Analysis of The Improvement of Students' Mathematical Reasoning Abilities Through the Implementation of The Problem Posing Method

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Abstract. Reasoning helps one understand mathematical concepts, while understanding mathematical content helps one develop reasoning skills. When solving challenges that affect a person's cognitive development and ability to make rational decisions, reasoning skills are essential. However, because there aren't many cutting-edge teaching strategies, pupils' mathematical reasoning skills are still regarded as lacking. The purpose of this study is to examine and assess how students' mathematical reasoning skills are improving. With pretest and posttest groups receiving training using a problem-posing technique, the research design is a quasi-experiment. The test consists of five essay questions on mathematical reasoning. When taught using the problem-posing approach, students' mathematical reasoning skills fall into the mediocre range. The mean scores are 5.53 on the pretest and 15.56 on the posttest before and after the treatment, showing a 41.79% improvement. The scholarly understanding this research adds to and the empirical foundation it provides for improving the calibre of mathematics instruction have ramifications for the field of education. Research establishing the effectiveness of the problem-posing method in enhancing students' mathematical reasoning skills allows it to be regarded as an innovative way to learning.

Keywords: Mathematical reasoning abilities, Innovative method, Problem posing

1 Introduction

Mathematics education is a crucial aspect in shaping students' cognitive abilities, particularly in the realm of mathematical reasoning. Mathematical reasoning is a fundamental skill of human intelligence [1]. It plays a key role in honing students' abilities to think logically, analyze problems, and find appropriate solutions [2]. According to Koeing (2007), in the learning process from preschool to high school, reasoning and proving activities should encompass the following elements: 1) Understanding reasoning and proving as fundamental aspects of mathematics; 2) Formulating and investigating hypotheses in the context of mathematics; 3) Developing and evaluating arguments in the field of mathematics; 4) Selecting and applying various methods of reasoning

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and proving. Thus, the ability in mathematical reasoning is one of the essential skills that students must possess [4].

One of these challenges is the low mathematical reasoning ability of students, as reflected in unsatisfactory exam results and evaluations. However, students' mathematical reasoning abilities remain low. This is evident in the average mathematics scores on the PISA, reaching 379 with an overall average score of 487, equivalent to a ranking of 73 out of 79 countries [5]. Students only have the ability to perform numerical calculations and struggle to apply them in everyday life. They lack the ability to analyze mathematical problems and cannot develop them because they are fixated on the standardized forms of mathematical formulas. This indicates that students' understanding is still limited, and they are unable to interpret the practical applications of their mathematical reasoning abilities.

The focus of attention has turned to the mathematics learning approach, where the problem posing method emerges as an interesting and potential alternative to enhance the capacity for mathematical reasoning in students. The technique of posing problems involves students in formulating their own mathematical questions or problems [6][7], which can improve their understanding of concepts [8], critical thinking skills, creative thinking abilities [9], and reasoning abilities [10]. In its implementation, the problem posing method yields five categories: problem posing as presenting new problems, reformulating existing issues, generating new issues or reformulating old ones, asking inquiries, and modelling [11].

The development of a learning method focusing on problem posing also has potential implications for increasing students' motivation towards mathematics. By providing students with the opportunity to play an active role in the learning process and connecting mathematical concepts to real-life situations, it is expected to generate greater interest and deeper understanding of the subject.

Given these issues, this research is expected to provide new insights into the effectiveness of the problem posing method in enhancing students' mathematical reasoning abilities. The results of this study are anticipated to lay the foundation for the development of better learning strategies and contribute to efforts to improve the quality of mathematics education at the relevant educational levels.

