

Mathematical modelling and verbal abilities: How they determine students' ability to solve mathematical word problems?

Ketut Sarjana¹, Laila Hayati¹, Wahidaturrahmi¹

Abstrak: Penelitian ini bertujuan menentukan tingkat kemampuan siswa SMP menyelesaikan soal cerita matematika dan seberapa besar pengaruh kemampuan membuat model matematika dan verbal terhadap kemampuan menyelesaikan soal cerita pada pelaksanaan kurikulum 2013. Penelitian ini melibatkan 411 siswa sebagai sampel yang ditentukan melalui teknik *stratified porposional random sampling*. Tes yang digunakan dinyatakan valid melalui uji validitas konstruk dan reliabel dengan *Alpha Cronbach*. Data dianalisis secara deskriptif dan inferensial. Secara deskriptif, kemampuan siswa dalam menyelesaikan soal cerita matematika masih tergolong sedang. Sedangkan secara inferensial diperoleh hasil bahwa (1) kemampuan verbal siswa berpengaruh secara signifikan terhadap kemampuan menyelesaikan soal cerita, dengan kemampuan verbal 47,6%; 2) kemampuan siswa dalam membuat model matematika berpengaruh secara signifikan terhadap kemampuan menyelesaikan soal cerita, dengan kemampuan membuat model matematika 84,6%; 3) kemampuan verbal dan membuat model matematika siswa berpengaruh secara signifikan terhadap kemampuan menyelesaikan soal cerita, dengan kemampuan verbal dan membuat model matematika sebesar 87,8%. Hal ini mengindikasikan bahwa peningkatan kemampuan siswa dalam menyelesaikan soal cerita matematika akan lebih optimal jika kemampuan verbal dan kemampuan membuat model matematika diperhatikan secara bersamaan dibandingkan hanya fokus pada salah satu kemampuan saja.

Kata kunci : *Kemampuan verbal, Model matematika, Soal cerita, Kurikulum 2013*

Abstract: This study aims to determine the level of lower secondary school students' ability in solving mathematical word problems and how much both mathematical modelling ability and verbal ability influence the ability to solve word problems in the implementation of *Kurikulum 2013* (Curriculum 2013). This study involved 411 students as samples determined by stratified proportional random sampling technique. The test used was declared valid through construct validity and reliability with Cronbach's alpha. Data were analyzed descriptively and inferentially. Descriptively, the students' ability in solving mathematical word problems was classified as medium. Meanwhile, inferentially, results were obtained indicating that: (1) students' verbal ability is significantly influential on the ability to solve word problems by 47.6%; (2) the students' ability in mathematical modelling is significantly influential on the ability to solve word problems by 84.6%; and (3) students' verbal and mathematical modelling abilities are significantly influential on the ability to solve word problems by 87.8%. This indicates that the increase in students' ability to solve mathematical word problems will be more optimal if the verbal ability and the mathematical modelling ability are considered simultaneously, rather than focusing on one ability only.

Keywords: *Verbal ability, Mathematical modelling, Word problems, Curriculum 2013*

¹ Department of Mathematics Education, Universitas Mataram, Jl. Majapahit No. 62, Mataram 83125, Indonesia, lailahayati.fkip@unram.ac.id

A. Introduction

In mathematics, students are required to achieve certain abilities such as to understand the problems, design mathematical models, and interpret the solutions (Permendikbud, 2014; Evagorou, Nicolaou, & Lymbouridou, 2020). Problem solving constitutes an exercise for students to deal with non-routine problems and try to solve them followingly (Simamora & Saragih, 2019). Problem solving ability is necessarily needed in solving various problems, so students need to be trained to solve problems that provide opportunities to explore their ability in order to put forward ideas or strategies in solving the problems (Rahmazatullaili, Zubainur, & Munzir, 2017; Pimta, Tayraukham, & Nuangchalerm, 2009). Strategies in solving problems related to mathematical problems are called heuristics because in learning mathematics, basically, students must be able to find their own knowledge (Guyen & Cabakcor, 2013; Shoimin, 2014). In mathematics learning, problem solving serves as an important component of mathematics education due to its practical role for individuals and society (Culaste, 2011). Moreover, through problem solving, students are trained to solve problems closely related to problems that often encountered in everyday life (Wiguna, Widiana, & Sudana, 2016).

The mathematics standard of process and assessment listed in Curriculum 2013 (K13) show students need to possess adequate knowledge and skills in answering the mathematical problems that already well designed their teachers. Regarding the authentic assessment applied in K13, Wormeli (2018) states that one of the aspects of authentic assessments is related to how students apply their learning outcomes in their daily life. Mathematical problems related to daily problems and closed to the needs of students are usually designed in interesting word problems (Rahardjo & Waluyati, 2011).

Mathematical word problems are mathematical problems presented in the form of word problems, containing problems of daily life (Verschaffel, Greer, & De Corte, 2000; Wahyuddin, 2016) and these require high reasoning ability to be able to interpret these problems into a mathematical language (Pongsakdi et al., 2020). Therefore, problem solving will be meaningful if mathematical problems are designed in word problems, in accordance with students' daily experiences or contextual problems (Pratiwi & Widjajanti, 2020). In this case, to be able to solve mathematical problems, problem solving ability is required.

