KnE Social Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

The Impact of Mathematical Reasoning and Critical Thinking Skills on Mathematical Literacy Skills

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Abstract.
For learning mathematics, mathematical skills are needed, some of which are mathematical reasoning skills, mathematical critical thinking skill, and mathematical literacy skills. This research aims to obtain information regarding the impact of mathematical reasoning and critical thinking skills on mathematical literacy skills. This research used a quantitative approach using an associative method with a correlational technique. The sample of this research was comprised 51 students who took integral calculus course in the Department of Mathematics and Mathematics Education, Faculty of Mathematics and Science in Universitas Negeri Jakarta, which were collected randomly using simple random sampling. The statistical analysis used in this research was multiple regression analysis. The results of this research showed that: 1) There was a positive impact of mathematical reasoning on mathematical literacy. 2) There was a positive impact of mathematical critical thinking skill on mathematical literacy. 3) There was an impact of both mathematical reasoning skill and mathematical critical thinking skill together on mathematical literacy. Further research is needed related to the impact of mathematical reasoning and critical thinking skills on mathematical literacy skills reviewed from the student's initial mathematical skill.

Keywords: critical thinking skills, mathematical literacy skills, mathematical reasoning.

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Published: 26 April 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

Mathematics holds an important role in life, especially in the field of education, it is shown by the fact that mathematics is a topic in every level at schools, and many departments in university involve mathematics as a topic. Mathematics belongs to a group of science and technology subjects which is needed in scientific behaviour [1]. Aspects contained in mathematics contribute in forming thinking framework that can be developed through mathematics learning [2].

In mathematics learning, mathematical skills are needed, one of which is mathematical literacy skill, that is a skill in reading an information in the form of both number and picture or graph, starts from identifying, understanding the problem and finding

solution as well as making decision towards the problem. Mathematical literacy skill has five competencies, namely problem solving, communication, mathematical reasoning, mathematical connection, and mathematical representation [3]. Mathematical literacy is a skill of formulating, applying and interpreting mathematics in various contexts in which mathematical reasoning exists in applying mathematical concept, procedure, fact, and tool in explaining and predicting mathematics in making a constructive decision [4].

One of the competencies in literacy skill is mathematical reasoning skill. Mathematical reasoning is mathematical skill and thinking process of outlining, generalizing, combining, and finding solution from the problem that is not routine by connecting existing concept [5]. Kusumawardani, et al. in their research showed that mathematical reasoning had an important role to increase mathematical literacy skill because mathematical reasoning is one of the competencies needed in mathematical literacy, so in order to increase mathematical literacy skill then mathematical reasoning skill should first be increased [6].

Critical thinking skill should also be owned by college students other than mathematical literacy and mathematical reasoning skill. Mathematical critical thinking is a mathematical skill in outlining and assessing information obtained from the result of observation, experience, reasoning, or communication to make a decision whether the information is trusted so that a valid conclusion can be obtained. College students who think critically are able to draw conclusion from the new information obtained which can be accountable [7].

A research conducted by Rojas showed that mathematical literacy skill could develop mathematical critical thinking skill [8], however, it is still unknown whether it applies biconditionally that critical thinking skill has also positive impact on mathematical literacy skill, therefore researchers were interested in conducting a study to prove whether mathematical critical thinking skill has also positive impact on mathematical reasoning skill. Meanwhile Sukmawati in her research showed that there was a significant relation between mathematical literacy skill and mathematical critical thinking skill on college students in general [6]. A person with high mathematical literacy skill has a high level of critical thinking as well.

2. RESEARCH METHOD

The sample of this research was comprised of 51 students who took integral calculus course in Department of Mathematics and Mathematics Education, Faculty of Mathematics and Science, Universitas Negeri Jakarta. This research used quantitative approach

because the data used to analyse the relation between variables were in the form of numerals, namely test results of mathematical reasoning skill, mathematical critical thinking skill and mathematical literacy skill. Associative method was used because the research aimed to find out the relation between variables, that were aimed to find out relation of influence (active) and influenced (passive) between mathematical reasoning skill and mathematical critical thinking skill on mathematical literacy using correlational technique. Mathematical literacy skill (Y) was a dependent variable in this research, while mathematical reasoning skill (X1) and mathematical critical thinking skill (X2) were independent variables defined by the following design.

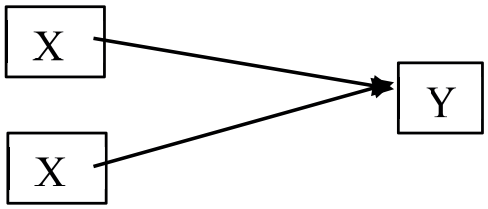

Figure 1: Research design.

