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Towards Effective Learning: Understanding the Connections of Vocabulary, Reasoning, and Mathematical Word Problem-Solving in Islamic Elementary Education

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***Abstract*—Word problems in mathematics require reasoning skills and the ability to visualize the relationship between mathematics and language. This study aimed to analyze the correlation between vocabulary mastery, reasoning ability, and the ability to solve mathematical word problems. The research focused on students at the Islamic elementary school level who are just starting to learn mathematical problem-solving. The sample consisted of 100 students from two public Islamic elementary schools and five private Islamic elementary schools. Data were collected through tests for each variable, and the research hypothesis was tested using simple correlation and multiple correlations with Minitab Pearson Correlation software. This study found that the three variables were significantly correlated. This suggests that vocabulary mastery and reasoning ability are crucial in optimizing the ability to solve story-counting problems. To enhance these variables, teachers are encouraged to develop innovative and creative teaching methods that focus on developing and practicing math vocabulary from an early age. By improving students' vocabulary mastery and reasoning ability, teachers can enhance their problem-solving performance and ultimately improve their mathematics skills.**

***Index Terms*—word problems, mathematics, vocabulary mastery, reasoning ability**

I. Introduction

Mathematical word problems are real-life scenarios presented in a linguistic format that require arithmetic solutions (Khoshaim, 2020). These problems differ from those expressed purely in mathematical notation (Boonen et al., 2016). As stated earlier, a four-step process has been identified for the resolution of mathematical word problems: (1) understanding the contextual aspects of the problem; (2) comprehending the problem's vocabulary and transforming it into mathematical notation; (3) selecting and employing an appropriate problem-solving strategy; and (4) verifying the validity and accuracy of the solution through a thorough review. Consequently, engaging in the practice of solving math word problems enhances students' capacity to utilize mathematical skills in practical, real-life scenarios beyond the confines of the classroom (Pongsakdi et al., 2019).

Students encounter difficulties in transferring the format of word problems to arithmetic or algebra (Gerofsky, 1996). Numerous studies conducted in Indonesia from the elementary to the tertiary level have revealed the prevalent difficulties faced by students. These include inadequate comprehension of the questions and an inability to convert word problems into mathematical format (Wulanningtyas & Marhaeni, 2022).

A lack of language skills, particularly vocabulary mastery, and inadequate mathematical reasoning abilities can be inferred from the inability to understand questions and translate word problems into mathematical expressions. This hypothesis aligns with several sources of evidence. Firstly, the Early Grade Reading Assessment (EGRA) results indicate that students in grades 2 and 3 can generally read words but fail to comprehend their meanings. Secondly, in 2016, the Indonesian National Assessment Program (INAP) or Indonesian Student Competency Assessment (AKSI) tested the

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reading skills of fourth-grade students and found that only 6.06% scored in the good category, while 47.11% and 46.83% scored in the sufficient and less categories, respectively, indicating low literacy skills among Indonesian students (Wiedarti et al., 2016). Thirdly, students encounter challenges in comprehending and converting questions into mathematical expressions, which is the first step in solving context-based PISA questions (Murtiyasa et al., 2020). In 2022 PISA research in urban and mountain found that 26.7- 60% of students in Class VIII from the three schools in Pangkajene and Islands Regencies had very low competence in finding information, with a score of <54 (Amir et al., 2023).

Vocabulary mastery refers to the ability to comprehend and effectively use words, expressions, and terms in various contexts. Understanding words' meanings in context positively influences students' active thinking and search processes (Nurgiyantoro, 2001). Similarly, reasoning is defined as a logical mode of thinking that enables individuals to conclude (Nuralam & Maulidayani, 2020). It is considered a High Order Thinking Skill (HOTS) and plays a critical role in solving non-routine problems, making it an essential aspect of mathematical problem-solving (Kaitera & Harmoinen, 2022). Students' reasoning abilities can be categorized into two levels: Levels 3-5 and Levels 6–8. At Levels 3-5, students make conjectures about mathematical relationships, investigate those conjectures, make mathematical arguments, and provide reasons for their claims. At levels 6–8, students understand that reasoning and proof are fundamental aspects of mathematics. They develop and evaluate mathematical propositions and proofs, create and investigate mathematical conjectures, and select and apply various types of reasoning and proof methods.

