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Gender and mathematical reasoning ability

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Abstract. This research is motivated by the low mathematical reasoning ability experienced by the students, considering the importance of mathematical reasoning ability for male and female students needed a study on gender factors to the ability of mathematical reasoning. The purpose of this study is to determine whether there is a significant difference in students mathematical reasoning abilities between male and female students after using the problem based learning approach on learning. This research as conducted at 24 female student and 20 male student in the 8th grade in one of junior high school in Cimahi, Indonesia. The method in this study is quasi experiment that is by comparing the reasoning ability of male and female students after getting learning with problem based learning and instrument as much as 3 pieces about mathematical reasoning ability test. First, both male and female students were given pre-test, secondly students were given learning using PBL as much 5 meetings and lastly students were given a post-test to compare reasoning skills between male and female students. The result of this research is there is no significant difference of mathematical reasoning ability between male and female students after using problem based learning approach in their learning., it means that the problem-based learning approach can reduce the difference in mathematical reasoning ability among male and female students.

1. Introduction

Mathematics is a science that requires reasoning in the process of thinking. One of the objectives of mathematics learning of Junior High School (SMP / MTS) students according to *Permendiknas* (Regulation of national education minister) number 22 of 2006 is that students should have the ability in using reasoning on patterns and traits, performing mathematical manipulations in creating generalization, compiling evidence or explaining mathematical ideas and statements [1]. It implicitly visible that the purpose of that learning of reasoning ability is needed in learning mathematics. In line with this NCTM formulated the objectives of learning mathematics include: learning to communicate, learn to reason, learn to solve problems [2], therefore reasoning is a mathematical power that needs attention to be improved.

Reasoning itself is a way of thinking in drawing a conclusion from cases that have been proved. Reasoning is the adoption of thought in order to produce statements and to reach conclusions on problem solving that are not always based on formal logic so as not to be limited to proof [3], mathematics has a close relationship with reasoning, reasoning widely used in the majors of mathematics including the extent of deductive reasoning, example-based reasoning and further education in mathematics [4]. Indicators of mathematical reasoning ability a) Drawing logical conclusions b) Providing explanations with models, facts, traits, and relationships c) Estimating answers and process solutions d) Using



patterns and relationships to analyze mathematical situations e) Preparing and reviewing conjectures, f) Define the opponent Following the rules of inference, checking the variance of the argument g) Preparing a valid argument, h) Establishing direct, indirect, and using mathematical inductions [5].

The issue of gender is the subject of recent studies, in learning mathematics, both male and female have their own characteristics as well as in mathematical ability, both male and female should have good mathematical skills. In one study it was found that women had mathematical communication ability, mathematical connection ability, mathematical reasoning ability, and mathematical solving ability that was more prominent than male [6]. In another study specifically examining the ability of reasoning found that male students more controlled indicators in mathematical reasoning than female students [7].

Based on the explanation, it is needed to discover a learning approach that eliminates the gap between male and female reasoning capability, its learning approach that can improve both male and female reasoning ability, this study we propose problem based learning approach as a solution of the problem. Problem-based learning is significantly better than conventional learning in improving high-level mathematical thinking skills of junior high school students in terms of gender differences [8]. for next in this article Problem Based Learning will be shortened to become (PBL)

PBL is a learning approach that emphasizes the problem of early learning, PBL steps: (1) Formulate the problem, (2) Analyze the problem, (3) Formulate the hypothesis, (4) Collect data, (5) The use of hypothesis. (6) To formulate the problem solving recommendation [8], from the PBL steps the students' reasoning and thinking can be honed because one of the advantages of PBL is to help the students to understand the essence of learning as a way of thinking not just understand the learning by teachers based on textbook [9].

Based on previous research the students' mathematical reasoning abilities using PBLs are better than those using the conventional approach [10], this is because the problems in PBL are effective, and it has characteristics; a) Authentic characteristics, it means the problem is based on the real world, b) Ill-structured, the problem has it complexity c) relevant, it means that the proposed problem must be in accordance with the context being taught, (d) Academically rigorous, meaning the problem of giving students the chance to think critically and creatively, e) Interdisciplinary in nature, that is, the problem refers to knowledge and experience from various disciplines [11], PBL learning process is formed from the disorder and complexity of problems that exist in the real world. It is used as a motivator for students to learn, to integrate and to organize the information, so that later it can always be remembered and applied to solve the problems. Problems designed in PBLs challenge students to develop critical thinking skills and solve problems effectively [12]. With the effective problems, it is expected that male and female students' reasoning ability is increasing. according to a previous study PBL showed positive learning outcomes in many countries worldwide, which shows this teaching method can be applicable in different setting if the curriculum reform was well planned and implemented [13].