Skills in reading and understanding the relationships between sentences are needed to understand word problems because students must be able to transform problem situations into mathematical expression in order to solve the given word problems (Staub & Reusser, 1995; Winarni & Harmini, 2011; Wahyu et al., 2020). Therefore, sufficient verbal ability is needed. The better the verbal ability owned, the better the ability to solve the word problems (Reinhold et al., 2020). Verbal ability serves as the ability to compose thoughts clearly and can be used competently through words to express thoughts in speaking, reading, and writing (Mar & Rain, 2015; Sari, Dantes, & Ardana, 2014; Hardiani, 2014; Wahyuddin & Ihsan, 2016). This includes the ability to understand and remember the meaning of mathematical expressions mentioned in the given word problem. Mistakes or errors in reading or understanding, even in only a word, will result in mistakes or errors in the entire completion process. Therefore, verbal ability is needed in solving mathematical word problems.

Mathematical word problems mostly provide students' everyday life situations, as well as the mathematical symbols often that used in solving the problems. To be able to understand the contextual mathematical problems, the ability to understand mathematical symbols, usually in the form of equations or inequalities, is required (Budhayanti, 2008). The association between

mathematical symbols and operations will result in simpler sentences, often called mathematical models. Solving mathematical word problems can be carried out in some steps (Uhden et al., 2012; Depaepe, De Corte, & Verschaffel, 2015), one of which is making mathematical models. According to Mulyana, Priyatno, and Dewi (2018), in the context of mathematical word problems, learning to understand problems constitutes learning that helps students turn words into mathematical models.

A model is an object or concept used to represent something reduced in size and converted into another form, so students can understand the problems more easily. Students' understanding of mathematical problems and mastery learning of mathematical concepts will greatly support students in developing the models, the more suitable and simple models in particular. The simpler the model obtained for the objectives to be achieved, the better the model in representing the given situation. In other words, the ability of students to make mathematical models is needed in solving word problems (Staub & Reusser, 1995; Verschaffel, Depaepe & Van Dooren, 2015).

From the above description, the ability to make mathematical models and verbal ability are factors that support students in solving mathematical word problems. Verbal ability is positively influential on the ability to solve word problems, in which the better or higher the students' verbal ability, the better or higher the student's ability to solve word problems (Wahyuddin, 2016; Wahyuddin & Ihsan, 2016; Reinhold et al., 2020). Furthermore, solving word problems is also influenced by the students' ability to make mathematical models (Isnawati, 2016; Elia, 2020). In this case, this study aims to simultaneously test the influence of verbal ability and the ability to make mathematical models on the ability of lower secondary school students in solving mathematical word problems that in line with the implementation of K13.

B. Methods

This study is a quantitative in nature. The population in this study was 1,315 third graders in four lower secondary schools in the city of Mataram, Indonesia. The sampling technique used was stratified cluster random sampling. In this study, the cluster random sampling technique has collaborated with stratified random sampling because the clusters in question were schools with different accreditation levels (two schools were "A" accredited, and the other two were "B" accredited). Furthermore, from "A" accredited school group, 6 classes consisting of 209 students were taken, while from "B" accredited school group, 7 classes with 202 students were taken. Therefore, in total, 13 classes were taken with a total sample of 411 students. This was 31.3% of the population.

The characteristics measured in this study were verbal ability, the ability to make mathematical models, and the ability to solve mathematical word problems. This study involved three variables: two independent variables, namely verbal ability (X_1) and ability to make mathematical models (X_2) and one dependent variable, which is the ability to solve mathematical word problems (Y). Data from each variable were collected by giving tests to third graders of public lower secondary school in Mataram. To collect the data, 3 types of tests were used, namely the verbal ability test (49 problems), the ability to make mathematical models test (30 problems), and the ability to solve mathematical word problems test (30 problems). The standard of contents for the lower secondary school level listed in Curriculum 2013 was used as a reference in the preparation of these tests (Abidin, 2014).

The verbal ability instrument was sufficiently reliable because the instrument was deliberately prepared for research and development purposes by the Postgraduate Program at the

State University of Malang (Tim Pascasarjana UM, 2003). Meanwhile, the instrument of the ability to make mathematical models and the ability to solve mathematical word problems is a test developed by the researcher. The validity of the instrument was assessed by experts (construct validity). In this case, after the instrument was constructed regarding indicators of mathematics learning in the third grade of lower secondary schools, it was then consulted with experts concerning improvements related to material and language, for example, the use of terminologies that familiar to lower secondary school students. After doing the construct validity, field trials were carried out. Instrument trials were given to 50 students out of the sample of the study, 25 students from “A” accredited schools, and 25 students from “B” accredited schools.

To determine the item validity on the tested instruments, the product-moment correlation formula was used. If the value of the correlation coefficient (R) on each item was more than or equal to 0.3 ($R \geq 0.3$), then the item was said to be valid (Widoyoko, 2012). The results showed that on the instrument of the ability to make mathematical models, 12 items were valid, while on the instrument of the ability to solve mathematical word problems, 26 items were valid. The next step was conducting a reliability test, in which the test instrument was said to be reliable if the instrument provided consistent results on each measurement. Cronbach’s alpha is one of the reliability coefficients, where an instrument is said to be reliable if it has a Cronbach alpha value of at least 0.70 (Uyanto, 2009). The Cronbach's alpha values for the instrument of the ability to make mathematical models and the ability to solve story problems were 0.753 and 0.880, respectively, so it was concluded that the instrument was reliable.

Data analysis was carried out descriptively and inferentially. The descriptive technique was aimed to describe the characteristics of the distribution of the respondents' scores for each variable (S). Qualifications were described on the basis of the ideal mean score (M_i) and the ideal standard deviation (SD_i) (Gunawan, 2013). By using three qualification levels, the criteria were structured in Table 1.

