**PAPER • OPEN ACCESS**

# Effect of Mathematical Concept Understanding and Mathematical Reasoning on Mathematical Literacy Abilities

To cite this article: S A A Kharis *et al* 2021 *J. Phys.: Conf. Ser.* **1747** 012042

View the article online for updates and enhancements.

# Effect of Mathematical Concept Understanding and Mathematical Reasoning on Mathematical Literacy Abilities

**S A A Kharis\*, E Salsabila and L D Haeruman**

Department of Mathematics, Faculty of Mathematics and Science, Universitas Negeri Jakarta, Jl. Rawamangun Muka, Jakarta, 13220, Indonesia


Email\*: sellyanas@yahoo.com

**Abstract.** This study aims to obtain information about the effect of mathematical concept understanding and mathematical reasoning on mathematical literacy abilities. The problems in this study include: 1) Is there an effect of mathematical concept understanding to the ability of mathematical literacy 2) Is there an effect of mathematical reasoning on mathematical literacy abilities and 3) Is there an effect of the ability to understand concepts and mathematical reasoning on mathematical literacy abilities. This research uses a quantitative approach with survey methods and correlational techniques. The variables in this study: the dependent variable is the ability of mathematical literacy (Y) and the independent variables are mathematical concept understanding (X1) and mathematical reasoning (X2). The population are all students of the Mathematics Department with sample of 51 students taken using the Simple Random Sampling method. The data obtained were analyzed including descriptive analysis and inferential analysis using SPSS software. Inferential analysis using multiple regression analysis after going through the process of checking the prerequisites/ assumptions of the analysis that must be met. From the research, there is an effect of the ability to understand mathematical concepts and mathematical reasoning together on the mathematical literacy of students in the amount of 35.3%.

## 1. Introduction

Mathematical literacy is an important thing that needs to be mastered because it is a balance between mathematics with numbers and without numbers (pictures, graphics, and patterns) [1,2]. However, the mathematical literacy ability of Indonesian students is still relatively low based on Program for International Students Assessment (PISA) published by the Organization for Economic Cooperation and Development (OECD). Indonesia was ranked 68th out of 74 PISA participating countries in 2009, 64th out of 65 PISA participating countries in 2012, 65th out of 72 PISA participating countries in 2015 [3], 70th out of 77 PISA participating countries [4]. Now the need to improve mathematical literacy among students must be a major focus for mathematics learning in Indonesia.

Many factors and competencies may be considered in the study of mathematical literacy. Various competencies are predicted make an effect to mathematical literacy. One of them is mathematical reasoning. The Minister of Education Regulation Number 22 of 2006 concerning Standard Content of Mathematics Subjects said that mathematics and mathematical reasoning process are two things that cannot be separated. Mathematics problems can be resolved through a process of reasoning, and mathematics reasoning can be drilled through learning mathematics. Students who have the mathematical reasoning ability will be easy in analyzing a question obtained with the information obtained. Through mathematical reasoning, students can better understand the concept of the subject

matter itself, not just as memorizing learning [5, 6]. Students with low mathematical reasoning ability will always have difficulty in dealing with various problems, because of the inability to connect facts to arrive conclusions. Therefore, it has been agreed that it needs to be developed in each individual.

Another competency is mathematical concept understanding. In mathematics discussion, students must understand mathematical concepts first in order to be able to solve problems and apply their learning in the real world. Understanding concepts is a very important foundation, because the mastery of concepts will facilitate students in understanding mathematics. With good mastery of concepts, students also have a good basis for achieving other basic abilities. The concepts in mathematics are organized systematically, logically, and hierarchically from the simplest to the most complex. A mathematical concept understanding is the basis for learning mathematics meaningfully. Concept mastery is the level of student learning outcomes so that they can define or explain in part or define learning material using their own sentences.

This study will analyze in detail the effect of mathematical concept understanding and mathematical reasoning on mathematical literacy abilities. The ability to understand concepts is very important in mathematics. With a good understanding of the concept, students can develop the ability and creativity in thinking so that students can solve existing mathematical problems. Whereas mathematical reasoning is an ability needed by students to analyze new situations, make logical assumptions, explain ideas and make conclusions. Both aspects of both the ability to understand concepts and mathematical reasoning are important in mathematics but the magnitude of their effect on mathematical literacy is not yet known. This study provides an analysis of the effect of mathematical concept understanding and mathematical reasoning on mathematical literacy abilities.