2 Methods

The method used in this research is a quasi-experimental method with a Problem Posing approach. The study employs a pretest and posttest research design, consisting of two purposively selected groups. At the beginning of the research, a pretest will be conducted, and at the end of the research, a posttest will be administered. The research sample consists of 34 ninth-grade students from one of the public junior high schools in the Cilebar district, Karawang. The research instrument is a set of 5 essay questions. These test questions have been analyzed beforehand to determine validity, reliability, discriminant power, and difficulty level [12] and have been declared valid. The level of mastery of mathematical reasoning ability is reflected in the high or low values obtained. The determination of scores is obtained using the following formula:

$$\text{Score} = \frac{\text{Total Raw Score}}{\text{Ideal Maximum Score (IMS)}} \times 100\% \quad (1)$$

Note: SMI = Number of essay questions x value weight

The value guidelines used in this research [13] presented in Table 1.

Table 1. Score Conversion Guidelines

Score	Category
90 – 100	Very Good
80 – 89	Good
65 – 79	Pretty Good
55 – 64	Not Enough
0 – 54	Verry Less

Meanwhile, to calculate the increase in mathematical reasoning abilities, the following gain formula is used [14] and normalize gain score criteria presented in Table 2.

$$\text{gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}} \quad (2)$$

Table 2. Normalized Gain Score Criteria

Gain Score	Criteria
$g > 0{,}7$	High
$0{,}3 < g \leq 0{,}7$	Medium
$g \leq 0{,}3$	Low

3 Results and Discussion

3.1 Results

This research was conducted over 10 sessions, focusing on statistics and probability for ninth-grade junior high school students. At the beginning of the sessions, students were given a pretest. Subsequently, they underwent mathematics learning using the problem posing method, and at the final session, students were given a posttest. Generally, the results of the mathematical reasoning ability test are presented in Table 3.

Table 3. Results of Students' Mathematical Reasoning Abilities

Aspects that are measured	Score (IMS = 24)		
	Pretest	Posttest	Gain
Average ($\bar{x}$)	5.35	15.56	0.54
Precentage (%)	22.30	64.83	-
Standard Deviation(s)	2.01	1.89	0.11

Description of the percentage (%):

$\bar{x} > 75\%$: High; $60\% \leq \bar{x} \geq 75\%$ 60% : Medium; $\bar{x} < 60\%$: Low

Based on Table 3, the average pretest score for mathematical reasoning in the group is 5.53 (22.04% of IMS), and the average posttest score is 15.56 (64.83% of IMS). Thus, the pretest score falls into the low category, while the posttest score is classified as moderate. The evaluation of students' mathematical reasoning abilities can be classified as follows:

Table 4. Classification of Students' Mathematical Reasoning Abilities

Number	Score	Test Score		Category
		Pretest	posttest	
1	90 – 100	0	0	Very Good
2	80 – 89	0	1	Good
3	65 – 79	0	17	Pretty Good
4	55 – 64	0	14	Not Enough
5	0 – 54	34	2	Verry Less
Total		34	34	

Table 4 indicates that all students fall into the "very less" category for the pretest scores. This is because the range of scores obtained by students is only from 8 to 38. In the posttest results, there is a significant improvement. Specifically, 3% of students fall into the "good" category, 50% fall into the "fairly good" category, 41% fall into the "poor" category, and 6% fall into the "very less" category. A clearer depiction is illustrated in Fig.1.