Table 1. Criteria for ability category

S Score Interval	Categories	X_1	X_2	Y
$S > M_i + SD_i$	High	$S > 16$	$S > 8$	$S > 16.67$
$M_i - SD_i < S \leq M_i + SD_i$	Medium	$8 < S \leq 16$	$4 < S \leq 8$	$8.33 < S \leq 16.67$
$S \leq M_i - SD_i$	Low	$S \leq 8$	$S \leq 4$	$S \leq 8.33$

Remarks: S = Ability score; $M_i = \frac{1}{2} \times \text{Maximum}$; $SD_i = \frac{1}{3} \times M_i$

The inferential analysis used linear regression analysis, correlation analysis, and path analysis with SPSS. The hypothesis proposed in this study was that verbal ability and the ability to make mathematical models were influential on the ability to solve mathematical word problems, either simultaneously or partially. Multiple linear regression analysis was used in simultaneous testing, while partial testing was carried out with simple linear regression analysis. The benefit of the results of regression analysis was to predict how far the values of the dependent variable would change if the value of the independent variable were manipulated, which could be seen from the regression equation. This would later become a consideration for deciding whether the increase or decrease in the dependent variable could be carried out by increasing the independent variables or not. Furthermore, the interpretation of the correlation coefficient obtained in the correlation analysis refers to the guidelines in Table 2.

Table 2. Guidelines for correlation coefficient interpretation

<i>R</i>	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 doing a correlation analysis, there was a number called the coefficient of determination, which was the square of the correlation coefficient (*R* square). This coefficient was called the coefficient of determination because the variance occurring in the dependent variable could be explained by the variance occurring in the independent variables. Furthermore, a path analysis, which is the development of regression analysis, was carried out. This analysis was used to describe and test the relationship model between variables. Through path analysis, it was to find the most appropriate and shortest path for the independent variables to the final dependent variable (Sugiyono, 2017).

C. Findings and Discussion

The first objective of this study is to determine the level of ability to solve mathematical word problems for public lower secondary school students in relation to the implementation of Curriculum 2013. To achieve this goal, data analysis of students' test results is carried out as presented in Table 3.

Table 3. Distribution of ability category frequency

Ability	Category		
	High (%)	Medium (%)	Low (%)
Verbal	81.02	18.98	0.00
Mathematical modelling	16.06	36.98	46.96
Solving word problems	18.74	50.12	31.14

Table 3 shows that most students have a medium ability in solving word problems (50.12%). The results conform to Wahyuddin's research (2016) which revealed that the students' level of ability to solve word problems is in the medium category. To solve word problems, verbal ability and the ability to make mathematical models are needed since mathematical word problems are defined as word problems, story problems, and verbal problems (Phonapichat, Wongwanich, & Sujiva, 2014). In this case, good verbal ability will help students understand mathematical problems (Daniyati & Sugiman, 2015). Therefore, the first step that the students must prepare is to understand the problems. With such understanding, students will find it easier to transform students' everyday life situations into abstract equations using mathematical symbols towards mathematical models. A good understanding commences with understanding and remembering the meaning of the mathematical words or terms contained in the problems. The ability to make mathematical models is related to the student's ability to transform a contextual problem into a mathematical expression, including to assume the given elements into variables, to compile mathematical models based on the information obtained from the understood problems, and to simplify the compiled mathematical models (Pitriani, 2016). The obtained mathematical models are used by students to solve the given mathematical word problems.

Only a small proportion of students have the ability to solve word problems within high category (18.74%). This must be given more concern from the school, particularly the teachers, to increase students' mastery in solving word problems. Ciltas and Isik (2013) and Kaprinaputri (2013) explain that to solve word problems, the ability to determine what is known and what is asked in the problems in order to make mathematical expression and to perform calculations and check the answers to its main question of the given problems are needed. The students' tendency to make mistakes in solving word problems lies on students' misinterpretation of the given problems and their lack of skills to identify the meaning of the problems (Khasanah & Utama, 2015). Furthermore, applying a learning model that actively involves students during learning can improve the ability to solve mathematical word problems (Sari, et al., 2014).

Table 4. Results of X_1 on Y correlation analysis

Model	<i>R</i>	<i>R Square</i>	Adjusted <i>R Square</i>
1	0.690	0.476	0.474

Table 4 shows that the relationship between verbal ability and the ability to solve mathematical word problems is positive and strong (0.690). This indicates that the better or the higher the students' verbal ability, the better or higher students' ability to solve the word problems will be. The degree of students' ability in solving word problems can be explained by their verbal ability (47.6%). The remaining (52.4%) is influenced by other variables that did not examine in this study.

Table 5. Results of simple linear regression X_1 on Y analysis

Model	Unstandardized Coefficients		<i>t</i>	Sig.
	<i>B</i>	Std. Error		
1 (Constant)	-12.922	1.318	-9.807	0.000
Verbal	1.321	0.069	19.259	0.000

Table 5 shows the relationship between verbal ability and the ability to solve word problems described by the formula $Y = 1.321X_1 - 12.922$. This equation indicates that the average score of the ability to solve mathematical word problems has increased by 1.321 for every increased verbal ability score. For example, if a student has a verbal ability score of 20 out of 49 items, the predicted score for the student's ability to solve word problems is 13.498. If the student corrects one of the incorrect answers such that his verbal ability score increases to 21, then the predicted score of the student's ability in solving word problems increases to 14.819. This formula is sufficiently significant, in which the obtained value is

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)} = \frac{0.476/1}{(1-0.476)/(409)} = 371.53$$

which is more than $F_{table} = F_{(0.05; 1; 409)} = 3.86$ and the value of $t = 19.259 > t_{table} = 1.97$ and $|t| = 9.807 > t_{table} = 1.97$. Therefore, it can be concluded that students' verbal ability is significantly influential on the students' ability in solving word problems.

