MATHEMATICAL REASONING SKILLS AMONG GRADE 12 STEM STUDENTS: BASIS FOR ENHANCEMENT PROGRAM

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ABSTRACT

This study was conducted to determine the level of Mathematical Reasoning Skills Among Grade 12 STEM students. The ability to think critically, spot patterns, and reach logical conclusions in the field of mathematics is known as mathematical reasoning. The goals of this study are to determine the level of mathematical reasoning skills of Grade 12 STEM students, to determine the significant difference of mathematical reasoning skills when analyzed by sex, and to propose an enhancement program based on the findings of the study. Using a descriptive-comparative research design, the data were collected from thirty (30) Grade 12 STEM students randomly chosen through stratified random sampling. Findings revealed that the level of mathematical reasoning skills among Grade 12 STEM students are considered high. Nonetheless, no significant relationship exists between male and female grade 12 STEM students.

Keywords: *Grade 12 STEM students, mathematical reasoning skills, enhancement program, Davao City, Philippines*

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- C.M.E.

- I.J.J.

- C.P.L.

- W.J.S.

- K.J.

TABLE OF CONTENTS

LIST OF TABLES

DEDICATION

The

researchers

sincerely and humbly dedicate

this research paper to the Almighty God,

who has enlightened, strengthened, mended,

and healed me throughout my study.

To my family, who encouraged and

supported me not only in

my financial needs

but also

with spiritual and

emotional needs. To my spiritual

family, who always supported me in

prayers, strengthened and encouraged me.

To my friends and loved ones, who

always gave me a piece

of advice and have

always been

there for

me.

1. INTRODUCTION

Mathematical reasoning skills refer to the ability to think logically and critically in the context of mathematics. It involves the application of logical deduction, inference, and prediction (Öz & Işik, 2017). Mathematical reasoning skills involve logical deduction, inference, and prediction. They are a crucial aspect of critical thinking skills and play a significant role in problem-solving in mathematics. Spatial and verbal skills mediate the relationship between spatial skills and mathematical skills. Critical thinking skills, including mathematical reasoning, have been found to correlate with academic success.

In America, the impact of learning difficulties on students' mathematical reasoning skills is discussed. The authors highlight that the main challenge in learning mathematics is a significant factor contributing to the difficulty in developing mathematical reasoning skills. This implies that students may encounter obstacles in understanding mathematical concepts and applying them to solve problems. (Palinussa et al. 2021). Overall, these studies indicate that American students face various difficulties in developing mathematical reasoning skills. These challenges include a lack of understanding of mathematical concepts, difficulties in transferring knowledge to real-world scenarios, struggles with abstract reasoning and formal proofs, problems in making logical connections and drawing conclusions, and underestimation of students' reasoning abilities.

Mathematics is an indispensable subject of the Department of Education (DepEd) K-12 curriculum of the Philippines which necessitates the use of critical thinking skills and is perceived as important in daily living as well as in the development of other sciences. However, studies in the context of Filipino student's, reveals that the majority of students excel only in knowledge acquisition but considerably low in understanding concepts which requires the use of their higher-order thinking skills (HOTS). This poor mathematics performance is evident in local, regional, national, such as the National Achievement Test (NAT). These showed that Filipino students are underachievers in Mathematics. Braza and Supapo claimed that the shortcomings that can affect students' achievements in Mathematics could be their lack of mastery of the basic concepts and skills, lack of problem solving and critical thinking skills, diverse behavior of students, and inappropriate teaching skills and approaches of teachers in dealing the students in the class of mathematics. (Artuz & Roble, 2021).

In the Division of Davao City, it was observed that students' performance in mathematics is very low based on the 2011 DepEd Advisory. Based on the ranking of all the Divisions in Region XI, Davao City is considered as low performing (Galabo, Abellanosa, & Gempes, 2018). Many students fear problem-solving because it is difficult. They lack the confidence to answer it, and they cannot focus because there is too much formula to use. Because of this, many students performed poorly on their mathematics quizzes and tests.