## 2. Materials and Method

### 2.1. Materials

The data were collected from 51 students studying in Mathematics and Mathematics Education, Faculty of Mathematics and Sciences, Universitas Negeri Jakarta. All students were enrolling Integral Calculus. The research was carried out from March until August 2020. Figure 1 show the overview of mathematical concept understanding instrument used in this study.

> 1. a. Jelaskan konsep integral tak wajar dengan fungsi integran tak hingga di titik dalam interval
>    b. Berikan satu contoh dan satu bukan contuk bentuk integral tak wajar pada soal 1a di atas.
>    …

**Figure 1**. Overview of Mathematical Concept Understanding Instrument

### 2.2. Method

This research uses a quantitative approach with survey methods and correlational techniques. The variables in this study include: the dependent variable is the ability of mathematical literacy (Y) and the independent variables are the mathematical concept understanding (X1) and mathematical reasoning (X2). The research constellation is shown in Figure 2.
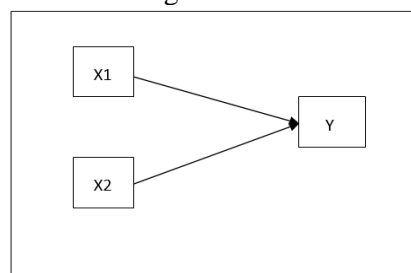


**Figure 2**. Study Design; X1: Understand Concepts; X2: Mathematical Reasoning; Y: Mathematical Literacy

## 3. Results and discussion

### 3.1. Research Instruments

The research instrument in this study consisted of three written test instruments: mathematical literacy test, mathematical concept understanding test and mathematical reasoning obtained from students of research samples in integral calculus courses. Indicators of mathematical concepts understanding test instrument are (1) Restarting a concept, (2) Give examples and not examples of concepts, (3) Classify objects according to certain properties according to their concepts, (4) Use and utilize and choose certain procedures or operations, (5) Presenting concepts in various forms of mathematical representation, (6) Applying concepts or algorithms to problem solving. The test form is 4 essay questions.

Indicators of mathematical reasoning test instrument are (1) Analyzing the mathematical situation: students understand the problem in mathematical problems, (2) Know what is known and what is asked in the problem and connect with the way it is solved, (3) Plan the process of completion: students can plan the process of solving a mathematical problem, (4) Solve problems with systematic steps: students are able to solve mathematical problems according to the sequence of steps that are good and right, (5) Interesting logical conclusion: students draw logical conclusions by giving reasons at the completion step. The test form is 4 essay questions.

Indicators of mathematical literacy test are (1) Communication skills: writing processes in reaching solutions, (2) Reasoning abilities and arguments: inferring from various mathematical arguments, (3) Mathematical abilities: using context understanding to solve mathematical problems, (4) Representation ability: connecting various kinds representation when solving problems, (5) The ability to choose strategies to solve problems: use strategies through various procedures that lead to mathematical solutions and conclusions, (6) the ability to use mathematical tools: use mathematical tools to recognize mathematical structures or to describe mathematical relationships. The test form is 4 essay questions.

The validity and reliability test applied for test instruments. The validity test used in this study is the content, construct and empirical validity, while the reliability test uses the Alpha Cronbach formula. The content and construct validity test was conducted by experts consisting of three lecturers in the Mathematics Education Study Program, Universitas Negeri Jakarta. After the test instrument was declared valid in content and construct, then the test instrument was tested on 25 students who were not sampled and had studied Integral Calculus. The empirical validity test used Pearson Product-Moment Correlation shown in equation (1).

$$r_{xy} = \frac{N\sum_{i=1}^{N} x_i y_i - (\sum_{i=1}^{N} x_i)(\sum_{i=1}^{N} y_i)}{\sqrt{\left\{N\sum_{i=1}^{N} x_i^2 - (\sum_{i=1}^{N} x_i)^2\right\}\left\{N\sum_{i=1}^{N} y_i^2 - (\sum_{i=1}^{N} y_i)^2\right\}}} \tag{1}$$