Considering the challenges students encounter in understanding and converting word problems into mathematical expressions, coupled with the importance of mathematics word problems in developing students' problem-solving skills for everyday life situations, it is interesting to investigate the relationship between vocabulary mastery, reasoning ability, and the ability to solve story-counting problems. The scarcity of research on the correlation between language proficiency and math word problem-solving in Indonesia makes this hypothesis intriguing (Fatmanissa & Novianti, 2022). Prior studies on mathematics word problems have predominantly focused on analyzing student errors in problem-solving and devising strategies to enhance performance (Fatmanissa et al., 2020). This research specifically concentrates on Islamic elementary school (Madrasah Ibtidaiyah) students who are in the initial stages of learning mathematical problem-solving, particularly in word problems that involve addition, subtraction, multiplication, and division (story counting problems). The research outcomes are anticipated to offer educators insights and recommendations for enhancing students' vocabulary mastery and reasoning abilities, which are vital prerequisites for resolving math word problem.

II. Research Objective

The overall research objective is to analyse word problems in mathematics require reasoning skills and the ability to visualize the relationship between mathematics and language, as well as to investigate the correlation between vocabulary mastery, reasoning ability, and the ability to solve mathematical word problems in Islamic Elementary Education.

III. The Research Method

This study employed a correlational-associative design through a survey approach. The data were collected ex post facto, meaning that the researcher did not manipulate the respondents' group. The data were collected through tests for each variable, with vocabulary mastery and reasoning ability as the independent variables and the ability to solve story-counting problems as the dependent variable. The study population comprised all sixth-grade students in Islamic elementary schools located in Manado City, while the sample consisted of 100 students from two state Islamic elementary schools and five private Islamic elementary schools.

In ensuring the validity and reliability of the research instruments, the three test instruments, each comprising 30 items, were evaluated on 20 Islamic elementary school students who were not part of the research sample but belonged to the research population. The validity test of the items was conducted using the Minitab Pearson Correlation subprogram, while the reliability test of the items was performed using the halving technique (even-odd), and the overall reliability coefficient was determined using the Spearman-Brown formula. Following the validity and reliability tests, it was confirmed that the vocabulary mastery test instrument comprised 28 items with an rcount value of 0.848 (> rtable = 0.623), the reasoning ability test instrument included 26 items with an rcount value of 0.866 (> rtable = 0.684), and the story count problem-solving instrument contained 28 questions with an rcount value of 0.861 (> rtable = 0.623). Thus, the three research instruments were deemed to be valid and reliable and, hence, can be used to measure variables. Furthermore, the expert had validated all three test instruments before their administration.

The study analyzed the correlation between vocabulary mastery and reasoning skills, as well as their relationship with the ability to solve story-counting problems. Both descriptive and inferential approaches were used to conduct the analysis. The descriptive analysis aimed to describe the scores of vocabulary mastery, reasoning ability, and the ability to solve story-counting problems. Meanwhile, the inferential analysis aimed to test the research hypothesis using a simple correlation formula and multiple correlations, which was conducted using the software Minitab Pearson Correlation.

Before testing the research hypothesis, the normality and homogeneity of the three variables were checked. The Lilliefors test technique (Sudjana, 1989) was used to test for normality in this research. This test is not restricted to small

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sample sizes and can be applied to large samples as well. Additionally, the Lilliefors method is a simple technique for normality testing. The homogeneity of population variance was examined using the Bartlett test (Sudjana, 1989).

IV. Result

Description of the Research Data

To determine the distribution of data for each research variable, the empirical data collected was used to present a data description of each variable. The distribution of the data was displayed in the form of a frequency distribution of scores for each respondent (student).

Distribution of Vocabulary Mastery Scores (Variable X_1)

The analysis of variable X1 data shows that the lowest score is 8 and the highest score is 26, out of a maximum possible score of 28 for vocabulary mastery. The distribution of the vocabulary mastery score data can be seen in Table 1, where the score data was organized using Sturges' rules (Sudjana, 1989) to determine class intervals. According to Sturges' rule, the class interval range is 18, comprising 7 intervals of length 3 each. Based on the data distribution presented in Table 1, statistical calculations reveal that the average vocabulary mastery score ($\bar{x}$) for 100 respondents was 20.5, with a standard deviation of 4.04.