The results of this study also confirm the results of the previous studies (e.g. Hardiani, 2014) which found that students' verbal ability is positively influential on their ability to solve word problems. The characteristics of students who have verbal ability are depicted from well-mannered writing and speaking habits, stronger in memorizing, and easy to understand a concept (Wulandari, 2018). These habits are indirectly very helpful in mathematics lessons, including

memorizing formulas and understanding the meaning of word problems. Another matter related to strengthening the process in K13 is the emphasis on language skills as a communication tool. In this case, verbal ability is needed in interpreting the problems that students are working on in solving word problems.

Word problems are an important part of learning mathematics because in the process of solving the given word problems, students are required to make a connection between their mathematical reasoning and knowledge and their everyday life situation. This is also related to how to solve word problems that help students develop skills and recognize when and how to apply mathematical knowledge in everyday life situation (Sepeng & Webb, 2012). Besides, verbal ability is an innate ability that already exists from birth, so it cannot be increased to a higher level, yet verbal ability can be optimized with learning experiences, one of which is by having lots of practices, particularly mathematical problems provided in mathematical word problems (Irawan & Kencanawaty, 2017).

Table 6. Results of X2 on Y correlation analysis

Model	R	R Square	Adjusted R Square
1	0.920	0.846	0.846

Table 6 shows that the relationship between the ability to make mathematical models and the ability to solve mathematical word problems is positive and strong (0.920). The better or the higher the ability to make mathematical models possessed by students, the better or higher students' ability to solve the word problems will be. The degree of students' ability in solving word problems is explained by the ability to make mathematical models (84.6%). The remaining 15.4% is influenced by other variables that did not examine in this study.

Table 7. Results of simple linear regression X₂ on Y analysis

Model	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
1 (Constant)	2.748	0.227	12.091	0.000
Model Ability	1.763	0.037	47.421	0.000

Table 7 shows the relationship between the ability to make models and the ability to solve word problems ($Y = 1.763X_2 + 2.748$). This equation indicates that the average score of the ability to solve mathematical word problems has increased by 1.763 for every increased score of the ability to make mathematical models. For example, if a student has a score of the ability to make a mathematical model of 10 out of 12 questions, the predicted score for the student's ability to solve the word problems is 20.378. If the student corrects one of the incorrect answers, so the score for the ability to make mathematical models increases to 11, then the predicted students' ability score in solving word problems increases to 22.141. This formula is sufficiently significant, in which the obtained value is

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)} = \frac{0.846/1}{(1-0.846)/(409)} = 2247.001$$

which is more than $F_{table} = F_{(0.05; 1; 409)} = 3.86$ and the value of $t = 47.421 > t_{table} = 1.97$ and $|t| = 12.091 > t_{table} = 1.97$. Therefore, it can be concluded that the students' ability to make mathematical models is significantly influential on the ability of these students to solve word problems.

The results confirm the results of several previous studies (e.g. Isnawati, 2016) which reveal a positive and significant influence between the ability to make mathematical models on the ability to solve word problems. Therefore, to be able to solve word problems, the ability to transform mathematical expression into mathematical symbols is very important. In other words, to be able to solve word problems, it requires the ability to make mathematical models (Crouch, 2004; Arseven, 2015; Rahmania & Rahmawati, 2016). Without this ability, students will experience difficulties in solving word problems (Mauliyda et al., 2020).

If students are able to make mathematical models with their own developed ways, they will be more enthusiastic and enjoy learning mathematics (Khikmiyah, Lukito & Patahudin 2012; Riyanto et al., 2019). The more difficult the word problems given, the more difficult the model made, and vice versa, the easier the word problems given, the easier the model will be. On the other hand, Budhayanti (2008) explains that model formulation is the translation of a problem into a mathematical equation or inequality that produces a mathematical model.

Table 8. Result of X_1 and X_2 correlation on Y analysis

Model	<i>R</i>	<i>R Square</i>	Adjusted <i>R Square</i>
1	0.937	0.879	0.878

Table 8 shows that the relationship between verbal ability and the ability to make mathematical models on the ability to solve mathematical word problems is positive and strong (0.937). The better or the higher the ability of the students, namely verbal and making mathematical models simultaneously, the better or higher student's ability to solve the word problems will be. The degree of the students' ability in solving word problems can be explained by their verbal ability and the ability to make mathematical models (87.8%). The remaining 12.2% is influenced by other variables that did not examine in this study.

Table 9. Result of multiple linear regression X_1 and X_2 on Y analysis

Model	Unstandardized Coefficients		<i>t</i>	Sig.
	B	Std. Error		
(Constant)	-4.051	0.678	-5.973	0.000
1 Verbal Ability	0.430	0.041	10.500	0.000
Making Model Ability	1.509	0.041	36.852	0.000

Table 9 shows the relationship between verbal ability and the ability to solve word problems ($Y = 0.43X_1 + 1.509X_2 - 4.051$). This equation explains that the average score of the ability to solve mathematical word problems has increased by 1.939 for every increased score of verbal ability and score of the ability to make mathematical models. For example, if a student has a verbal ability score of 20 out of 26 questions and has a score of the ability to make a mathematical model of 10 out of 12 questions, the predicted score for the student's ability to solve word problems is 19.639. If the student corrects one of the incorrect answers on both tests, so the verbal ability score increases to 21 and the ability score to make mathematical models increases to 11, then the predicted score of the student's ability in solving word problems increases to 21.578. This formula is sufficiently significant, where the value of $F_{\text{count}} = 1479.834$ is more than $F_{\text{table}} = 3.018$. Therefore, it can be concluded that the verbal ability and the ability of students to make mathematical models are significantly influential on the students' ability to solve word problems.