Where $r_{xy}$ is Pearson's correlation coefficient, $N$ is number of paired scores, $\sum_{i=1}^{N} x_i$ is score of the first variable, $\sum_{i=1}^{N} y_i$ is score of the second variable, $\sum_{i=1}^{N} x_i y_i$ is the product of the two paired scores. Correlation coefficient value which was obtained for each item of question was compared with the correlation coefficient value which was on the $r$ table with $\alpha = 0,05$. If $r_{xy} > r_{\text{table}}$, then the correlation coefficient value is significant and considered as empirical valid [7]. The reliability test was measured with *Alpha Cronbach* formula shown in equation (2). Where $r_{11}$ is alpha cronbach coefficient, $n$ is number of items, $s_i^2$ is the variance of the total score formed by summing all items, $s_t^2$ is total variance. If the value of alpha is $> 0.9$ = Excellent, $> 0.8$ = Good, $> 0.7$ = Acceptable, $> 0.6$ = Questionable, $> 0.5$ = Poor, and $< 0.5$ = Unacceptable [8]. From the test, the instrument considered as empirical valid and reliable

$$r_{11} = \left[\frac{n}{n-1}\right]\left[1 - \frac{\sum_{i=1}^{n} s_i^2}{s_t^2}\right] \tag{2}$$

*3.2. Statistical Hypothesis*

The statistical hypotheses tested in this study were:

| | |
|---|---|
| $H_0: \beta_1 = \beta_2 = 0$ | There was no significant linear relationship between independent variables and mathematical literacy |
| $H_1$: there is at least one $\beta_k \neq 0, k = 1, 2$ | There was a significant linear relationship between independent variables and mathematical literacy |
| $H_0: \beta_1 \leq 0$ | There was a negative (or nothing) linear relationship between mathematical concept understanding and mathematical literacy |
| $H_1: \beta_1 > 0$ | There was a positive linear relationship between mathematical concept understanding and mathematical literacy |
| $H_0: \beta_2 \leq 0$ | There was a negative (or nothing) linear relationship between mathematical reasoning and mathematical literacy |
| $H_1: \beta_2 > 0$ | There was a positive linear relationship between mathematical reasoning and mathematical literacy |

*3.3. Data Analysis*

Descriptive analysis and inferential analysis were conducted. Descriptive analysis was conducted to determine the tendency to centralize and disseminate data, while inferential analysis was conducted to test the research hypothesis. Boxplots were used for the descriptive analysis and multiple regressions were used for the inferential analysis. Before analyzing the data, a normality test, homogeneity test, and independence test were carried out. All tests were mentioned above were analyzed with the SPSS software in significance level 0.05.

*3.4. Data Description*

The research data was obtained from 51 students consisting of 24 students of the 2019 batch of mathematics study program and 27 of the 2019 class of mathematics students. Table 1 presented the descriptive statistics from mathematical concept understanding (MCU), mathematical reasoning (MR), and mathematical literacy (ML).

**Table 1.** Descriptive Statistics

| | MCU | MR | ML |
|---|---|---|---|
| N | 51 | 51 | 51 |
| Mean | 87.2157 | 87.0980 | 77.8824 |
| Median | 87 | 88 | 78 |
| Mode | 83 | 83 | 75 |
| Std. Deviation | 7.50017 | 6.01417 | 5.72939 |
| Variance | 56.253 | 36.170 | 32.826 |
| Skewness | -0.151 | -0.438 | -0.170 |
| Kurtosis | -0.816 | -0.273 | -0.536 |
| Range | 29 | 25 | 23 |
| Minimum | 70 | 72 | 66 |
| Maximum | 99 | 97 | 89 |
| First quartile ($Q_1$) | 83 | 83 | 75 |
| Third quartile ($Q_3$) | 93 | 92 | 82 |

In Table 1, it is known that the average score of MCU, MR and ML test results are 87.22, 87.1, and 77.88. It is seen that the average score of MCU test results is slightly higher than the average score of the ML test results, while the average score of the ML test results is much lower than both the average score of the MCU and MR test results. This shows that the students in the study sample still have

difficulty in doing the ML test, so that the average score obtained is lower than the average score of MCU and MR tests. Based on the calculation of the standard deviation of the three scores, the MCU test results have the largest standard deviation of the other, this shows that the MCU test score data is more diverse than MR and ML test score data. For more details, the three-test results data are presented in the following boxplot diagram in Figure 3 obtained using SPSS software.
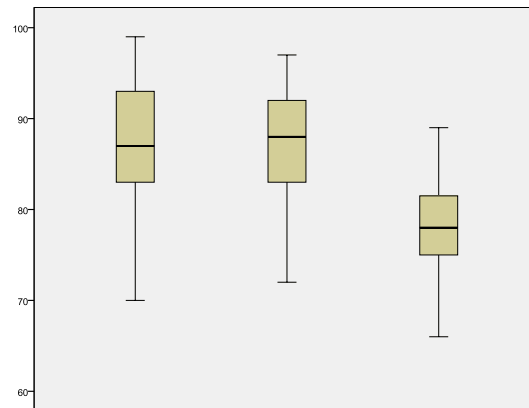