Data used in this research was the result of integral calculus final test. Mathematical literacy skill test was measured using written test instrument in essay form consisted of 4 question items which were compiled involving aspects of integral calculus and indicator of mathematical literacy skill, while to measure mathematical reasoning, written test instrument was used in essay form consisted of 4 question items which were compiled based on indicator of mathematical reasoning skill and indicator of integral calculus concept achievement. The instrument used to measure mathematical critical thinking skill was a written test instrument in essay form consisted of 5 question items which were compiled based on indicator of mathematical critical thinking skill and indicator of integral calculus concept achievement.

Questions used on the test in this research had been reviewed by experts and had been tested in order to determine the question items quality. Experts reviewed were done by three mathematics education lecturers in Universitas Negeri Jakarta, while instrument trial test were conducted towards the students excluding the research sample. The validity and reliability of the instrument trial test result were calculated using SPSS software and it was obtained that $r_{stat} > r_{table}$ using the significance of $\alpha = 0.05$ which means that all instruments were valid. After that, reliability test was conducted and reliability coefficient of $r_i = 0.71$ was obtained where $0,60 < r_i < 0,80$ which based on Guilford's classification of reliability coefficients interpretation Table 1 [9], the instrument had a high reliability so that it was feasible to use.

3. RESULT AND DISCUSSION

3.1. Data Description

The research data was the test results of mathematical reasoning skill (MR), mathematical literacy (ML), and mathematical critical thinking skill (CTS) of students from the research sample which is shown by Table 1.

TABLE 1: Data description of test results.

	MR	ML	CTS
N	51	51	51
Mean	87.10	77.88	87.04
Range	25	23	30
Minimum	72	66	70
Maximum	97	89	100
Std. Deviation	6.014	5.729	7.048
Variance	36.170	32.826	49.678

Table 1 shows that the mean of MR, ML, and CTS are 87.10, 77.88, and 87.04 consecutively. It can be seen that the mean of the test result score from MR skill is higher than ML and CTS skills, while test result of ML got the lowest average compared to MR and CTS, it shows that the students had difficulty doing the ML test.

3.2. Prerequisite Test

Prerequisite test was conducted to test the normality and homogeneity of residuals, as well as autocorrelation and multicollinearity test. The normality test of residuals was conducted using Kolmogorov –Smirnov test in SPSS software. The result obtained was sig.= 0.8 > 0.05, this shows that the regression residuals data was distributed normally. The next prerequisite test was homogeneity test of residuals which was conducted using levene's test in SPSS software. The result obtained was sig.= 0.305> 0.05, which means the regression residuals data was homogeneous. Next one was Durbin-watson test which was one of autocorrelation test, was conducted to find out whether the residuals were independent. The result obtained was sig.= 1.719, which situated in the interval score between 1 until 3 which means the regression residuals were independent. The last prerequisite test was multicollinearity test. In multicollinearity test, the result obtained of VIF for variable MR and CTS was 1.007, thus between variable MR and CTS, there was no multicollinearity as the score of both VIF was less than 10.

From all the prerequisite test of multiple regression analysis above, the assumptions of normality, homogeneity and independency then had been fulfilled so inferential statistical analysis using multiple regression analysis with two predictor variables could be conducted.

3.3. Statistical hypothesis

After conducting prerequisite analysis test then the next step was conducting statistical hypothesis test using multiple regression analysis. The test was conducted to find out the impact of independent variables, namely mathematical critical thinking skill and mathematical reasoning skill on dependent variable, that is mathematical literacy skill. Multiple regression analysis was conducted using SPSS software and the regression equation obtained was: Y = 29.553 + 0.535 X1 + 0.200 X2.

In testing the significance of regression coefficient, the test was conducted on such hypothesis: H0 : ⊠1 ⊠ 0, H1 : ⊠1 > 0 and H0 : ⊠2 ⊠ 0, H1 : ⊠2 > 0. Using SPSS software for coefficient of variable MR, it was obtained tstat = 4.684 and Sig. = $\frac{0.000}{2}$ = 0.000 < 0.05 thus H0 was rejected and it shows that the mathematical concept understanding skill had a positive impact on mathematical literacy skill. For coefficient of variable CTS, it was obtained tstat = 2.002 and Sig. = $\frac{0.084}{2}$ = 0,042< 0,05 thus H0 was rejected, which means that mathematical critical thinking skill had a positive impact on mathematical literacy.

The next test was testing the significance of multiple regression equation by testing the hypothesis: H_0 : b1 = b2, and H_1 : b_1 ^{1} b_2. This test was conducted using SPSS software and the statistics score obtained was Fstat = 10.987 and p- value/sig = 0.000 < 0.005, thus H_0 : b_1 = b_2 was rejected, which means that there was an impact of mathematical critical thinking skill and mathematical reasoning skill together on mathematical literacy skill.

