17. Ketut Sarjana

by Ketut Sarjana

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Verbal and Numerical Ability: Their Correlation with Mathematical Modeling Ability

Ketut Sarjana[1], Ni Made Intan Kertiyani[2]

[1]Mathematics Education Department, Faculty of Teacher Training and Education, University of Mataram
[2]Mathematics Education Department, Faculty of Teacher Training and Education, University of Mataram
Corresponding author: *intan@unram.ac.id*

Abstract: *This study focuses on analyzing the relationship between verbal and numerical abilities in the ability to make mathematical models. The population is 9th grade students who use the 2013 curriculum in Mataram City. The research sample was taken with a stratified cluster sampling system. The sample used was 411 students. Data were taken using 3 tests, namely verbal ability test, numerical ability, and ability to make mathematical models. The data was analyzed using descriptive statistics and inferential statistics, namely multiple linear regression analysis. Descriptive statistics show that more than half of the respondents are in the medium or high category for the three abilities tested. Furthermore, based on the results of inferential statistics, it is found that verbal and numerical abilities have a significant effect on the ability to make mathematical models. The relationship between the three variables, namely* $Y=0.355X_1+0.204X_2-5.446$*, where Y is the score of the ability to make mathematical models,* X_1 *is the score of verbal ability and* X_2 *is the score of numerical ability. Together, verbal and numeric abilities affect the ability to make mathematical models by 61.2%. Meanwhile, the verbal ability has a direct effect on the ability to make mathematical models at 35.5%. The numerical ability has a direct effect on the ability of mathematical models by 56.6%. The findings imply that enhancing both verbal and numerical abilities at the same time can boost the effectiveness of mathematical models more effectively than enhancing each ability separately.*

Keywords:*Numerical ability, verbal ability, mathematical modeling, correlation, multiple linear regression*

Abstrak: Penelitian ini berfokus untuk menganalisis hubungan antara kemampuan verbal dan numerik terhadap kemampuan membuat model matematika. Populasi dari penelitian ini adalah siswa SMP yang menggunakan kurikulum 2013 di Kota Mataram. Sampel penelitian diambil dengan sistem stratified cluster sampling. Sampel diambil berjumlah 411 orang. Data diambil menggunakan 3 tes, yaitu tes kemampuan verbal, kemampuan numerik dan kemampuna membuat model matematika. Data dioleh menggunakan menggunakan statistika dekriptif dan statistika inferensia yakni analisis regersi linier berganda. Secara keseluruhan, statistiika deskriptif menunjukan lebih dari setengah responden berada pada kategori sedang atau tinggi untuk ketiga kemampuan yang diujikan. Selanjutnya, berdasarkan hasil statistika inferensia diperoleh hasil bahwa kemampuan verbal dan numerik berpengaruh secara signifikan terhadap kemampuan membuat model matematika. Hubungan antara ketiga variable, yaitu $Y = 0.355X_1 + 0.204X_2 - 5.446$, dengan Y adalah skor kemampuan membuat model matematika, X_1 adalah skor kemampuan verbal dan X_2 adalah skor kemampuan numerik. Kedua kemampuan ini secara bersama-sama berpengaruh terhadap kemampuan membuat model matematika sebesar 61.2% sedangkan 31,8% dipengaruhi oleh aspek lain yang tidak ditinjau dalam penelitian ini. Sementara itu, secara terpisah, kemampuan verbal berpengaruh langsung terhadap kemampuan membuat model matematika sebesar 35,5%. Sementara itu, kemampuan numerik berpengaruh langsung berpengaruh langsung terhadap kemampuan membuat model matematika sebesar 56,6%. Temuan ini mengindikasikan bahwa meningkatkan kedua kemampuan verbal dan numerik secara simultan lebih efektif untuk meningkatkan kemampuan membuat model matematika dibandingkan meningkatkan masing-masing kemampuan secara terpisah.