**Figure 3.** The Boxplot Diagrams of MCU, MR, and ML

In the boxplot diagram above, Q1 is represented by the horizontal line on the bottom of the rectangle, Q2 is represented by the horizontal line on the inside of the rectangle, and Q3 is represented by the horizontal line on the inside of the rectangle. In MCU and ML data, the value of Q2 is closer to the value of Q1, so it can be said that the data is more centered below the median and more spread out over the median. In the MR data, the Q2 value is closer to the Q3 value, so it can be said that the data is more centered above the median and more spread out below the median. In the box-line diagram, it can also be seen that in the ML data, the two tails have the same length below and above the box, this shows that the data distribution in the three data is symmetric, while in MCU and MR it is not symmetrical.

*3.5. Precondition Data Analysis Test*

The regression error normality test is performed as a prerequisite for the multiple regression analysis of the two predictors to be used. Regression error is obtained from the difference between the ML test scores (Y observations) and the Y model. The regression error normality test was carried out using the Kolmogorov Smirnov and the Shapiro Wilk test through SPSS software. From test of normality output, the Kolmogorov-Smirnov test obtained sig = 0.2 while with the Shapiro-Wilk test the regression error data obtained sig = 0.602. Thus, all of them showed a Sig> 0.05, so that Ho was accepted, means that the regression error data was normally distributed. The homogeneity test of regression errors was carried out with Levene's Test through SPSS software. From the table of Lavene's Test output results, it can be seen that the value of Sig = 0.467 > 0.05, so that Ho is accepted, it means that the variance of data groups is the same or the regression error data is homogeneous.

The independence test also needs to be done as a prerequisite for the two-predictor multiple regression analysis to be used, in addition to the normality test and the regression error homogeneity test. This independence test includes the autocorrelation test and multicollinearity test. An autocorrelation test is performed to check whether the regression error is independent. This test can be seen from the results of the Durbin-Watson test on the SPSS output for the regression equation model test, if the Durbin-Watson statistical test values are obtained from 1 to 3, it is said that the regression error is independent. From the results of the Durbin-Watson test, the value is 1.791, thus the regression error is independent.

The next independence test is the multicollinearity test which is conducted to check whether the independent variables are independent or not multicollinearity occurs. This test can be seen from the VIF value at the SPSS output to test the significance of the regression equation coefficient. Based on the data above, it is found that the VIF value of the MCU variable = 2.421 and the VIF value of the MR

variable = 2.421, thus the two VIF values <10 which indicate that the independent variables MCU and MR are independent or do not occur multicollinearity. From the prerequisite tests for the multiple regression analysis above, the assumptions of normality, homogeneity and independence have been fulfilled so that inferential statistical analysis using two predictor multiple regression analysis can be carried out.

*3.6. Statistical Hypothesis Test*

Multiple regression analysis was conducted to test the effect of independent variables on the dependent variable. The first step was to determine multiple linear regression equations of the MCU, MR, ML, and also to determine the coefficient of regression equations. From the analysis result, multiple linear regression equation for the dependent variable ML (Y) on the MCU independent variable (X1) and the MR independent variable (X2) was Y = 32.372 + 0.236X1 + 0.759X2. The significance test of the regression equation coefficient was done to test the hypotheses: H0: $\beta1 \leq 0$ vs. H1: $\beta1 > 0$ and H0: $\beta2 \leq 0$ vs. H1: $\beta2 > 0$. From data analysis, MCU variable coefficient obtained thit = 1,711 and Sig. = 0.094 / 2 = 0.047 < 0.05. Thus, H0 is rejected, which means that the ability to mathematical concept understanding has a positive effect on mathematical literacy. Meanwhile, for the MR variable coefficient, it is obtained thit = 4,410 and Sig. = 0,000 / 2 = 0,000 < 0.05. Thus, H0 is rejected, which means that mathematical reasoning has a positive effect on mathematical literacy.