The results of this analysis are supported by correlation analysis. The contribution of students' ability in solving word problems can be explained simultaneously by the two variables (87.8%) rather than partially by the respective independent variables (47.6% and 84.6%). This indicates that to improve students' ability to solve mathematical word problems, it is more optimal if the verbal ability and the ability to make mathematical models are considered simultaneously rather than only focusing on one ability. This implies that if mathematical word problems are presented in a language that students have mastered, it will make it easier for them to transform the word problems into mathematical models. This confirms the research stating that the mistakes produced by lower secondary school students in solving mathematical word problems tend to be caused by the lack of students' ability to transform sentences into mathematical models (Khasanah & Sutarna, 2015; Dila & Zanthly, 2020). In this case, students' modelling ability must be of concern to teachers in mathematics learning (Cahyono, 2020; Jankvist & Niss, 2020).

The ability to make models and students' verbal ability is needed in solving non-routine problems in the form of words in order to make it meaningful to students. In solving non-routine problems, students must have problem solving ability in accordance with the demands of Curriculum 2013. In solving problems, students must have various strategies. Strategies for solving problems in this way are called heuristics because, basically, learning must be able to find the solution by themselves (Guyen & Cabakcor, 2013).

The path analysis in this study refers to Kartini (2017) who suggests that there is an influence of verbal ability on students' ability to make mathematical models. This indicates that the alleged verbal ability indirectly influences the ability to solve word problems through the ability to make models. Figure 1 shows the influence of verbal ability on the ability to solve word problems through the ability to make mathematical models.

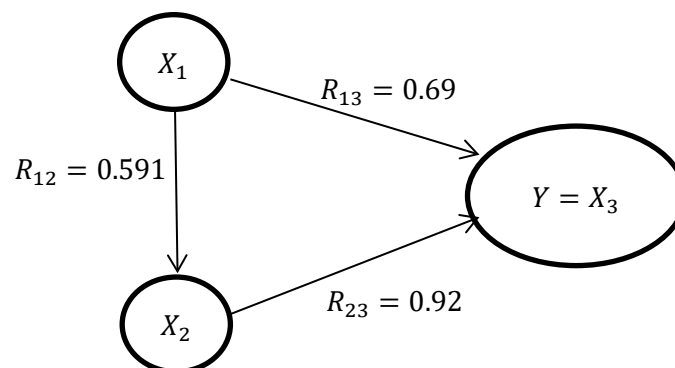


Figure 1. Result of path analysis

Based on the results of the path analysis (Figure 1), there is a direct influence of verbal ability on the ability to solve word problems, $P_{31} = 0.225$, a direct influence of the ability to make models on the ability to solve story problems, $P_{32} = 0.786$, while the indirect effect through the ability to make mathematical models is 0.465. This indicates that the variable ability to solve word problems can be explained more by the verbal ability's variable simultaneously with the ability to make mathematical models. In this case, it can be concluded that to improve students' ability to solve word problems, it is better if a verbal ability is increased together with the ability to make mathematical models, particularly in the implementation of the Curriculum 2013 at the lower secondary school level.

Based on the results of this study, several issues that need to be of concern of the teachers in supporting the ability of students to solve mathematical word problems are: *First*, mathematics teachers are expected to explain in advance some terms potentially to cause students' error in solving mathematical problems. *Second*, to be meaningful learning, it is best if the mathematics teachers relate the teaching topics to students' everyday life problems. Furthermore, the teachers should enhance students' mathematical modelling ability related to the given problems. This also serves as an effort to implement the Curriculum 2013 that emphasizes more problem solving aspects. *Third*, the parameter of lower secondary school students' mastery learning in solving mathematical word problems is not only two factors as described in this study. For this reason, further researchers are expected to establish in order to find other factors that can contribute to students' ability to solve mathematical word problems as expected by the Curriculum 2013.

D. Conclusion

This study finds that, partially, the verbal ability and the ability to make mathematical models of lower secondary school students are significantly influential on the students' ability to solve word problems. The degree of students' ability contribution in solving word problems can be explained by their verbal ability (47.6%) and the ability to make mathematical models (84.6%). Simultaneously, the verbal ability and the ability to make mathematical models of lower secondary school students are significantly influential on the students' ability to solve word problems (87.8%). To be able to solve word problems, students need the ability to make mathematical models, so they are able to transform mathematical expression into mathematical symbols. Without having this ability, students will experience difficulties in solving word problems. Besides, verbal ability is also needed for the student to interpret and solve the given word problems. Therefore, mathematics teachers need to support students' mathematical modelling and verbal abilities simultaneously in order to solve mathematical word problems.