Given this situation, the researcher concluded it was important to conduct a study on the Mathematical Reasoning Skills of Grade 12 STEM students. The researcher was of the opinion that this study may provide a number of benefits to many stakeholders, including;

Research Objectives

The main objective of this study is to propose an enhancement design on Mathematical Reasoning Skills among Grade 12 STEM students on the basis of the study result.

The specific objectives are enumerated as follows:

1. To determine the level of Mathematical Reasoning Skills among grade 12 STEM students.

2. To determine the significant difference of Mathematical Reasoning Skills among grade 12 STEM students when respondents are analyzed by:

2.1. Sex

3. To propose an enhancement program on the basis of the results of the study.

Hypothesis

The null hypothesis of the study is that there is no significant difference on the level of Mathematical Reasoning Skills among Grade 12 STEM students when the respondents are grouped by sex. This will be tested at 0.05 level of significance.

Literature Review

This section contains the related literature that is pertinent to the current study that was gathered from a variety of sources, including publications, newspapers, journals, and the internet.

Mathematical Reasoning

Studies show how problem-based learning helps students build higher-order thinking skills, such as their capacity for mathematical reasoning. Additionally, they emphasize how higher-order mathematical thinking capabilities, such as mathematical reasoning skills, may be enhanced by mathematical literacy. (Marsitin & Sesanti, 2023).

The use of mathematical modeling activities in the context of STEM education has been found to positively improve students' mathematical modeling skills (Yaprak & Bal, 2023). Mathematical modeling involves using mathematical concepts and reasoning to solve real-world problems, which can enhance students' ability to reason mathematically and apply mathematical knowledge in practical situations.

Researchers analyzed students' mathematical reasoning abilities based on higher-order thinking skills. They categorized students into low, moderate, and

high reasoning groups and found that high reasoning students were able to make conjectures, perform mathematical manipulations, provide reasons or evidence for solutions, and draw conclusions. This study highlights the importance of problem-solving and higher-order thinking skills in developing mathematical reasoning abilities. (Herawati & Amelia, 2021) In order to succeed academically and in their future employment, STEM students in grade 12 need to have strong mathematical thinking abilities. Several studies have examined the significance of developing STEM students' mathematical reasoning abilities and have offered insights into efficient methods for accomplishing this goal.

Mathematical reasoning is a technique that is used to reach a conclusion based on logical mathematical premises based on relevant information and sources that are presumed to be true. This was also imparted by Wahyudi, who stated that mathematical reasoning is a procedure for deriving conclusions based on known or assumed mathematical premises. According to the description above, mathematics and mathematical reasoning are related (Wahyudi, et al, 2016).

Learning complex mathematics corresponds to the improvement of reasoning skills. However, they also suggest that the nature of this development may be more complex than previously thought. This suggests that developing strong mathematical thinking abilities may depend on more than just learning complicated mathematics, but other factors may also be important. (Attridge & Inglis, 2013)

2. METHODOLOGY

Research Design

In descriptive-comparative research, the researcher considers 2 variables that are not manipulated, and establishes a formal procedure to conclude that one is better than the other (Julion, 2020). Pre-experimental research and informal comparative research are other names for it. In the context of this research, the researcher will determine if there is a significant difference when the respondents are analyzed according to sex. On the other hand, the quantitative data collection utilized a four-point Likert Scale where responses were very high, high, low, and very low.

Statistical Tool

The data were treated using the following statistical tools.

Mean. This will be used to determine the level of Mathematical Reasoning Skills among STEM students.

Standard Deviation. This will be used to determine the measure of dispersion of data from the level of Mathematical Reasoning Skills among grade 12 STEM students.

T-test. This will be used to determine the significant difference on the level of Mathematical Reasoning Skills among grade 12 STEM students when analyzed by sex.