To test the significance of the regression equation, is to test the hypothesis: $H_0 : \beta_1 = \beta_2$, and $H_1 : \beta_1 \neq \beta_2$. From the ANOVA table above, Fhit = 13.090 and p-value / sig = 0.000 <0.005 is obtained, thus H0 is rejected, which means that there is an influence on the ability to mathematical concept understanding and mathematical reasoning together (simultaneously) on mathematical literacy. While the coefficient of determination is shown by R Square = 0.353, which means that 35.3% of the variability of mathematical literacy (Y) can be explained by the ability to mathematical concept understanding (X1) and mathematical reasoning (X2) or it can be said that the effect of the ability to mathematical concept understanding and mathematical reasoning simultaneously on mathematical literacy amounted to 35.3% and 64.7% influenced by other factors. From the significance test of this partial correlation coefficient between MCU and ML with controlling MR obtained $r_{y1.2}$ = -0,240 and p-value = 0.094 <0.05. Thus, H0 is rejected, which means that the correlation coefficient between the ability to mathematical concept understanding and mathematical literacy by controlling mathematical reasoning is significant. From the significance test of this partial correlation coefficient between MR and ML with controlling MCU obtained $r_{y1.2}$ = 0.537 and p-value = 0.000 <0.05. Thus, H0 is rejected, which means that the correlation coefficient between mathematical reasoning and mathematical literacy by controlling the ability to mathematical concept understanding is significant.

*3.7. Discussion*

The Effect of Mathematical Concept Understanding on Mathematical Literacy

From the results above, it is found that the ability to understand mathematical concepts has a positive effect on mathematical literacy. The results also show that the correlation between the ability to understand mathematical concepts and mathematical literacy by controlling mathematical reasoning is significant. The results obtained thus if it is examined, it is possible to occur because the ability to understand mathematical concepts is the cognitive ability of students to be able to understand the underlying concepts to be able to learn, process or obtain further concepts. Mastery of concepts will help students in solving math problems. A student to solve mathematical problems must know the relevant rules and these rules are based on the concepts he/she gets. This is in line with the OECD [3] definition of mathematical literacy. Mathematical literacy is defined as the capacity of students to formulate, apply, and interpret mathematics in various contexts. This implies that mathematical literacy is not only in mastering the material, but also to the use of mathematical concepts, facts, and tools so that one can recognize the role of mathematics in the world and make decisions as a citizen.

The ability to understand mathematical concepts empirically through field data testing has been shown to have a positive effect on students' mathematical literacy. This means that changes that occur in students' mathematical literacy are also influenced mathematical concepts understand. In terms of the correlation between mathematical concepts understand and mathematical literacy by controlling mathematical reasoning, a significant correlation is obtained, this shows that there is a very meaningful relationship between mathematical concepts understand and mathematical literacy after mathematical reasoning is controlled. This is in accordance with Lailiyah's research [9] that mathematical literacy will provide understanding to students about the role that mathematics plays in the modern world.

*The Effect of Mathematical Reasoning on Mathematical Literacy*

From the results above, it is found that mathematical reasoning has a positive effect on mathematical literacy. The results also show that the correlation between mathematical reasoning and mathematical literacy by controlling mathematical concepts understand is significant. The demands of students' abilities in mathematics are not only having the ability to count, but the ability to reason logically and critically in problem solving. According to the theory stated that in mathematical reasoning includes the ability to analyse mathematical situations, plan the process of solving, solve problems with systematic steps, and draw logical conclusions.

The important part of mathematical literacy is the process of mathematics, namely the process of formulating, using, and interpreting and evaluating mathematics in various contexts. Someone who has been able to apply his knowledge in a problem may not necessarily be able to apply it to a different problem. In this case, mathematical reasoning is needed so that it can solve problems in various situations and different contexts in order to use the skills effectively. Thus, in theory mathematical reasoning will be needed, support or influence in solving mathematical problems in various contexts. This has been shown by empirical data in the field and the results of the analysis that tested students 'mathematical reasoning has a positive effect on students' mathematical literacy. This means that changes that occur in students 'mathematical literacy are also influenced by students' mathematical reasoning, the better the students 'mathematical reasoning, the better the students' mathematical literacy. In terms of the correlation between mathematical reasoning and mathematical literacy by controlling the ability to understand mathematical concepts, a significant correlation is obtained, this indicates that there is a very meaningful relationship between mathematical reasoning and mathematical literacy after the ability to understand mathematical concepts is controlled.

