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Mathematical Reasoning Ability of Male and Female Students in Problem Base Learning

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ABSTRACT

Considering the objectives and standards of the mathematics learning process, mathematical reasoning is an ability that students are expected to have. Nonetheless, the mathematical reasoning abilities of Indonesian students are still inadequate, and learning resources are still inadequate. The researcher then tries to solve it by combining the problem-based learning (PBL) paradigm with the use of GeoGebra in the classroom. The aim of this research is to identify and analyze the effect of GeoGebra and Gender-assisted problem-based learning (PBL) models on students' mathematical reasoning abilities. The study involved 35 students of XI State Senior High School at one of the schools in Mataram City. The research instrument used a mathematical reasoning ability test consisting of five essay questions. The study applied a one-group pretest-posttest design to observe the increase in students' mathematical reasoning abilities. Mathematical reasoning ability tests were given before and after the implementation of the GeoGebra-assisted PBL model. Data analysis used descriptive statistics, paired t-tests, and independent t-tests. The results of the analysis show that improving students' mathematical reasoning abilities can be done by applying the GeoGebra-assisted PBL model in the classroom. Observation of the psychological aspects of Gender showed significant results in students' mathematical reasoning abilities.

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A. INTRODUCTION

Mathematical reasoning is understanding, modeling, and solving mathematical problems (Öztürk & Sarikaya, 2021). Mathematical reasoning abilities will assist in visually representing and understanding mathematical concepts, recognizing patterns, and developing mathematical concept connections (Ariati & Juandi, 2022; Cahyani & Sritresna, 2023; Husniah & Azka, 2022; Marfu, 2022) (Ariati & Juandi, 2022; Cahyani & Sritresna, 2023; Husniah & Azka, 2022; Marfu, 2022). Strong mathematical reasoning abilities are essential for problem-solving in mathematics, science, technology, and other professions requiring analytical thinking (Farah Deeba, Sana Hafeez, 2021).

In general, students' mathematical reasoning abilities can be influenced by various variables, including the learning environment, learning techniques used, and inherent talents or dispositions (Aslan, 2021; Bosica et al., 2021; Ghazali et al., 2021; Patricia, 2020; Ping et al., 2020). In addition, students' mathematical reasoning abilities can be assessed through various tests, such as tests of critical and analytical thinking, tests of understanding mathematical concepts, and tests of solving mathematical problems.

Several studies have shown that the mathematical reasoning abilities of Indonesian students are still lagging behind students from other countries (Ayuningtyas et al., 2019; Mumu & Tanujaya, 2019; Negara et al., 2022; OECD, 2018; Sandy et al., 2019; Sumartini, 2015; TIMSS, 2015). Lack of understanding of mathematical ideas needed to answer a problem is one variable affecting students' mathematical reasoning abilities. This low ability may be based on the current curriculum in Indonesia, which emphasizes understanding mathematical ideas above mathematical reasoning abilities. So that children are only taught to remember and spit out mathematical formulas and concepts without having time to think critically and imaginatively.

Improving students' mathematical reasoning abilities is one of the main goals of mathematics education. Teachers may use problem-solving, discovery-based, and problem-based learning techniques that emphasize the development of students' mathematical reasoning abilities in the process of teaching and learning mathematics. By utilizing these strategies, students should be able to best improve their mathematical reasoning abilities and use them in everyday situations.

The problem-based learning (PBL) model is a learning model that might improve students' mathematical reasoning abilities (Anam et al., 2020; Kladchuen & Srisomphan, 2021; Mahmudi, 2010; Negara et al., 2022; Sumartini, 2015; Suparman et al., 2021; Susanti et al., 2020). The PBL model is learning that uses context, situation, or problem as a trigger for students' learning processes in developing knowledge or mathematical abilities. The PBL model places problems early in the learning stage before students learn formal knowledge. Based on the knowledge possessed, students identify information that is known and needed to solve the problem, conduct investigations, analyze, conclude, and evaluate these conclusions. Through such activities, students are expected to be able to acquire relevant knowledge and, at the same time, be able to develop mathematical abilities, such as mathematical reasoning abilities. It is possible the knowledge formed by students is still informal, which is not in accordance with formal knowledge. However, through the discussion process, this knowledge will be more consolidated so that it is in accordance with formal knowledge.