Table 1
Data Distribution of Vocabulary Mastery Scores

Scores Interval	Absolute Frequency	Relative Frequency
7 – 9	1	1 %
10 – 12	3	3 %
13 – 15	7	7 %
16 – 18	21	21 %
19 – 21	20	20 %
22 – 24	31	31 %
25 – 27	17	17 %
Total	**100**	**100**

Distribution of Reasoning Ability Scores (Variable X_2)

Table 2 displays the data distribution for the reasoning abilities of Islamic elementary school students, which were obtained from 100 research respondents. The lowest score recorded among the respondents for the reasoning ability variable (X_2) was 6, while the highest score achieved was 24 out of a maximum possible score of 26. Sturges' rule was applied to analyze the distribution of data for the X_1 variable scores, and the same method was used to determine the distribution of data for the X_2 variable scores. The statistical analysis revealed that the average score ($\bar{x}$) of students' reasoning abilities was 18.25, and the standard deviation was 4.22.

Table 2
Data Distribution of Reasoning Ability Scores

Scores Interval	Absolute Frequency	Relative Frequency
5 – 7	2	2 %
8 – 10	2	2 %
11 – 13	11	11%
14 – 16	17	17%
17 – 19	22	22%
20 – 22	29	29%
23 – 25	17	17%
Total	100	100

Distribution of Scores of the Ability to Solve the Story Counting Problems (Variable Y)

According to data collected from 100 respondents, the ability to solve story counting problems (represented by variable Y) has a range from a minimum score of 4 to a maximum score of 25, out of an ideal maximum score of 28. Table 3 shows the distribution of scores for variable Y, following the same rules used to determine the distribution of variables X_1 and X_2. According to the statistical analysis, the mean ($\bar{x}$) of the ability to solve story counting problems is 17.56, and the standard deviation of the data is 4.74.

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TABLE 3
DISTRIBUTION OF SCORE DATA OF THE ABILITY TO SOLVE STORY COUNTING PROBLEMS

Scores Interval	Absolute Frequency	Relative Frequency
3 – 5	1	1%
6 – 8	3	3%
9 – 11	6	6%
12 – 14	18	18%
15 – 17	19	19%
18 – 20	23	23%
21 – 23	18	18%
24 – 26	12	12%
Total	100	100

Hypothesis Tests

Requirements for Statistical Analysis Testing

1) Normality Requirement

The data for each variable, namely vocabulary mastery, reasoning ability, and ability to solve story counting problems, underwent a normality test using the steps (Sudjana, 1989). The Lilliefors method was used for the analysis, and the results showed that all three populations were normally distributed at a significance level of 0.05. Table 4 displays the results of the normality testing of the three population variance characteristics. The maximum L_{count} of the test result for the three research variables was smaller than the L 0.95 (100) list obtained from the critical value table list L for the Lilliefors test (= 0.0886). This indicates that the three population characteristics are normally distributed, fulfilling one of the conditions for testing the research hypothesis using the correlation formula.

TABLE 4
RESULT OF DATA NORMALITY TEST

Number	Variable	L_{count} maximum of Test Result	L 0.95 (100) Table List
1.	Vocabulary Mastery	0.0869	0.0886
2.	Reasoning Ability	0.0864	
3.	The Ability to Solve Story Counting Problems	0.0864	

2) Homogeneity of Population Variances Requirement

To fulfill the second requirement for hypothesis testing analysis, the homogeneity of variance was assessed using the Bartlett method, following the steps (Sudjana, 1989). This method was employed because the population's variance being tested for similarity exceeded two. The test results show that $\chi^2_{count} = 2.755$ and $\chi^2_{table} = 5.591$, with χ^2_{count} being less than χ^2_{table}. Hence, it can be inferred that the three research variables have homogeneous variances at a significance level of 0.05 with 2 degrees of freedom, which is equal to the number of subject groups minus one.

Hypothesis Tests

Hypothesis testing comprised four parts: (a) assessing the correlation between variable X1 and variable Y, (b) examining the correlation between variable X2 and variable Y, (c) evaluating the correlation between variable X1 and variable X2, and (d) analyzing the correlation between variable X1 and variable X2 simultaneously with variable Y.

1) The correlation between vocabulary mastery (X_1) and ability to solve the story counting Problems (Y)

The results of a correlation analysis between variables X_1 and Y indicated a correlation coefficient of r = 0.8555. The value was re-tested with a t-test to determine whether the correlation was significant or not, with the aim of testing the hypothesis that:

$H : \rho = 0$

$A : \rho \neq 0$(two-tailed test)

The acceptance criterion for the hypothesis test was that the t-statistic should fall between the critical values of t at the $(1 - \alpha/2)$ and $\alpha/2$ levels of significance. If the calculated t-value exceeded the critical value, the null hypothesis would be rejected, indicating a significant relationship between variables X_1 and Y.