Based on the above exposures the purpose of this study is to determine whether there is a difference in mathematical reasoning ability between male and female students after using PBL. The results of this study found there is no significant differences in mathematical reasoning ability between male and female students after learning using PBL, and in terms of improving it so.

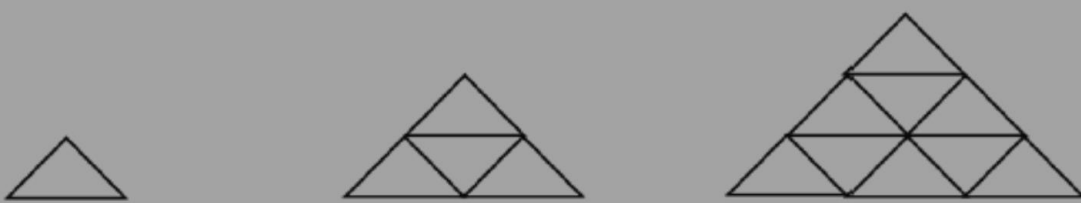
2. Research method

The method in this research is quasi-experimental method because there is manipulation of treatment in one class, this research involves 44 students in grade 8 in junior high school in Cimahi consisting of 20 male students and 24 female students of academic year 2016/2017. The instrument used is three questions of mathematical reasoning ability test on triangle and rectangular material. Prior to being treated with Problem-Based Learning approach students are given pre-test to see how far the initial ability possessed by students and analyze the ability of mathematical early reasoning of male and female students, after that done learning on triangle and quadrilateral material by using PBL 5 meetings. At the end of the meeting, students are given post-test to see their achievements.

3. Results and discussion

Here are 3 mathematical reasoning given to students to analyze obstacle epistemology, presented in figure 1.

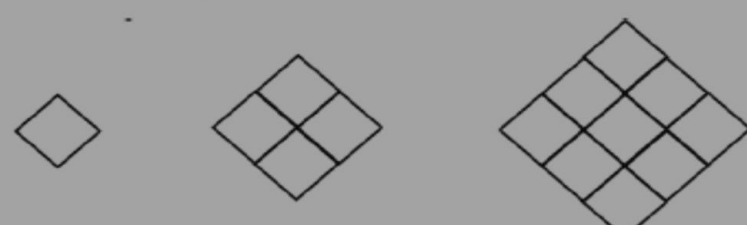
1. Observe the figure below !



Pattern 1 Pattern 2 Pattern 3

it is known that the small triangles are equilateral triangles with side length 4 cm, what is the area of triangle on the 6th pattern?

2. Observe the figure below !



Given the length of the diagonals of the rhombus of the 1st pattern is 8cm and 6cm. What is the circumference of the wake on the 6th pattern?

3. the circumference of a window of length and width similar to the circumference of the 20R frame. What is the value of x and y (In inches)

Figure 1. Mathematics reasoning ability problems [14].

After five meetings treatment using Problem Based Learning, then pre-test, post-test and N-Gain processed using SPSS software, following are summary of descriptive statistics explain in table 1

Table 1. Summary of descriptive statistics between male and female students.

	Pre-test*			Post-test*			N-Gain		
	$\bar{x}$	s	N	$\bar{x}$	s	N	$\bar{x}$	s	N
Male	17.95	6.64	20	28.60	7.77	20	0.40	0.20	20
Female	22.92	8.85	24	27.92	10.10	24	0.31	0.25	24

*SMI =45

Table 1 is a descriptive statistical summary of the results of pre-test, posttest and improved mathematical reasoning ability. Before the experiment begins students are given pre-test, from the results of pre-test obtained average male students' reasoning ability is 17.95 and 22.92 women, we roughly see those female students have higher value than male students, then on post-test that is given after the treatment shows that the average value of male students' reasoning becomes 28.60 and female students become 27.92, we can analyze that the average of both is not much different. Here is an example of the work of male and female students in solving mathematical reasoning at pre-test.