Kata kunci: kemampuan numerik, kemampuan verbal, pemodelan matematika, korelasi, analisis regresi berganda

INTRODUCTION

Word problem is a problem that presents a problem in everyday life in the form of a narrative (Febrilia, Juliangkary, Korida, 2019). This question involves meaningful sentences to know students' reasoning in connecting concepts (Muntaha, Wibowo, and Kurniasih, 2020). In mathematics, word problems are made in a certain form so that the use of symbols for mathematical operations is not presented directly (Pandiangan and Zulkarnaen, 2021).

Students must possess the skills necessary to answer word problems, including the ability to comprehend the issue at hand, create a mathematical model, and establish a connection between issues by using the appropriate calculations and formulas (Rahmi, et al, 2017). In this case, constructing a mathematical model is one of the important things in the stages of solving a word problem. The lack of students to perform mathematical modeling has an impact on their capacity to resolve word problems as well (Isnawati, 2016; Elia, 2020; Zulkarnaen, 2020). Students who have difficulty in making mathematical models would not be able to determine the solution of a story problem or other contextual problem (Mulyana, Priyatno, Dei, 2018).

Mathematical modeling is a mathematical process that involves observing events, predicting relationships, and applying mathematical analysis (Bahmael, 2011). The mathematical model formed in this process is a model created using concepts such as functions and equations by converting things that exist in the real world into abstract mathematical concepts (Towers, Edwards and Hamson, 2020:3, Maulida, et al (2020)). The problem is then solved in the abstract world of mathematics and the solution obtained is translated into a solution that can be applied in the real world. Mathematical modeling goes through 6 stages, namely 1) finding problems in real situations, 2) making assumptions, 3) making mathematical problems, 4) making mathematical models, 5) building mathematical solutions, and 6) interpreting solutions (Immersion, 2016). The following diagram 1 is a diagram of the mathematical modeling process.

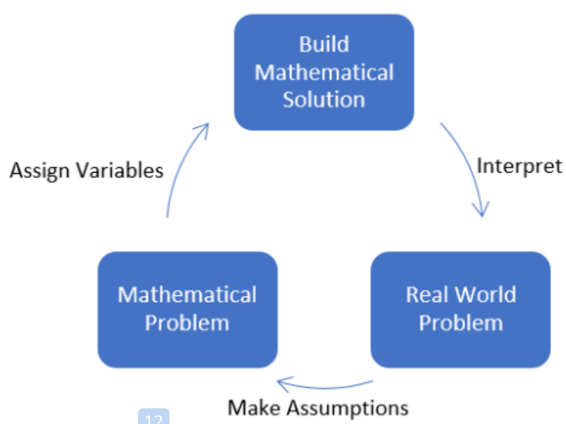

Diagram 1. Mathematical Modeling Process (Adapted from Immersion, 2016)

Several aspects affect students' ability to solve word problems including verbal and numerical abilities (Sarjana, Sridana, and Kurniati, 2018). Verbal ability is the ability to understand vocabulary and verbal analogies (Vukovic and Lesaux, 2013). This ability can make a person understand a language, then translate it into another form so that it is more easily communicated by others (Irawan and Kencanawaty, 2017). This ability has a positive effect on mathematics (Jonah and Igbojinwaekwu, 2015) to understand the material and interpret complex questions in the form of pictures, tables, graphs, and other mathematical symbols that are easier to understand (Daniyanti and Sugiman, 2015; Sobirin, 2014).

In solving word problems, verbal skills include the ability to understand mathematical expressions contained in the questions (Bachelor, Laila, and Wahidaturrahmi, 2020). This ability affects students' ability to solve world problems because in solving those problems students must be able to interpret real problems into mathematical problems with certain expressions (Wahyu, et al, 2020). Wahyudin (2016) revealed that the higher the verbal ability of students, the higher their ability to solve story problems.

Numerical ability is related to numbers and numerical literacy (Hardiani, 2014). This ability concerns the accuracy in counting using operations (+, -, ×, :) which are often used in mathematics (Chen and Wang, 2021; Jelatu, et al, 2019, Othman, 2006: 87). In working on word problems, students usually transform the word problems into arithmetic problems and the solution also requires arithmetic solutions (Daroczy, et al, 2015). This causes the mastery of numerical skills needed to make the process of finding solutions becomes easier.