3. RESULTS

The data gathered from the respondents on Mathematical Reasoning Skills Among Grade 12 STEM students are presented, analyzed and interpreted in this chapter based on the research objective previously stated. Discussions of

topics are arranged based on subheadings as follows: level of Mathematical Reasoning Skills Among Grade 12 STEM students. Significant difference on the level of Mathematical Reasoning Skills Among Grade 12 STEM students when analyzed by sex. And the enhancement program based on the results of the study.

Level of Mathematical Reasoning Skills Among Grade 12 STEM students

It could be observed from Table 1 that the overall level of Mathematical Reasoning Skills Among Grade 12 STEM students obtained a mean rating of 2.89 or qualitatively described as *high*. This conveys that the Mathematical Reasoning Skills Among Grade 12 STEM students are oftentimes manifested. The overall equivalent standard deviation is 0.194 signals that the responses of the respondents to all items of this variable are aggregated within the mean. Articulating the specific result of the sub-indicators on the level of academic preparedness among grade 12 STEM students, the data are organized from highest to lowest mean ratings with its corresponding standard deviations. 3.17 or *high* with a standard deviation of 0.699 for item *believe that mathematical proofs are necessary to learn mathematics*; 3.13 or *high* with a standard deviation of 0.681 for item *can only understand a mathematical proof when the teacher has done it*; 3.10 or *high* with a standard deviation of 0.759 and 0.712 respectively for items *consider it as true after mathematical result is demonstrated* and *can understand Mathematics through example, whether a thing is true or not*; 3.03 or *high* with a standard deviation of 0.964 for item

believe that the mathematics that we taughtin high school is different from university; 2.97 or *high* with a standard deviation of 0.765 for item *like definition*

Table 1. The level of Mathematical Reasoning Skills among Grade 12 STEM students

Item	Standard Deviation	Mean	Descriptive Equivalent
1. consider it as true after mathematical result is demonstrated.	.759	3.10	High
2. can understand Mathematics through example, whether a thing is true or not.	.712	3.10	High
3. like to make mathematical proof.	.75	2.70	High
4. believe that mathematical proofs are necessary to learn mathematics.	.699	3.17	High
5. want to finish lessons composed of mathematical proofs immediately.	.691	2.93	High
6. am not bored with teachers' discourses which privilege mathematical proofs.	.747	2.83	High
7. like definition more (than theorems), because its demonstrations does not exist.	.765	2.97	High
8. can easily decide what mathematical data to use, while I do a mathematical proof.	.765	2.63	High
9. can easily decide how to continue after my findings while I do a mathematical proof.	.699	2.83	High
10. don't have difficulties in understanding the demonstration while I generally understand the statement of a mathematical proof.	.765	2.63	High
11. easily understand what hypothesis and result when I do mathematical proof.	.607	2.90	High
12. can only understand a mathematical proof when the teacher had done it.	.681	3.13	High
13. believe that is possible to pass exams in university by memorizing mathematical proofs.	.679	2.77	High
14. believe that the mathematics that we taught in high school is different from university.	.964	3.03	High
15. don't have difficulties now because of the difference between mathematics in high school and university.	.770	2.60	High
Overall	**.194**	**2.89**	**High**

more (than theorems), because it's demonstrations does not exist; 2.93 or *high*

with a standard deviation of 0.691 for item *want to finish lessons composed of*

mathematical proofs immediately; 2.90 or *high* with a standard deviation of 0.607 for item *easily understand what hypothesis and result when I do mathematical proof*; 2.83 or *high* with a standard deviation of 0.747 and 0.699 respectively for items *am not bored with teachers' discourses which privilege mathematical proofs* and *can easily decide how to continue after my findings while I do a mathematical proof*; 2.77 or *high* with a standard deviation of 0.679 for item *believe that is possible to pass exams in university by memorizing mathematical proofs*; 2.70 or *high* with a standard deviation of 0.75 for item *like to make mathematical proof*; 2.63 or high with a standard deviation of 0.765 respectively for items *can easily decide what mathematical data to use, while I do a mathematical proof* and *don't have difficulties in understanding the demonstration while I generally understand the statement of a mathematical proof*; 2.60 or *high* with a standard deviation of 0.770 for item *don't have difficulties now because of the difference between mathematics in high school and university*.