After testing the significance of multiple regression equation, the next was then testing the significance of multiple correlation coefficient with R = 0.560 and Fstat = 10,987 with p-value = 0,000 < 0,05 which caused Ho to be rejected, that means multiple correlation coefficient between variable X1 and X2 on variable Y was significant. Meanwhile, coefficient of determination was shown by *R Square* = 0,314. It means that 31,4% variability of mathematical literacy (Y) could be explained by mathematical reasoning skill (X1) and mathematical critical thinking skill (X2) or it could be said that the impact of mathematical reasoning skill and mathematical critical thinking skill together on mathematical literacy was 31,4% and of 68,6% was impacted by other factors.

The last statistical hypothesis test was testing the significance of partial correlation coefficient, that was, testing the correlation between CTS and ML by controlling the impact of MR and testing the correlation between MR and ML by controlling the impact of CTS. From the result of correlation test between CTS and ML, it was obtained that $ry_{1,2} =$ -0,240 and p-value = 0,004 < 0,05. It could be concluded that H0 was rejected, so correlation coefficient between mathematical critical thinking skill and mathematical literacy by controlling mathematical reasoning was significant, while from the result of correlation test between MR and ML skills, it was obtained $ry_{1,2} =$ 0,560; p-value = 0.000 < 0,05, thus H0 was rejected, which means that correlation coefficient between mathematical reasoning and mathematical literacy skill by controlling mathematical critical thinking skill was significant.

3.4. The Impact of Mathematical Reasoning Skill on Mathematical Literacy

Mathematical reasoning skill also had a positive impact on mathematical literacy, proved by the result of data analysis that the correlation or relation between mathematical reasoning skill and mathematical literacy by controlling critical thinking skill was significant. This is in line with the research conducted by Kusumawardani, et al. which mentioned that mathematical reasoning had an important role to increase literacy skill [6].

Mathematical reasoning skill makes someone do their first move by recalling the concept or the prior related knowledge when they were faced to a new concept or knowledge, which means that the better the college students' mathematical reasoning skill, the better the college students' mathematical literacy because mathematical reasoning skill gives a positive impact on mathematical literacy skill.

3.5. The Impact of Mathematical Critical Thinking Skill on Mathematical Literacy

Based on the data analysis, it was obtained that mathematical critical thinking skill had a positive impact on mathematical literacy. By controlling mathematical reasoning, a significant correlation between critical thinking skill and mathematical literacy could be obtained. If being analyzed further, it was because critical thinking skill is an important skill owned by students.

One of the indicators of critical thinking skill is connecting the prior knowledge to the new one, making college students have a wider insight so when they receive a

new concept, the upcoming respond will be evaluating that concept systematically until they get a valid conclusion. Critical thinking skill and mathematical literacy is directly proportional, it can be said that the better the college students' critical thinking skill, the better the mathematical literacy skill they have. This is in line with Sukmawati's research result which concluded that there was a significant relation between mathematical literacy skill and critical thinking skill [10], from her research result it was obtained that college students with high mathematical literacy skill, had also high level of critical thinking. College students who are able to solve mathematical literacy skill questions will also be able to solve critical thinking skill questions.

3.6. The Impact of Mathematical Reasoning Skill and Mathematical Critical Thinking Skill on Mathematical Literacy

Both mathematical reasoning skill and mathematical critical thinking skill had a positive impact on mathematical literacy skill. That was because critical thinking skill and mathematical reasoning skill have relation to each other, that is, connecting the prior knowledge to the new one which is obtained and combined until the valid conclusion is acquired.

Other than that, in integral calculus course, it requires preliminary skills that have to be owned by college students, like the basic concept of integral on how to compute indefinite and definite integral, various technique of integrating, and application of integral which had been learned previously in high school level. Therefore, further research is needed related to the impact of mathematical reasoning skill and mathematical critical thinking skill on mathematical literacy reviewed from the students' initial mathematical skill.

4. CONCLUSION

Based on the research result, it was concluded that: 1) There was a positive impact of mathematical reasoning on mathematical literacy of the students of Department of Mathematics and Mathematics Education, Faculty of Mathematics and Science, in Universitas Negeri Jakarta, 2) There was a positive impact of mathematical critical thinking skill on mathematical literacy of the students of Department of Mathematics and Mathematics Education, Faculty of Mathematics and Science, in State University of Jakarta, 3) There was an impact of both mathematical reasoning and mathematical critical thinking skill together on mathematical literacy of the students of Department

of Mathematics and Mathematics Education, Faculty of Mathematics and Science, in Universitas Negeri Jakarta. Further research is needed related to the impact of mathematical reasoning skill and mathematical critical thinking skill on mathematical literacy reviewed from the students' initial mathematical skill.

Acknowledgments

This research is fully funded and supported by Lembaga Penelitian dan Pengabdian Masyarakat Universitas Negeri Jakarta.

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