*The Effect of Mathematical Concept Understanding and Mathematical Reasoning on Mathematical Literacy*

From the results of the data analysis above, it is found that there is an effect of the ability to understand mathematical concepts and mathematical reasoning simultaneously on mathematical literacy. The results also show that the effect of the ability to understand mathematical concepts and mathematical reasoning together on mathematical literacy is 35.3%. This means that changes in the mathematical literacy variable by 35.3% can be explained because of the joint influence of the variable understanding of mathematical concepts and mathematical reasoning. When the results are obtained, if reviewed, it is possible because to be able to work with problems related to mathematical literacy, students need to first understand the concept of integral calculus such as the concept of integral, area wide, and master the methods of integral folding, after that students need to communicate ideas - his ideas about mathematical problems are in the form of explaining, arranging or organizing these ideas using mathematical symbols, mathematical expressions or mathematical language so that a mathematical literacy process is formed and the solutions it does are accepted correctly.

Mastery of mathematical concepts is very important. Mathematical statements such as definitions, theorems and other mathematical problems cannot be learned by rote, thus students need to understand existing concepts so that they become a series of thoughts and can apply them in solving problems in everyday life. On the other hand, an important part of mathematical literacy is the process of mathematics, namely the process of formulating, using, and interpreting and evaluating mathematics in

various contexts. Someone who has been able to apply his knowledge in a problem may not necessarily be able to apply it to a different problem. In this case, mathematical reasoning is needed so that it can solve problems in various situations and different contexts in order to use the skills effectively.

Thus, in theory the ability to understand mathematical concepts and mathematical reasoning together will affect students' mathematical literacy. It can be shown by empirical data in the field and the results of the analysis that the ability of understanding mathematical concepts and mathematical reasoning of students is tested to have a joint influence on literacy. student math. This means that changes that occur in student mathematics literacy are influenced jointly by the ability to understand mathematical concepts and student mathematical reasoning. This is in accordance with Afifah's research [10] that mathematical literacy as the power to use mathematical thinking to include a problem-solving mindset, logical reasoning, communicating, and explaining.

## 4. Conclusion

Based on the results of the research and discussion obtained in the previous chapter, the following conclusions can be drawn: 1) There is a positive effect on the ability of understanding mathematical concepts to the mathematical literacy of students in the Mathematics and Mathematics Education study program, Faculty of Mathematics and Natural Sciences, UNJ, 2) There is a positive effect of mathematical reasoning on the mathematical literacy of students of the Mathematics and Mathematics Education Study Program of FMIPA UNJ, 3) There is an effect of the ability to understand mathematical concepts and mathematical reasoning together on the mathematical literacy of students in the Mathematics and Mathematics Education study program, UNJ. The changes that occur in the mathematics literacy of Mathematics and Mathematics Education students of FMIPA UNJ by 35.3% can be explained because of the joint influence on the ability to understand mathematical concepts and mathematical reasoning.

## References

[1]    E Salsabila *et al*. 2019 Analysis of Mathematical Literacy on Students' Metacognition in Conic Section Material. *J. Phys. Conf. Ser.* **1417** 012057

[2]    A Nurutami *et al*. 2018 The Analysis of Students' Mathematical Literacy Based on Mathematical Ability. *Adv. in Intelligent Syst. Res. (AISR)* **157** 162-6

[3]    Hayati, T., R & Kamid. 2019. Analysis of Mathematical Literacy Processes in High School Students. *Int. J. Trends Math. Educ. Res.* **2** 116-9.

[4]    Schleicher A 2019 PISA 2018: Insights and Interpretations OECD 2019

[5]    Sukirwan *et al*. 2018 Analysis of students' mathematical reasoning. *J. Phys.* **948** 012036

[6]    Carolina *et al*. 2016 The Enhancement of Mathematical Reasoning Ability of Junior High School Students by Applying Mind Mapping Strategy. *J. Educ. Practice* **7** 50-8

[7]    El Abbadi, Nidhal, and Elaf A 2014 An Efficient Storage Format for Large Sparse Matrices based on Quadtree. *Int. J. Comput. Appl.* **105** 25-30

[8]    Orion L 2013 In-memory data compression for sparse matrices. *Proc. of the 3rd Workshop on Irregular Appl.: Architectures and Algorithms* 1-7

[9]    Lailiyah S 2017 Mathematical Literacy Skills of Student's in Term of Gender Differences. *AIP Conf. Proc.* **1868** 1-12

[10]   Afifah A, Khoiri M, and Qomaria N 2018 Mathematics Preservice Teachers' Views on Mathematical Literacy. *Int. J. Trends Math. Educ. Res.* **1** 92-94