In solving word problems, doing mathematical modeling is one of the stages that must be mastered by students. The ability to do mathematical modeling is a key standard in education almost all over the world (Asempapa and Sturgil, 2019). Mastery of students over this ability is very necessary. For this reason, every aspect that is expected to contribute to the improvement of mathematical modeling abilities needs to be investigated further. However, another set of skills that have an impact on how well word problems are solved is verbal and numerical aptitude. With the connection of word problem solving with mathematical modeling, it is necessary to explore the relationship between verbal and numerical abilities to mathematical modeling abilities.

Research on verbal ability, numerical, or mathematical modeling has been carried out by several researchers. Irawan (2016) examined the relationship between verbal and numerical abilities to critical thinking skills. Wahyudin (2016) investigated the relationship between verbal ability and the ability to make story questions. Mukaromah and Hasyim (2017) investigated the influence of numerical and verbal abilities on the ability to make story questions. Daroczy et al (2015) examined the difficulties in solving story problems related to language (verbal) and numerical aspects.

From several studies that have been conducted, not many studies have examined the effect of verbal and numerical abilities on the ability to perform mathematical modeling. For this reason, this study focuses on investigating the relationship between verbal and numerical abilities in the ability to perform mathematical modeling. In the future, the results of this study can be used as a reference for improving the mathematical modeling abilities of junior high school students.

RESEARCH METHOD

This research is a correlational study that focuses on revealing the relationship between several independent variables (numerical and verbal abilities) and the dependent variable (the ability to perform mathematical modeling). The population in this study were grade 9 junior high school students in Mataram City who used the 2013 Curriculum. The amount of population was 1,315 students. Samples were taken using a stratified cluster random sampling technique from schools accredited A and B. The distribution of sampling is presented in Table 1.

Tabel 1. Distribution of Sampling

School	Number of classes	Number of students
School with accreditation A	6	209
School with accreditation B	7	202
Total	13	411

Table 1 shows that from the A-accredited school, the researcher took as many as 209 students spread over 6 classes, while from the B-accredited school, the researcher took 7 classes consisting of 202 students. The total sample is 411 students. This sample represents 31.3% of the population.

The research methodology used in this study can be seen in Diagram 2.

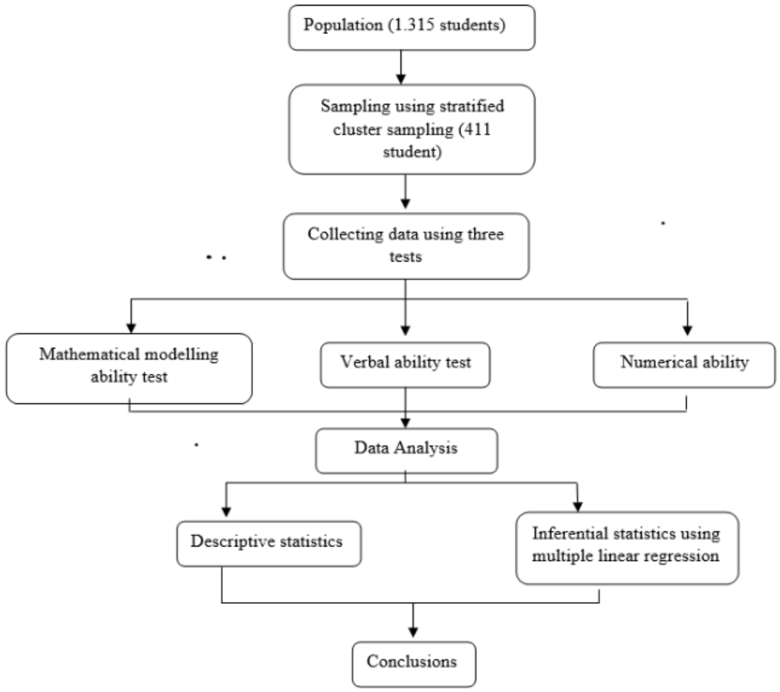

Diagram 2. The Research Method

According to Diagram 2, after sampling was conducted, the research data was taken by using a test. There are 3 tests used, namely verbal ability test, numerical ability test, and mathematical modeling ability test. The test is structured according to the content standards of the 2013 curriculum for Junior high school mathematics.