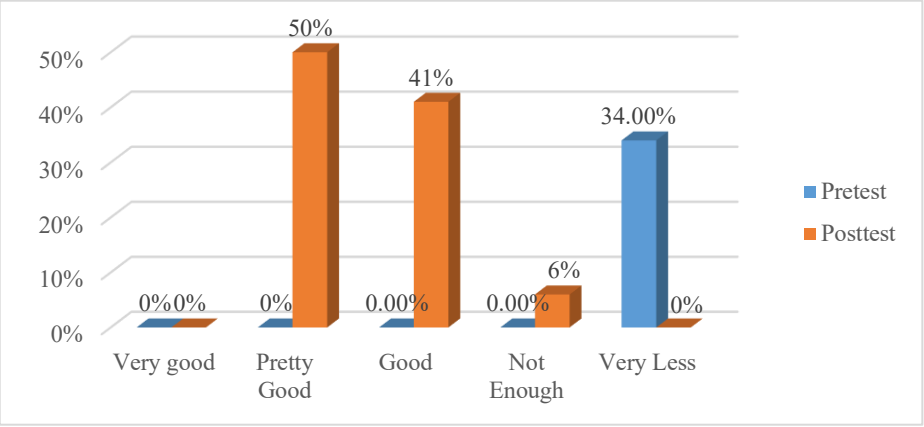

Fig. 1. Percentage of Students' Mathematical Reasoning Ability Score

The students' pretest and posttest scores were then analyzed to obtain the gain values. The gain values were tested using the Mann-Whitney Test, revealing a significant difference in students' initial mathematical reasoning abilities. The obtained p-value is 0.00, where the p-value is less than 0.05. This indicates a significant improvement in students' mathematical reasoning abilities.

3.2 Discussion

At the beginning of the learning process using the problem posing method, students experienced confusion because they were accustomed to receiving knowledge from the teacher and practicing exercises without formulating their own problems. As a result, the first meeting using the problem posing method did not achieve optimal results as students needed to adapt to the steps of the method. The application of the problem posing method in the learning process has a very broad positive impact [7].

The first step in starting the learning process is to present a problem to the students. Students are asked to analyze the problem to obtain the necessary data to solve it. Students are guided to understand the lesson material using Student Worksheets (LKS) containing structured questions. The questions asked are designed systematically to ensure that the learning process progresses in an organized manner, and the questions are relevant to the context of the material being taught.

The Problem Posing method can enhance students' mathematical reasoning abilities because it provides an opportunity for students to analyze the given problems. In this analysis process, students can explore the data present in the problem and offer their solutions. Students are trained to continuously stimulate their thinking about problem-solving strategies. They can question why data is transformed into a specific form, consider the importance of solving the problem, and explore whether there are other possible methods that can be applied. Even after solving a problem, students still consider the possibility of new problems arising from that situation.

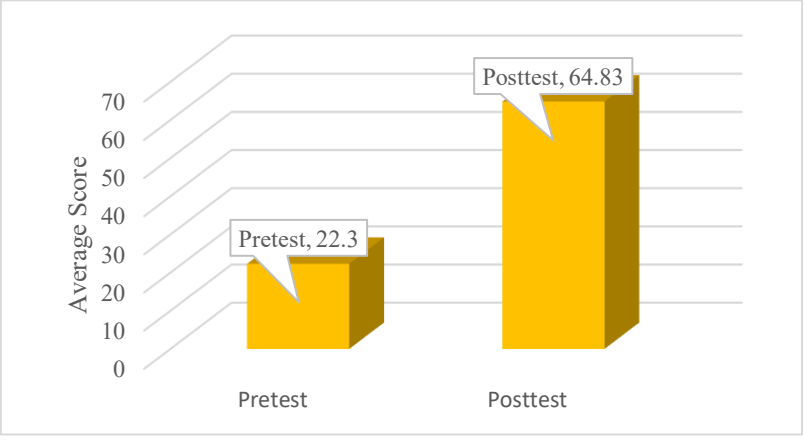

Fig. 2. Average Student Score

The average increase in scores from pretest to posttest (see Fig.2) indicates improvement in all mathematical reasoning questions. The lowest increase was observed in question number 5 with the indicator of performing mathematical calculations based on agreed-upon rules or formulas. The cause was that students were still unfamiliar with the types of cards in a set of bridge cards, which were used as the source of question material. Meanwhile, the highest improvement was seen in question number 3 with the

indicator of drawing logical conclusions. Thus, students were able to draw logical conclusions from presented problems or data.

4 Conclusion

Based on the results and discussion, the average pretest score for students was only 5.53, indicating that all students received very poor scores. However, after being taught using the problem posing method, the average student score changed to 15.56, showing an improvement of 41.79%. Therefore, it can be concluded that the problem posing method has proven to enhance students' mathematical reasoning abilities. The problem posing method serves as an innovative alternative method that can be utilized by teachers in the teaching process.

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