References

- Abidin, Y. (2014). *Desain sistem pembelajaran dalam konteks kurikulum 2013* [Educational system design in the context of Curriculum 2013]. Bandung: Refika Aditama.
- Arseven, A. (2015). Mathematical modelling approach in mathematics education. *Universal Journal of Educational Research*, 3(12), 973-980. Doi: [10.13189/ujer.2015.031204](https://doi.org/10.13189/ujer.2015.031204)
- Budhayanti, C. I. S., Baskoro, J. T., Roostanto, E. A., & Simanullang, B. (2008). *Pemecahan Masalah Matematika* [Mathematical problem solving]. Jakarta: Depdiknas.
- Cahyono, A. N., Sukestiyarno, Y. L., Asikin, M., Miftahudin, Ahsan, M. G. K., & Ludwig, M. (2020). Learning mathematical modelling with augmented reality mobile math trails program: How can it work? *Journal on Mathematics Education*, 11(2), 181-192. Doi: [10.22342/jme.11.2.10729.181-192](https://doi.org/10.22342/jme.11.2.10729.181-192)
- Ciltas, A., & Isik, A. (2013). The effect of instruction through mathematical modelling on modelling skills of prospective elementary mathematics teachers. *Educational Sciences: Theory and Practice*, 13(2), 1187-1192. Retrieved from <https://eric.ed.gov/?id=EJ1017272>
- Crouch, R., & Haines, C. (2004). Mathematical modelling: Transitions between the real world and the mathematical model. *International Journal of Mathematical Education in Science and Technology*, 35(2), 197-206. Doi: [10.1080/00207390310001638322](https://doi.org/10.1080/00207390310001638322)
- Culaste, I. C. (2011). Cognitive skills of mathematical problem solving of grade 6 children. *International Journal of Innovative Interdisciplinary Research*, 1(1), 120-125.
- Daniyati, N. A., & Sugiman. 2015. Hubungan antara kemampuan verbal, kemampuan interpersonal, dan minat belajar dengan prestasi belajar matematika [The relationship between verbal ability, interpersonal ability, and learning interest with mathematics learning achievement].

- interpersonal ability, and interest in learning with mathematics achievement]. *Pythagoras: Jurnal Pendidikan Matematika*, 10(1), 50-60. Doi: 10.21831/pg.v10i1.9109
- Depaepe, F., De Corte, E., & Verschaffel, L. (2015). Students' non-realistic mathematical modeling as a drawback of teachers' beliefs about and approaches to word problem solving. In B. Pepin & B. Roesken-Winter (Eds.), *From beliefs to dynamic affect systems in mathematics education. Exploring a mosaic of relationships and interactions* (pp. 137-159). Cham: Springer.
- Dila, O. R., & Zanthly, L. S. (2020). Identifikasi kesulitan siswa dalam menyelesaikan soal aritmatika sosial [Identification of students difficulties in solving social arithmetic problems]. *Teorema: Teori dan Riset Matematika*, 5(1), 17-26.
- Elia, I. (2020). Word problem solving and pictorial representations: insights from an exploratory study in kindergarten. *ZDM Mathematics Education*, 52, 17-31. Doi: 10.1007/s11858-019-01113-0
- Evagorou, M., Nicolaou, C., & Lymbouridou, C. (2020). Modelling and argumentation with elementary school students. *Canadian Journal of Science, Mathematics and Technology Education*, 20, 58-73. Doi: 10.1007/s42330-020-00076-9
- Gunawan, M. A. (2013). *Statistik untuk penelitian pendidikan* [Statistics for educational research]. Yogyakarta: Parama Publishing.
- Güven, B., & Cabakcor, B. O. (2013). Factors influencing mathematical problem-solving achievement of seventh grade Turkish students. *Learning and Individual Differences*, 23, 131-137. Doi: 10.1016/j.lindif.2012.10.003
- Hardiani, N. (2014). Pengaruh kemampuan verbal dan numerik terhadap kemampuan menyelesaikan soal cerita sistem persamaan linier [The influence of verbal and numerical abilities for students' ability to solve system of linear equations word problems]. *Beta: Jurnal Tadris Matematika*, 7(1), 64-71.
- Irawan, A., & Kencanawaty, G. (2017). Peranan kemampuan verbal dan kemampuan numerik terhadap kemampuan berpikir kritis matematika [The role of verbal and numerical abilities for mathematics critical thinking skills]. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 5(2), 110-119. Doi: 10.24127/ajpm.v5i2.669
- Isnawati, B. (2016). Pengaruh kemampuan membuat model matematika terhadap kemampuan menyelesaikan soal cerita siswa SMP Negeri se-Kecamatan Kalikajar [The influence of students' ability to develop mathematical models for solving word problems for public lower secondary school in district of Kalikajar]. *Ekuivalen*, 23(1), 7-10. Doi: 10.37729/ekuivalen.v23i1.3148
- Jankvist, U. T., & Niss, M. (2020). Upper secondary school students' difficulties with mathematical modelling. *International Journal of Mathematical Education in Science and Technology*, 51(4), 467-496. Doi: 10.1080/0020739X.2019.1587530
- Kaprinaputri, A. P. (2013). Kemampuan menyelesaikan soal cerita matematika [Skills for solving mathematical word problems]. *Jurnal Ilmiah Visi*, 8(1), 10-15. Doi: 10.21009/JIV.0801.2
- Kartini, R. A. (2017). Pengaruh kemampuan verbal dan membaca pemahaman terhadap kemampuan membuat model matematika siswa SMP [The influence of verbal ability and reading literacy for lower secondary school students' ability in creating mathematical model]. *Ekuivalen*, 29(2). Doi: 10.37729/ekuivalen.v29i2.4120
- Khasanah, U. & Utama. (2015). Kesulitan menyelesaikan soal cerita matematika pada siswa SMP [The lower secondary school students' difficulties in solving mathematical word problems]. *Proceedings of the National Conference on Mathematics Education, UMS*. Retrieved from <http://hdl.handle.net/11617/6131>
- Khikmiyah, F., Lukito, A., & Patahudin, S. M. (2012). Students' modelling in learning the concept of speed. *Indonesian Mathematical Society Journal on Mathematics Education*, 3(1), 87-98. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1078585.pdf>
- Mar, R. A., & Rain, M. (2015). Narrative fiction and expository nonfiction differentially predict verbal ability. *Scientific Studies of Reading*, 19(6), 419-433. Doi:10.1080/10888438.2015.1069296
- Mauliyda, M. A., Annizar, A. M., Hidayati, V. R., & Mukhlis, M. (2020). Analysis of students' verbal and written mathematical communication error in solving word problem. *Journal of Physics: Conference Series*, 1538(1). Doi:10.1088/1742-6596/1538/1/012083
- Mulyana, Y., Priyatno, S., & Dewi, N. R. (2018). Penerapan model SSCS untuk meningkatkan kemampuan membuat model matematis dan kerja sama siswa [The implementation of SSCS model for enhancing students' ability in creating mathematical model and cooperation]. In *PRISMA, Proceedings of National Mathematics Conference, 1*, 225-232. Retrieved from <https://journal.unnes.ac.id/sju/index.php/prisma/article/view/19519/9513>