The data that has been collected is then processed and analyzed using SPSS. The analysis carried out includes descriptive and inferential statistics. Descriptive statistics are used to describe the characteristics of the distribution of the research subject's scores. Meanwhile, the inferential statistics used are multiple linear regression analyses. The aim of this statistic is 1) to investigate whether there is a correlation between the independent variables, namely verbal and numerical abilities on the dependent variable, namely the ability of mathematical modelers, 2) to see the relationship between the independent and dependent variables in the form of mathematical equations, and 3) how much influence the independent variables to the dependent variable.

When performing a correlation study, a statistic known as the coefficient of determination—which was the correlation coefficient squared—was calculated (R square). The variance in the dependent variable could be described by the variance in the independent variables, hence the name "coefficient of determination" for this coefficient. Table 2 provides the recommendations for correlating coefficient interpretation.

Table 2. Guidelines for Correlation Coefficient Interpretation

R	Interpretation
0.00-0.199	Very Low
0.20-0.399	Low
0.40-0.599	Medium
0.60-0.799	Strong
0.80-1.00	Very Strong

In addition, a path analysis—a development of regression analysis—was performed. Using this technique, the relationship model between the variables was described and put to the test. Finding the best and quickest route for the independent variables to the final dependent variable was the goal of path analysis (Sugiyono, 2017).

RESULT AND DISCUSSION

Descriptive statistics from the data analysis carried out are shown in Table 3.

Table 3. Descriptive statistics from Data Analysis

Ability	**Category**		
	High (%)	Moderate (%)	Low (%)
Verbal	0,00	81,02	18,98
Numerical	23,36	54,01	22,63
Mathematical Modelling	16,06	36,98	46,96

According to Table 3, the majority of the research participants have moderate verbal skills. More than 50% of research participants have moderate numerical aptitude in this area. At 23.36 percent and 22.63 percent, respectively, the distribution of numerical ability levels in the high and low categories is nearly identical. More than 50% of the students have skills in the medium or high category for creating mathematical models. Overall, for the three abilities measured, more than half of the research participants fell into the moderate or high range. This indicates that more than 50% of the individuals have these three skills at a suitable level. On the other hand, students with low categories are mostly in the aspect of making mathematical models. Therefore, it is necessary to enhance students' capacity for developing mathematical models.

After analyzing through descriptive statistics, the next analysis was carried out through inferential statistics. The analysis used is multiple linear regression analysis. The results of data processing with SPSS are shown in Table 4.

Table 4. Results of Multiple Linear Regression Analysis of Verbal (X_1) and Numerical (X_2) Abilities on the Ability to Make Mathematical Models (Y)

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-5.446	.591		-9.215	.000
Verbal	.355	.034	.355	10.507	.000
Numerical	.204	.012	.566	16.738	.000

Table 4 shows the significance of the variables of verbal ability and numerical ability on the ability to make mathematical models is 0.0000. This significance is smaller than the level of significance of 0.05. This means that verbal ability and numerical ability have a significant effect on the ability to make mathematical models.

Table 4 also shows the relationship between the three variables, namely $Y=0.355X_1+0.204X_2-5.446$. The explanation of the following relationship is as follows: each 1-point increase in verbal ability (X_1) and numerical ability (X_2) variables will cause an increase in mathematical modeling ability by 0.559 points. For example, a student gets a score of 20 out of a maximum score of 30 on a verbal ability test and gets a score of 15 out of a maximum score of 30 on a numerical ability test. To find the approximate score of the ability to make mathematical models, substitute the scores of verbal and numerical abilities into the equation $Y=0.355X_1+0.204X_2-5.446$, so that the estimated score of the ability to make mathematical models is 4.714. Furthermore, suppose the student increases his verbal ability score by 1 point to 21 and his numerical ability score also increases by 1 point to 16, then the predicted score of ability to make mathematical models becomes 5.273. This means that there is an increase in the score of the ability to make mathematical models from 4.714 to 5.273. This increase is 0.559 points which occurs when verbal and numerical skills are added by 1 point together.