As previously explained, students' mathematical reasoning abilities can be influenced by various variables, such as gender (Ahmad & Sehabuddin, 2017; Aminah & Ayu Kurniawati, 2018; Azizah et al., 2022; Bahri et al., 2022; Escudero et al., 2022; Lindner et al., 2022; Santosa et al., 2022).This difference in character is one of the factors that show how students' habits and behavior in understanding problems, as well as reasoning on certain concepts to be used in solving problems encountered (Khasawneh et al., 2023; Manurung et al., 2022; Ramadhani, 2022). In general, girls are more interested in activities that pay attention to the people around them, while boys enjoy tinkering with sophisticated things such as cars, equipment, and other things like that (Firmanti, 2018).

Several studies explain that men are superior to women in mathematics (Agustiani et al., 2021; Carr et al., 2018; Harris et al., 2020; Kurniawan et al., 2022; Syuhriyah et al., 2021). The abilities girls acquire in class are associated with the "housewife job." They are expected to be calm, considerate, respectful, reliable, and cooperative. Typically, academic competency requirements for boys include knowledge, intellectual prowess, and work ethic. On this basis, girls in schools prefer "feminine" extracurricular activities, such as art. Men enjoy "masculine" hobbies such as athletics and physically demanding nature-loving activities. However, in other studies, it was explained that there were no differences between male and female students in learning mathematics (Escudero et al., 2022; Kirçali & Özdener, 2022). The existence of these various differences in results explains that the gender factor is one of the factors that influence students' abilities in learning mathematics, especially mathematical reasoning abilities.

Based on the explanation above, research is interested in observing mathematical reasoning abilities by applying the PBL model combined with GeoGebra in the learning process. Providing GeoGebra as a follow-up effort on the results of research that has implemented the PBL model (Anam et al., 2020; Kladchuen & Srisomphan, 2021; Mahmudi, 2010; Negara et al., 2022; Sumartini, 2015; Suparman et al., 2021; Susanti et al., 2020). Furthermore, by observing the psychological factor, namely gender, the researcher hopes that the research results can enrich information related to improving mathematics learning, especially students' mathematical reasoning abilities. So the purpose of this study was to find out and analyze the effect of the GeoGebra and Gender-assisted problem base learning model on students' mathematical reasoning abilities. The research questions that were derived as a guide to reaching the research objectives in the form of (1) How are students' mathematical reasoning abilities after learning to use the GeoGebra-assisted PBL model?; (2) Is there an increase in students' mathematical reasoning abilities before and after the implementation of the GeoGebra-assisted PBL model?; and (3) Are there differences in the achievement and improvement of students' mathematical reasoning abilities based on gender?.

B. METHODS

This study applied a quantitative approach with a one-group pretest-posttest design (Fraenkel et al., 2013). The study involved 35 students (18 boys and 17 girls) of class XI senior high school in one of the schools in Mataram City who were obtained by using a purposive sampling technique. The research includes (1) giving a pretest; (2) implementation of GeoGebra-assisted PBL learning; and (3) posttest administration. Learning is carried out on limit function material which is carried out for six weeks, where the learning flow includes (1) problem presentation; (2) Problem investigation; (3) Solution problems; and (4) Evaluation process (Cho et al., 2021; Hastuti et al., 2022), with the use of GeoGebra given as a reinforcement of the concept related to the problem given in the limit function material. In addition to observing the impact of applying GeoGebra-assisted PBL, the researchers also observed gender as a factor influencing differences in students' mathematical reasoning abilities. The instrument consists of a mathematical reasoning ability test in the form of an essay totaling five questions which include indicators (1) memorized reasoning; (2) algorithmic reasoning; (3) novelty; (4) plausible; and (5) mathematical foundation (Jonsson et al., 2014; Negara et al., 2022). Data analysis related to the results of implementing GeoGebra-assisted PBL used descriptive statistics and paired t-tests, while analysis related to achievement and improvement of mathematical reasoning skills used independent t-tests. Data on the achievement of mathematical reasoning abilities are based on posttest data, while data on improving mathematical reasoning abilities are based on the n-gain score obtained through formula (1), with the improvement criteria being practiced based on Table 1 (Negara et al., 2022). The parametric prerequisite test assumes that the distribution of pretest, posttest, and n-gain data on mathematical reasoning ability is normally distributed, and the variance of populations is homogeneous (Bluman, 2013), as shown in Table 1.