- Permendikbud. (2014). *Peraturan Menteri Pendidikan dan Kebudayaan Nomor 58 tahun 2014 tentang Kurikulum 2013 Sekolah Menengah Pertama/Madrasah Tsanawiyah* [The Ministry of Education and Culture regulation number 58 of 2014 about curriculum 2013 for lower secondary school]. Jakarta: Kemendikbud.
- Phonapichat, P., Wongwanich, S., & Sujiva, S. (2014). An analysis of elementary school students' difficulties in mathematical problem solving. *Procedia-Social and Behavioral Sciences*, 116(1), 3169-3174. Doi: [10.1016/j.sbspro.2014.01.728](https://doi.org/10.1016/j.sbspro.2014.01.728)
- Pimta, S., Tayraukham, S., & Nuangchalerm, P. (2009). Factors influencing mathematic problem-solving ability of sixth grade students. *Journal of Social Sciences*, 5(4), 381-385. Retrieved from <https://eric.ed.gov/?id=ED506983>
- Pitriani. (2016). Kemampuan pemodelan matematika dalam realistic mathematics education (RME) [The mathematical modelling ability in realistic mathematics education (RME)]. *Jurnal Edukasi dan Sains Matematika (JES-MAT)*, 2(1), 65-82. Doi: [10.25134/jes-mat.v2i1.282](https://doi.org/10.25134/jes-mat.v2i1.282)
- Pongsakdi, N., Kajamies, A., Veermans, K., Lertola, K., Vauras, M., & Lehtinen, E. (2020). What makes mathematical word problem solving challenging? Exploring the roles of word problem characteristics, text comprehension, and arithmetic skills. *ZDM*, 52(1), 33-44. Doi: [10.1007/s11858-019-01118-9](https://doi.org/10.1007/s11858-019-01118-9)
- Pratiwi, S. A., & Widjajanti, D. B. (2020). Contextual problem in mathematical problem solving: Core ability in realistic mathematics education. *Journal of Physics: Conference Series*, 1613(1). Doi: [10.1088/1742-6596/1613/1/012018](https://doi.org/10.1088/1742-6596/1613/1/012018)
- Rahardjo, M., & Waluyati, A. (2011). *Pembelajaran soal cerita operasi hitung campuran di sekolah dasar* [Mixed arithmetical operations word problems learning in primary school]. Yogyakarta: Kementerian Pendidikan Nasional.
- Rahmania, L. & Rahmawati, A. (2016). Analisis kesalahan siswa dalam menyelesaikan soal cerita persamaan linier satu variabel [The students' error analysis in solving linear equation word problems]. *JMPM: Jurnal Matematika dan Pendidikan Matematika*, 1(2), 165-174. Doi: [10.26594/jmpm.v1i2.639](https://doi.org/10.26594/jmpm.v1i2.639)
- Rahmazatullaili, R., Zubainur, C. M., & Munzir, S. (2017). Kemampuan berpikir kreatif dan pemecahan masalah siswa melalui penerapan model project-based learning [Students' creative thinking and problem solving abilities through the implementation of model project-based learning]. *Beta: Jurnal Tadris Matematika*, 10(2), 166-183. Doi: [10.20414/betajtm.v10i2.104](https://doi.org/10.20414/betajtm.v10i2.104)
- Reinhold, F., Hofer, S., Berkowitz, M., Strohmaier, A., Scheuerer, S., Loch, F., ... & Reiss, K. (2020). The role of spatial, verbal, numerical, and general reasoning abilities in complex word problem solving for young female and male adults. *Mathematics Education Research Journal*, 32(2), 189-211. Doi: [10.1007/s13394-020-00331-0](https://doi.org/10.1007/s13394-020-00331-0)
- Riyanto, B., Zulkardi., Putri, R. I. I., & Darmawijoyo. (2019). Senior high school mathematics learning through mathematics modeling approach. *Journal on Mathematics Education*, 10(3), 425-444. Doi: [10.22342/jme.10.3.8746.425-444](https://doi.org/10.22342/jme.10.3.8746.425-444)
- Sari, N. R. U., Dantes, N. & Ardana, M. P. P. I. M. (2014). *Pengaruh model pembelajaran missouri mathematics project terhadap kemampuan menyelesaikan soal cerita matematika ditinjau dari kemampuan verbal* [The influence of Missouri mathematics project learning model for the ability to solve mathematical word problems based on students verbal ability] (Doctoral dissertation, Ganesha University of Education). Retrieved from <https://media.neliti.com/media/publications/123072-ID-pengaruh-model-pembelajaran-missouri-mat.pdf>
- Sepeng, P., & Webb, P. (2012). Exploring mathematical discussion in word problem-solving. *Pythagoras*, 33(1). Doi: [10.4102/pythagoras.v33i1.60](https://doi.org/10.4102/pythagoras.v33i1.60)
- Shoimin, A. (2014). *68 Model pembelajaran inovatif dalam kurikulum 2013* [68 innovative learning models in Curriculum 2013]. Yogyakarta: AR-RUZZ MEDIA.
- Simamora, R. E., & Saragih, S. (2019). Improving students' mathematical problem-solving ability and self-efficacy through guided discovery learning in local culture context. *International Electronic Journal of Mathematics Education*, 14(1), 61-72. Doi: [10.12973/iejme/396](https://doi.org/10.12973/iejme/396)
- Staub, F.C., & Reusser, K. (1995). The role of presentational structures in understanding and solving mathematical word problems. In C.A. Weaver, S. Mannes, & C.R. Fletcher (Eds.), *Discourse comprehension. Essays in honor of Walter Kintsch* (pp. 286-305). Hillsdale, NJ: Lawrence Erlbaum.
- Sugiyono. (2017). *Statistika untuk penelitian* [Statistics for research]. Bandung: Alfabeta.
- Tim Pascasarjana UM. (2003). *Berfikir verbal* [Thinking verbally]. Malang: Penelitian dan Pengembangan Universitas Negeri Malang.