Additionally, by searching for R squares, the strength of the relationship between verbal and numerical skills and the capacity to create mathematical models was examined. Table 5 displays the data processing outcomes.

Table 5. The Correlation Value of Verbal and Numerical Ability to the Ability to Make Mathematical Models

	R	R Square	Adjusted R Square	Std. Error of Estimate
1	.784	.614	.612	1.866

Table 5 shows the correlation coefficient obtained is 0.612. This demonstrates that the capacity to create mathematical models is influenced by verbal and numerical skills to the amount of 61.2 %, with other variables contributing 38.8 % of the total. The correlation of 61.2% is included in the category of strong correlation.

Path diagram analysis is also carried out as can be seen in Diagram 3.

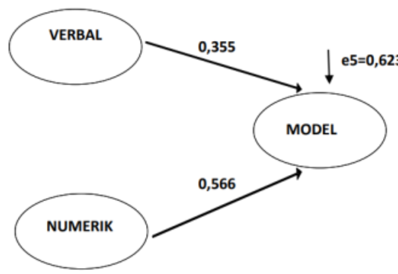

Diagram 3. Path Diagram of the Effect of Verbal and Numerical Ability on the Ability to Make Mathematical Models

Based on the path diagram, a direct correlation of 35.5% exists between verbal ability and the capacity to create mathematical models. The ability of students to perform mathematical modeling was also influenced by verbal skills, as discovered by Kartini (2017) dan Daniyati dan Sugiman (2015). Meanwhile, 56.6% of mathematical models' performance is directly influenced by numerical skill. This means that numerical ability has a greater effect on the ability of mathematical models than verbal ability. The diagram does not reveal any evidence of an indirect relationship between verbal and numerical skills and mathematical modeling skills. The relationship between the verbal and numerical ability for mathematical modeling was also found to be unrelated.

According to the obtained correlation coefficients and path diagrams, improving both verbal and numerical skills at the same time can increase the efficiency of mathematical models. This is more favorable than enhancing verbal and mathematical abilities separately.

CONCLUSION AND RECOMMENDATION

Conclusion

In total, for the three abilities tested, more than half of the research participants were classified into the moderate or high range. This indicates that more than 50% of the subjects have these three abilities to a sufficient level. On the other hand, students in the low category are mostly in the aspect of making mathematical models. Therefore, it is necessary to develop students' mathematical modeling abilities.

The capacity to create mathematical models is strongly influenced by verbal and numerical skills. The equation for the three variables is $Y=0.355X_1+0.204X_2-5.446$, where Y is the numerical model-making score, X_1 is the verbal model-making score, and X_2 is the numerical model-making score. Every 1-point increase in the verbal ability (X_1) and numerical ability (X_2) variables will result in a 0.559-point rise in the ability to create mathematical models.

The capacity to generate mathematical models is directly impacted by verbal ability by 35.5%. The capability of mathematical models is directly impacted by numerical skill by 56.6 percent. The ability of mathematical models is thus more influenced by numerical skill than by verbal skill. Together, verbal and numerical skills have a 61.2% impact on one's capacity to create mathematical models, whereas other factors, not covered in this study, have a 38.8% impact.

Recommendation

The obtained correlation coefficients and path diagrams suggest that simultaneously enhancing verbal and numerical abilities can boost the effectiveness of mathematical models. Furthermore, the study found that while 31.8% of the capacity to create mathematical models is impacted by other factors not covered in this study, verbal and numerical skills together have a 61.2% influence on this ability. Other factors that influence the capacity to create mathematical models can be investigated in further research. Furthermore, only junior high school students were included in this study. Given that the characteristics of mathematical modeling at the elementary and high school levels differ from those at the junior high school level, it is advised that future study concentrates on elementary or high school students.

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