**	Beta			
(Constant)	-28.895	13.363		-2.162	0.032	
Metacognitive Skills	3.680	2.987	0.097	1.232	0.220	Not Rejected
Mathematical Resilience	11.215	1.881	0.472	5.961	0.000	Rejected

Dependent Variable: Problem-solving Skills *Adjusted R Square: 0.247*
F-ratio: 22.469 *p-value: 0.000*

The findings also demonstrated that students' problem-solving skills are not significantly influenced by metacognitive skills, as evidenced by the p-value of 0.220. The result suggests that its influence on problem-solving skills is overshadowed by other variables. Further, mathematical resilience and metacognitive skills account for 24.7% of the variability in problem-solving skills, according to the R-squared value of 0.247. However, 75.3% indicates that other factors or variables are responsible for the remaining variation in problem-solving skills.

The results are in line with a study by Suhendris (2020) that showed how problem-solving skills of students are significantly influenced by their mathematical resilience. Additionally, Attami et al. (2020) pointed out that one of the factors that could influence students' problem-solving skills is mathematical resilience. Similarly, Hakim and Murtafiah (2020) found that students' problem-solving skills are positively influenced by mathematical resilience.

On the contrary, the findings of this study negate the idea of Guner and Erbay (2021) and Ozturk et al (2020) who emphasized the connection between metacognitive skills and how they influence problem-solving skills of students. Similarly, the result also contradicts the findings of Guner and Erbay (2021) who highlighted that metacognitive skills of students are related and positively influence the problem-solving of skills of students.

V. Conclusion and Recommendation

The study revealed that students have high metacognitive and mathematical resilience, alongside problem-solving skills. Metacognitive skills demonstrated a low but positive correlation with problem-solving skills, while mathematical resilience showed a moderate positive correlation. Furthermore, mathematical resilience has a significant influence on problem-solving skills of students. The findings suggest that while metacognitive skills play a small role in improving problem-solving skills, mathematical resilience is a more substantial factor. This indicates the importance of fostering resilience in mathematics education to improve students' problem-solving skills effectively.

Moreover, based on the findings of the study, it is recommended that different institutions and teachers may develop new initiatives and implement different strategies to further enhance the problem-solving skills of students. Also, students are encouraged to take actions on how to improve their problem-solving skills and strengthen their metacognitive skills and mathematical resilience.

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