Figure 2 shows two examples of student work on a pre-test. The left side (female student) shows a triangle with base 4 and height $t = \sqrt{4^2 - 2^2} = \sqrt{16 - 4} = \sqrt{12} = 2\sqrt{3}$. The area of the triangle is calculated as $\frac{1}{2} \times 4 \times 2\sqrt{3} = 4\sqrt{3}$. The area of the triangle is then multiplied by 4 to get $16\sqrt{3}$, and then by 9 to get $36\sqrt{3}$, and finally by 6 to get $24\sqrt{3}$. The right side (male student) shows a triangle with base 4 and height $t = \sqrt{4^2 - 2^2} = \sqrt{16 - 4} = \sqrt{12} = 2\sqrt{3}$. The area of the triangle is calculated as $\frac{1}{2} \times 4 \times 2\sqrt{3} = 4\sqrt{3}$. The area of the triangle is then multiplied by 4 to get $16\sqrt{3}$, and then by 9 to get $36\sqrt{3}$, and finally by 6 to get $24\sqrt{3}$.

Figure 2. Examples of student work on Pre-test, female (left) and male (right).

In figure 2 The female student is correct in determining the height of the triangle then appropriately determining the area of triangle in the 3rd pattern but, on the 6th pattern he mistakenly determines the area of the triangle, this is because the picture provided is only up to the 3rd pattern. In the male students do the thing mistaken at the beginning of the settlement is in determining the area of the triangle in the first pattern, this is because he does not know how to find the height of the triangle. After learning with PBL is implemented, male and female students experience improvement in solving the problem, following example of student in solving post-test problem shown in figure 3.

Figure 3 shows two examples of student work on a pre-test. The left side (male student) shows a triangle with base 4 and height $t = \sqrt{4^2 - 2^2} = \sqrt{16 - 4} = \sqrt{12} = 2\sqrt{3}$. The area of the triangle is calculated as $\frac{1}{2} \times 4 \times 2\sqrt{3} = 4\sqrt{3}$. The area of the triangle is then multiplied by 4 to get $16\sqrt{3}$, and then by 9 to get $36\sqrt{3}$, and finally by 6 to get $24\sqrt{3}$. The right side (female student) shows a triangle with base 4 and height $t = \sqrt{4^2 - 2^2} = \sqrt{16 - 4} = \sqrt{12} = 2\sqrt{3}$. The area of the triangle is calculated as $\frac{1}{2} \times 4 \times 2\sqrt{3} = 4\sqrt{3}$. The area of the triangle is then multiplied by 4 to get $16\sqrt{3}$, and then by 9 to get $36\sqrt{3}$, and finally by 6 to get $24\sqrt{3}$.

Figure 3. Examples of student work on pre-test, female (right) and male (left).

After getting treatment with PBL shown in figure 3 both male and female students have been right in solving the problem of reasoning by following the pattern done in sequential, male students think of many possibilities therefore they use different strategies [15]. The increase of reasoning ability becomes one of the main focus for the researcher.

3.1. Normality test of pre-test and post-test of mathematical reasoning of male and female students

As we know, the normality test is a prerequisite test before we test the parametric difference in this case t-test. The criterion of the normality test is if the value of Sig. ≥ 0.05 then the data is normally distributed, if the Sig Value < 0.05 then the data is not normally distributed. The following summarizes the results of normality test Data Pre-test, post-test, and N-Gain both male and female students explain in Table 2.

Table 2. Kolmogorov-Smirnov Normality Test (KS) pre-test, post-test and N-gain reasoning results of male and female mathematical reasoning ability.

	Pre-test		Post-test		N-Gain	
	KS	Sig	KS	Sig	KS	Sig
Male	0.221	0.011	0.095	0.200	0.144	0.200
Female	0.087	0.200	0.155	0.139	0.211	0.007

In table 2. Sig value. for male pre-test data equal to 0,011 this value <0.05 then pre-test data of male students not normally distributed, while for data of female student prity with Sig value. of $0.200 \geq 0.05$, then the data is normally distributed, as well as in post-test data both male and female post-test values are normally distributed because of the Sig value. ≥ 0.05 is 0.200 and 0.139. At the Sig value. N-Gain female students is $0.007 < 0.05$, then N-Gain data for female students is not normally distributed. In Pre-test and N-Gain data there is one data that is not distributed, so to test the difference of both used non parametric test that is Mann-Whitney

3.2. Differentiation test of pre-test, post-test and n-gain of mathematical reasoning ability among student's male and female

we need to analyze the Initial ability of the students to see how far the mathematical reasoning ability of male and female students before experiments. Normality test has been done before and obtained that one of the data is not normally distributed, therefore to test the significance of the average difference is done non-parametric test ie Mann-Whitney test, with criterion if $\text{Sig} \geq 0.05$ there is no difference in the ability of early mathematical reasoning between male and female students, This summarizes the results of data processing using SPSS software shown in table 3.