The results of the hypothesis testing indicated that t_{count} was 31.5890, which was greater than $t_{\alpha\ (100-2=\ 98)}$, obtained through linear interpolation as 1.6633. Therefore, the null hypothesis was rejected, indicating that the degree of association between the two variables was not equal to zero. This conclusion confirmed that the correlation coefficient of 0.8555 was statistically significant at the 95% confidence level.

2) The correlation between reasoning ability (X2) dan the Ability to Solve the story counting problems (Y)

The two variables X_2 and Y were used to represent the correlation between reasoning ability and the ability to solve story counting problems, respectively. The correlation value of X_2 and Y was found to be 0.9450 through survey data analysis for hypothesis testing. To determine the significance of this coefficient of correlation value, a t-test was used. The hypothesis that was under testing was:

$H : \rho = 0$

$A : \rho \neq 0$ (two-tailed test)

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To accept the hypothesis, the t-value needed to be between t(1-α) and tα, where α is the significance level. If the t-count value was greater than the t-table value, there would be a significant relationship between X_2 and Y. The results of the hypothesis testing showed that t_{count} was 87.4299, which was greater than the $t_{\alpha\,(100-2=98)}$ value of 1.6633 obtained from linear interpolation. Therefore, the hypothesis was rejected, and it was concluded that the degree of association between the two variables was not equal to zero. This means that the correlation value of 0.8555 was significant at the 95% confidence level.

3) The correlation between vocabulary mastery (X1) and reasoning ability (X2)

The results of correlation analysis between vocabulary mastery (X_1) and reasoning ability (X_2) revealed a correlation coefficient of 0.9278. To determine the significance of this correlation, a t-test was conducted using the following hypothesis:

$H : \rho = 0$

$A : \rho \neq 0$ (two way test)

The acceptance criteria for this hypothesis were that the t-value falls between (1-α)/2 and (1+α)/2, while the null hypothesis was rejected if the t-count value exceeded the t-table value. This would indicate a significant relationship between X_1 and X_2.

The results of the hypothesis testing showed that t-count was 31.5890, while tα (98) was 1.6633, obtained through linear interpolation. Based on this, it was concluded that the degree of association between the two variables was not equal to zero, and that the correlation coefficient of 0.9278 was significant at the 95% confidence level.

TABLE 5
SIMPLE CORRELATION BETWEEN RESEARCH VARIABLES

Variables	X_1	X_2	Y
X_1	1		
X_2	0.9278 (significant)	1	
Y	0.8555 (significant)	0.9450 (significant)	1

Description: X_1 : Vocabulary Mastery
X_2 : Reasoning Ability
Y : The Ability to Solve Story Counting Problems

Table 5 presents the results of the simple correlation tests for: (a) analyzing the correlation between variable X_1 and variable Y; (b) analyzing the correlation between variable X_2 and variable Y; and (c) analyzing the correlation between variable X_1 and variable X_2, based on the testing results of hypotheses 1, 2, and 3, respectively.

4) Correlation between the vocabulary Mastery (X1) and Reasoning Ability (X2) with Ability to Solve Story Counting Problems (Y)

The multiple correlation technique was used to test the hypothesis that there is a correlation between vocabulary mastery and reasoning ability, and their ability to solve story counting problems. The F-test was used to determine the significance of the multiple correlation among the three variables.

A correlation coefficient of 0.9465 and an F-test value (Fcount) of 407.1818 were obtained from testing the research hypothesis. As the Fcount value (407.1818) was greater than the Ftable value (3.093), the hypothesis that there is a significant and positive multiple correlation between vocabulary mastery and reasoning ability, simultaneously with their ability to solve story counting problems, was accepted with a 95% degree of confidence level, or a significant level of 0.05. Table 6 presents the results of the multiple correlation testing for the correlation between variables X_1 and X_2, simultaneously with variable Y, based on the testing results of hypothesis 4.