Significant Differences on the Level of Mathematical Reasoning Skills Among Grade 12 STEM students when analyzed by sex

Shown in table 2 is the computation on the significant difference on the level of Mathematical Reasoning Skills Among Grade 12 STEM students when analyzed by sex. The assessment of the respondents was compared by various sex brackets on the indicators indicating no significant difference since the p-value is more than 0.05 significance level. This means that there is no significant difference when the respondents are grouped by sex.

Table 2: Significant Difference on the level of Mathematical Reasoning Skills among grade 12 STEM students when analyzed by sex.

	Sex						t	Significance (2-tailed)
Mathematical Reasoning Skills	Male		Female		Total		1.9	0.07
.	Mean	S.D	Mean	S,D	Mean	S.D		
	2.98	0.18	2.83	0.24	2.89	0.19		

P>0.05

However, the computed overall t-value 1.9 with p-value .007, which is greater than 0.05 shows no significant difference and therefore leads to the none rejection of the null hypothesis. This means that the male and female respondents disclosed there is no difference in the level of mathematical reasoning skills in its total.

Enhancement Program

In answer to the last objective of this study, the enhancement scheme has been crafted out based on results of the study. The paper is found in the succeeding page complete with the matrix of activities.

Metacognitive Strategies Program For Mathematical Reasoning Skills Among Grade 12 STEM Students

Rationale

In the study on the level of Mathematical Reasoning Skills Among Grade 12 STEM students, it is indicated that all questions have descriptive equivalence of high. Furthermore, female and male students have a high level of mathematical reasoning skills.

In the context of STEM education, metacognitive strategies are particularly important. Activities such as planning how to approach a learning task, monitoring comprehension, and evaluating progress contribute to successful problem-solving in STEM learning contexts (Huvard et al., 2020). It provides learners with more metacognitive insight into their own reasoning – linking intuition, modeling, and conceptualization representation — and are important to mathematical practices that promote deeper mathematical learning.

Metacognition also enables students to drive their own learning, progressing from the support of a teacher's modeling to self-driving practice of skills and concepts. Another advantage of this technique is that when teachers use strong focusing questions that need deeper thought, they are also teaching students how to ask clarifying questions in a way that will aid students better in later stages of learning, especially when they ask themselves such thought wrecking questions (Hattie, 2017).

In planning strategy, students plan how to complete their tasks. In the next phase, the students monitor their activities to complete the tasks and view the progress of their activities. In the evaluation strategy, the students evaluate the effectiveness of their strategies to complete the tasks. Several studies have been

conducted in different countries of the world to assess the effect of metacognition on mathematical reasoning (Kani & Shahril, 2015).

However, problem-solving in mathematics is frequently difficult for both students and teachers, and this must be addressed by adding suitable skills and strategies into mathematics teaching and learning. Metacognitive talents and strategies must be learned in order for a student to achieve academic success, notably in mathematical problem-solving. Participating in group discussions and reflecting on their own views could also help learners solve mathematical problems more easily (Tachie, 2019).

Objectives

The enhancement program has the following objectives:

1. To increase the level of mathematical reasoning skills among grade 12 STEM students from high to very high level.

2. To increase the level of mathematical reasoning skills among male grade 12 STEM students to equate to the female respondents.