Table 3. Mann-whitney test of pre-test about mathematical reasoning ability between male and female students.

	Pre-test
Mann-Whitney U	158.500
Z	-1.926
Asymp. Sig (2-tailed)	0.04

From table 3. We can see that the Sig Value. is 0.04, this value is <0.05 , based on the criteria then the conclusion there is a difference of initial mathematical reasoning ability between male and female students before the students get the learning with Problem Based Learning

Previously known that post-test data both male and female normally distributed, then to analyze the difference in achievement using t-test, but before that we have to test homogeneity with Levene Test, with criterion if Sig value. ≥ 0.05 , then the variance data of male and female post-test value is homogeneous. After the homogeneity test then tested the difference of mathematical reasoning achievement of male and female students by using t-test, with sig (2-Tailed) ≥ 0.05 , there is no difference in mathematical reasoning achievement between male and female students and if sig (2-Tailed) <0.05 then there is a difference in mathematical reasoning achievement between male and female students. Here is a summary of Homogeneity and Test-t-test results describe in table 4.

Table 4. Homogeneity test and mean difference test achievement between male and female students' reasoning skills.

	Levene's Test for Equality of Variances		T	df	Sig (2-Tailed)	Mean Difference
	f	Sig				
Equal variances Assumed	3.325	0.075	0.247	42	0.806	0.683
Equal Variances not Assumed			0.253	41.765	0.801	0.683

From table 4. Homogeneity test with Levene's Tests obtained 3,325 with sig value. 0.075, this value is ≥ 0.05 , then the variance of the two homogeneous classes, Next t arithmetic for equal variance assume of 0.247 and the value of sig (2-Tailed) of. 0806 this value $>$ from 0.05, then the conclusion there is no difference in achievement of mathematical reasoning ability between male and female students after

both get treatment with problem based learning approach, therefore to see the significance of the difference the achievement is done by non-parametric test of Mann-Whitney, with criterion if sig (2-Tailed) ≥ 0.05 . Here's a summary of Mann-Whitney test results explain in table 5.

Table 5. Mann-Whitney Test Increased Mathematical Reasoning Skills Between Male and Female Students

	N-Gain
Mann-Whitney U	142.000
Z	-2.311
Asymp. Sig (2-tailed)	0.052

Table 5 shows that the value of Sig (2-tailed) is 0.052, this value > 0.05 it can be concluded that there is no difference in the increase of mathematical reasoning ability among male and female students after they get learning with problem based learning.

After being treated with PBL and post-test processed it turns out that the mathematical reasoning abilities of male and female students did not differ significantly, as did the N-Gain mean that the improvement of male and female students' reasoning ability did not differ significantly. This Research in line with previous research that reveal that gender does not make any significant difference in mathematical performance [16]. Apparently this result is not in accordance with previous studies which states that the mathematical reasoning ability of male and female students is different [8], this is because the learning approach used is different. The division of heterogeneous learning small groups is one of the factors that causes no difference in mathematical reasoning ability between men and women to help each other in group learning. Small groups from diverse background can help in overcoming social barriers amongst students and allow collaborative learning amongst them [17]. Students need to develop social skills in order to be active in group discussion and exercise independent learning [18]. PBL can reduce the differences in mathematical reasoning ability of male and female students, this is because in PBL there is cooperation and exchange of ideas between heterogeneous groups in which there are male and female students, both men and women no more dominant, in PBL offers students the freedom of learning and students are expected to identify problems, collect data and strategize which they find most appropriate to solve problems. No routine problems that are related to the real world are a primary component of the PBL approach [19]. Because the characteristic of PBL focuses on the problem, it is expected that the students' reasoning can be sharpened.

4. Conclusion

Based on data analysis, it can be concluded that there is no difference in mathematical reasoning ability between male and female students after learning using PBL approach, both male and female students have increased the ability of mathematical reasoning. Whereas before the treatment of mathematical reasoning ability among male and female students significantly different, this means that the PBL approach can reduce the difference in reasoning ability that occurs.

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