- Uhden, O., Karam, R., Pietrocola, M., & Pospiech, G. (2012). Modelling mathematical reasoning in physics education. *Science & Education*, 21, 485–506. Doi: [10.1007/s11191-011-9396-6](https://doi.org/10.1007/s11191-011-9396-6)
- Uyanto, S. S. (2009). *Pedoman analisis data dengan SPSS* [Guidelines for data analysis with SPSS]. Yogyakarta: Graha Ilmu.
- Verschaffel, L., Depaepe, F., & Van Dooren, W. (2015). Individual differences in word problem solving. In R. C. Kadosh & A. Dowker (Eds.), *Oxford handbook of numerical cognition* (pp. 953–974). Oxford: Oxford University Press.
- Verschaffel, L., Greer, B., & De Corte, E. (2000). *Making sense of word problems*. Lisse: Swets and Zeitlinger.
- Wahyu, K., Kuzu, T. E., Subarinah, S., Ratnasari, D., & Mahfudy, S. (2020). Partitive fraction division: Revealing and promoting primary students' understanding. *Journal on Mathematics Education*, 11(2), 237-258. Doi: [10.22342/jme.11.2.11062.237-258](https://doi.org/10.22342/jme.11.2.11062.237-258)
- Wahyuddin & Ihsan, M. (2016). Analisis kemampuan menyelesaikan soal cerita matematika ditinjau dari kemampuan verbal pada siswa kelas VII SMP Muhammadiyah se-Kota Makassar [The analysis of students' ability in solving mathematical word problems based on their verbal ability of 7 grader students in Muhamadiyah lower secondary school in the district of Makassar]. *Suska Journal of Mathematics Education*, 2(2), 111-116. Doi: [10.24014/sjme.v2i2.2213](https://doi.org/10.24014/sjme.v2i2.2213)
- Wahyuddin. (2016). Analisis kemampuan menyelesaikan soal cerita matematika ditinjau dari kemampuan verbal [The analysis of mathematical word problems solving ability based on students' verbal ability]. *Beta: Jurnal Tadris Matematika*, 9(2), 148-160. Doi: [10.20414/Betajtm.V9i2.9](https://doi.org/10.20414/Betajtm.V9i2.9)
- Widoyoko, S. E. P. (2012). *Teknik penyusunan instrumen penelitian* [Techniques for developing research instrument]. Yogyakarta: Pustaka Pelajar.
- Wiguna, S. G. A., Widiana, I. W., & Sudana, D. N. (2016). Penerapan pembelajaran berbasis otak untuk meningkatkan kemampuan pemecahan masalah matematika siswa kelas V [The implementation of brain-based learning for enhancing 5 grader students' mathematical problem solving ability]. *Mimbar PGSD Undiksha*, 4(1), 1-11. Doi: [10.23887/jjpgsd.v4i2.7776](https://doi.org/10.23887/jjpgsd.v4i2.7776)
- Winarni, E. S & Harmini, S. (2011). *Matematika untuk PGSD* [Mathematics for primary school teacher education]. Bandung: Remaja Rosdakarya.
- Wormeli, R. (2018). *Fair isn't always equal: Assessing & grading in the differentiated classroom*. Stenhouse Publishers.
- Wulandari, A. Y. R., & Nurhayati, N. (2018). The relationship between verbal ability and critical thinking skill: The implementation of susan loucks horsley model. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 7(1), 89-97. Doi: [10.24042/jipfalbiruni.v7i1.2507](https://doi.org/10.24042/jipfalbiruni.v7i1.2507)