$$\text{Normalized Gain } (g) = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal maximum score} - \text{pretest score}} \quad (1)$$

Table 1. Criteria for Increasing the Normalized Gain Score

***Normalized Gain Score* (N-Gain)**	**Interpretation**
g ≥ 0,70	High
0, 30 ≤ g < 0,70	Medium
g < 0, 30	Low

C. RESULT AND DISCUSSION

The presentation of research results is presented in harmony to answer the research questions that have been posed. The Following shows the results of the descriptive analysis of students' mathematical reasoning abilities as a presentation in explaining how students' Mathematical Reasoning Abilities after learning to use the GeoGebra-assisted PBL model, as shown in Table 2.

Table 2. Results of Descriptive Analysis of Mathematical Reasoning Ability

		N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**
Pretest	Man	18	36,3889	8,54152	25,00	55,00
	Woman	17	28,2353	12,74034	5,00	50,00
	Total	35	32,4286	11,39991	5,00	55,00
Posttest	Man	18	75,2778	7,75967	65,00	90,00
	Woman	17	61,7647	12,98330	45,00	90,00
	Total	35	68,7143	12,50546	45,00	90,00
N-Gain	Man	18	,6117	,10772	,46	,87
	Woman	17	,4745	,14599	,17	,80
	Total	35	,5450	,14377	,17	,87

Table 2 shows that the average mathematical reasoning ability of students as a whole before treatment (pretest) is 32.4286. After learning is given (posttest), the average mathematical reasoning ability of students is 68.7143. Descriptively, there was an increase in students' mathematical reasoning abilities after learning to use the GeoGebra-assisted PBL model with an increase (N-gain) of 0.5450, where the category of increase experienced was in the medium category. Furthermore, taking into account the gender factor, it was also seen that the average mathematical reasoning ability of male students after treatment was 75.2778, which was previously only 36.3889, with an increase of 0.6117. The mathematical reasoning ability of male students descriptively outperformed female students, where the average mathematical reasoning ability of female students before treatment was 28.2353 to 61.7647 after being given treatment, with an increase experienced only 0.4745. Even though the increase experienced by male students outperformed female students, the category of improvement experienced by both of them was in the moderate category. Furthermore, to ensure the results of the descriptive analysis, a parametric test was carried out using a paired t-test to find out whether there was an increase in students' mathematical reasoning abilities before and after the GeoGebra-assisted PBL model was applied. The results of the analysis are presented in Table 3 and Table 4, respectively.

Table 3. Paired Samples Correlations

		N	**Correlation**	**Sig.**
Pair 1	Pretest & Posttest	35	,693	,000

Table 4. Paired Samples Test

		Paired Differences					
		Mean	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig. (2-tailed)**
Pair 1	Pretest - Posttest	-36,28571	9,42016	1,59230	-22,788	34	,000

Based on Table 4, it can be seen that the comparison of pretest and posttest students' mathematical reasoning abilities obtained sig. = 0.000 < 0.05 = α. The results of this analysis show that there is an increase in students' mathematical reasoning abilities before and after the implementation of the GeoGebra-assisted PBL model, with a mean difference (before-after) of -36.28571. Furthermore, Table 3 shows the relationship between pretest and posttest scores of mathematical reasoning abilities, with a correlation value (r) of 0.693 and a significant level of 0.00. This means that there is a significant positive relationship between the pretest and posttest mathematical reasoning abilities of students who learn with the GeoGebra-assisted PBL model. The research findings strengthen the results of the research Aslan (2021); Bosica et al. (2021); Ping et al. (2020), which explains that the PBL model is able to develop mathematical abilities which lead to aspects of students' mathematical reasoning abilities. The characteristics of the problems given at the beginning of learning become a stimulus for students to be able to relate problems to the mathematical concepts being studied. So that the success of students depends on the ability of students to relate information that has been previously owned, then by presenting GeoGebra to visually display the concept of limits can strengthen the concept and help understand the form of the function and the limit value of the function from the given problem. The application of GeoGebra is in line with research results Kladchuen & Srisomphan (2021); Negara et al. (2022); Putri & Wardika (2020); Tong et al. (2022) which combines digital games and problem-based learning, where the results of this combination can help improve higher-order thinking skills. Subsequent analysis was carried out to find out whether there were differences in the achievement and improvement of students' mathematical reasoning abilities based on gender. The following are the results of the analysis carried out by comparing the posttest and n-gain scores between male and female students, as shown in Table 5.