KEY RESULTS AREA	**OBJECTIVES/ ACTIVITIES**	**TIMEFACTOR**	**PERSON INVOLVED**	**EXPECTED**
A. High	A. High mean scores	Twi	Instructors and	Students will

mean scores of mathematical reasoning skills among grade 12 stem students B. The high mean scores of mathematical reasoning skills among grade 12 stem student's	of mathematical reasoning skills among grade 12 stem students. 1.Regular practice and exploration of mathematical concepts are key to improving your mathematical reasoning skills. 2. Motivate and empower students to put in their best efforts and excel in mathematical reasoning skills. 3. Encourage students to talk about mathematical topics, solutions, and	ce in a week	Students	enhance their mathematical reasoning skills and academic performance through diligence and persistence.

	alternative approaches to solve problems. 4. Create math-related stories or situations that need mathematical reasoning to solve difficulties and connect them to real-life scenarios for improved comprehension. B. The high mean scores of mathematical reasoning skills among grade 12 stem students. 1. Organize or participate in advanced problem-solving workshops where	Twice in a week Once a	Instructors and Students Instructors and Students	Students will continue to make strides and discover their unique paths to persevere and make progress. Students exposes to problems that go beyond the standard

	students work on complex mathematical problems. 2. Teach and help other students to reinforce your level of understanding about the topic. 3. Frequently involve students in high-order thinking mathematical problems and questions to maintain their very high mathematical reasoning skills. 4. Motivated students to individually investigate complex mathematical subjects on their own.	week		curriculum and push the boundaries of their mathematical reasoning skills.

4. DISCUSSION

Presented in this chapter is the discussion of data on the level of mathematical reasoning skills among Grade 12 STEM students and the significant difference on the level of mathematical reasoning skills among Grade 12 STEM students when analyzed by sex.

Level of Mathematical Reasoning Skills Among Grade 12 STEM students

The high reasoning skills of students found by the researchers from what the students have demonstrated. These students were able to make conjectures, perform mathematical manipulations, provide reasons or evidence for solutions, and draw conclusions. This study highlights the potential of students to develop high-level mathematical reasoning skills (Herawati & Amelia, 2021).

Several factors have been identified as influencing mathematical reasoning abilities. Additionally, the cognitive style of students has been found to impact mathematical reasoning abilities, with the intermediate field cognitive style category being associated with higher mathematical reasoning abilities (Afifah et al., 2022).

Furthermore, students' learning interests and their mathematical reasoning skills relate to one another. Study suggests that increasing students' interest in learning can improve their mathematical reasoning skills. This highlights the importance of engaging students and fostering their interest in mathematics to enhance their reasoning abilities (Yuliani, 2021).

Significant difference of the Level of Mathematical Reasoning Skills Among Grade 12 STEM students when grouped by sex

When the mathematical reasoning of STEM students was evaluated by sex, the findings revealed no significant difference. The majority of the items in the study on the level of mathematical reasoning skills among male and female students had almost the same equivalent, which is classified as high qualitatively. Similarly, a study found that the development of male students' mathematical reasoning was significantly better than that of female students (Marasabessy Marasabessy, 2021).

However, it is important to consider the influence of stereotype threat on gender differences in mathematical performance. (Stoevenbelt et al., 2022) and (Flore et al. Flore et al., 2018) both discuss how stereotype threat theory proposes an explanation for the gender gap in mathematics performance, suggesting that women may underperform due to the additional pressure of the negative stereotype that women have lower mathematical ability.

The results show that males had a mean score of 2.98, while females got a score of 2.83. Both means are considered high. Similarly, researchers conducted a meta-analysis and concluded that there were no significant differences between boys' and girls' spatial skills, verbal skills, or mathematical achievement. Furthermore, both male and female students have excellent mathematical reasoning skills (Atit et al., 2021).

Conclusion

Established from the findings and results of the study, the following conclusions are drawn: The level of mathematical reasoning skills is high which means that the mathematical reasoning skills in Grade 12 STEM students is often manifested. There is no significant difference on the level of mathematical reasoning skills among the respondents when analyzed by sex. Nonetheless, the male grade 12 STEM students showed higher mathematical reasoning skills.

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