TABLE 6
TEST RESULT OF MULTIPLE CORRELATION COEFFICIENT

Correlation	Correlation Coefficients' Value (R^2)	Value of F		Conclusion
		Count/Test	Table	
r_{X1X2Y}	0.9465	407.1818	3.093	Significant

Discussion

The relationship between vocabulary mastery, reasoning ability, and the ability to solve story counting problems is significant, indicating that language skills and reasoning contribute to optimizing mathematical abilities. This finding is consistent with prior research indicating that: 1) language skills can predict both initial arithmetic or numeracy abilities (Aunio et al., 2019) and advanced mathematical development through arithmetic (Kleemans & Segers, 2020), 2) language literacy (Fatmanissa & Sagara, 2017) and verbal skills (Strohmaier et al., 2021) impact word problem-solving ability, 3) reading comprehension skills play a role in both scientific reasoning (Schlatter et al., 2020) and solving mathematical problems (Boonen et al., 2016; Duo-Terron et al., 2022), 4) according to the 2018 PISA results, students who enjoy reading have a math score that is 6.53 points higher than those who do not enjoy reading (Nur'aini et al., 2021), and 5) the accuracy with which one reads word problems influences the ability to solve mathematical problems.

Thorough reading refers to the practice of comprehending the ideas and details presented in a reading text (Lutvaidah & Hidayat, 2019). By carefully reading story questions, students can develop the ability to understand the question's intent

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and transform it into mathematical form. Consequently, the better students comprehend the meaning of story questions, the more likely they are to solve problems successfully (Andanik & Fitrianawati, 2019).

Moreover, optimizing reasoning abilities creates opportunities for students with lower performance to excel (Vista, 2016). As a result, teachers can act as learning facilitators by designing or modifying various learning models, approaches, strategies, and media to stimulate and enhance students' language skills, especially their mastery of Indonesian vocabulary and reasoning abilities, starting from a young age and extending to higher levels.

To enhance vocabulary mastery in Early Childhood and Elementary Schools, a range of media can be employed, including literacy books based on Augmented Reality (Hartanti & Kurniawan, 2022), Flash Card Path to Literacy Indonesian language adaptation (Fitria et al., 2022), and Anagrams (Oktaviani & Yanti, 2022). Furthermore, teachers should gain an understanding of students' mathematical vocabulary to boost their problem-solving abilities (Amen, 2006).

Furthermore, to optimize reasoning abilities in solving mathematical problems, various approaches can be applied, including differentiated learning with RME-based teaching materials (Cindyana et al., 2022), , the Discovery Learning model (Sary et al., 2022), Error-Analysis Based Learning (Khasawneh et al., 2022), the Problem-Based Learning model with ethnomathematic nuances (Maidiyah et al., 2021), the module-assisted ICARE learning model with the STEM approach (Pratiwi et al., 2021), Schema-Based Instruction (Hughes & Cuevas, 2020), Inquiry-Based Instruction (Schlatter et al., 2020), Auditory Intellectually Repetition (AIR) model (Nuralam & Maulidayani, 2020), Missouri Mathematics Project (MMP) learning with a problem-solving approach (Aprisal & Abadi, 2018), learning model of Kolb-Knisley Mathematics (Kusumayanti & Wutsqa, 2016), Relating, Experiencing, Applying, Cooperating, Transferring strategies (REACT) (Kurniawati et al., 2021), Hybrid Strategy in minimizing errors in understanding and transforming problem-solving (Rosli et al., 2020), Video Media (containing sharing tasks and jumping tasks) through the PMRI approach and collaborative learning (Khoirunnisa & Putri, 2022) and remediation programs (Wulanningtyas & Marhaeni, 2022). Additionally, for evaluating learning at the elementary level, teachers should consider the importance of visual representation in solving math word problems (Kaitera & Harmoinen, 2022) by allowing students to express their thoughts in different ways, such as writing down the completion of story questions in the form of mathematical symbols (mathematical symbol language), pictorial language, or common language (natural language) (Joutsenlahti & Kulju, 2017).

V. Conclusion

The relationship between vocabulary mastery, reasoning ability, and the ability to solve math word problems was examined, and the results showed a correlation coefficient of 0.8555 between vocabulary mastery and the ability to solve story counting problems, a correlation coefficient of 0.9450 between reasoning ability and the ability to solve story counting problems, a correlation coefficient of 0.9278 between vocabulary mastery and reasoning ability, and a correlation coefficient of 0.9465 between vocabulary mastery, reasoning ability, and the ability to solve story counting problems, all with a 95% confidence level. These findings highlight the importance of vocabulary mastery and reasoning ability in optimizing the ability to solve story-counting problems. Therefore, teachers are encouraged to utilize creative and innovative learning models, approaches, strategies, and media to optimize Indonesian vocabulary mastery, reasoning abilities, and story problem-solving abilities, as well as to cultivate and develop students' understanding of mathematics vocabulary from an early age.

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