Table 5. Results of Analysis of Achievement and Improvement of Mathematical Reasoning Ability based on Gender

		t-test for Equality of Means				
		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**
Post-Test	Equal variances assumed	3,763	33	,001	13,51307	3,59110
	Equal variances not assumed	3,711	25,848	,001	13,51307	3,64154
N-Gain	Equal variances assumed	3,176	33	,003	,13719	,04319
	Equal variances not assumed	3,149	29,375	,004	,13719	,04357

Table 5 shows that the achievement (sig. = 0.001) and improvement (sig. = 0.003) of students' mathematical reasoning abilities differed significantly by gender. Table 2 shows the achievement of male students' mathematical reasoning abilities outperforming female students' mathematical reasoning abilities, where this was also followed by an increase in abilities experienced by male students (0.6117) after learning to use the GeoGebra-assisted PBL model, which was higher than the increase in experienced by female students (0.4745). Overall, male students obtained scores based on indicators of mathematical reasoning ability, namely memorized reasoning, algorithmic reasoning, novelty, plausible, and mathematical foundation, outperforming female students' scores. The findings of this study provide confidence in the conclusions reached by other studies Azizah et al. (2022); Dzarian et al. (2021); Johnson et al. (2022); Lindner et al. (2022); Mutiarani & Sofyan (2022); Narpila (2019); Tarigan et al. (2022) that gender differences play a role in the capacity to understand ideas. Boys and girls acquire and perfect their mathematical abilities in fundamentally different ways (Azizah et al., 2022; Bahri et al., 2022; Escudero et al., 2022; Lindner et al., 2022; Santosa et al., 2022). When measured with male students, female students outperformed them in terms of precision and accuracy but failed in terms of reasoning (Agustiani et al., 2021; Carr et al., 2018; Harris et al., 2020; Kurniawan et al., 2022; Syuhriyah et al., 2021). When compared to their female counterparts, boys are much more likely to accurately extrapolate information from speech and apply logic to situations. It has been proven that female students perform very well in class and in their interpersonal (Dzarian et al., 2021; Mutiarani & Sofyan, 2022; Tarigan et al., 2022). In addition, it was shown by Escudero et al. (2022); Narpila (2019) that male students have a more regular approach to repeating concepts, which makes them more suitable for studying geometry. Even though female students may have lower spatial IQs than male students, their verbal talent is much greater Breda et al. (2018); Girelli (2022); Imamuddin (2017); Stoet & Geary (2020) so that the psychological aspects of gender play an important role in the process of students arriving at an understanding of information, especially with regard to understanding mathematical ideas when learning mathematics.

D. CONCLUSION AND SUGGESTIONS

The results showed that the GeoGebra-assisted PBL model had an effect on increasing students' mathematical reasoning abilities. The learning experiences presented in this model can provide experiences for students to be able to reason, look for connections and draw conclusions from the problems given. The reinforcement provided using GeoGebra provides a visualization of the concept of function and function limit so that this can provide a better understanding in understanding the given problem. Further results show that gender is an important aspect of student learning success, especially in terms of students' mathematical reasoning abilities, where male students' mathematical reasoning abilities can outperform female students. Based on a series of studies that have been conducted and provided results as described previously, the researcher hopes that this research can be used as a reference for further researchers and/or teachers in managing learning situations in class. However, the limitations of choosing a research design that only applies the one-group Pretest-Posttest design make the results of this study less robust for some researchers. Thus, further research can expand this research by adding a control class or making comparisons with other learning models.

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