The Effect of Mathematical Communication, Critical Thinking, and Problem-Solving Skills on Mathematical Concepts Understanding in Indonesia

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Abstract
Mathematics is one of the important subject to be taught to children from an early age. Mathematics concept understanding can shape students' knowledge so as to help in the development of knowledge at a higher level of education. The purpose of this study was to determine the effect of mathematical communication, critical thinking and problem-solving skills on the understanding of mathematical concepts possessed by grade VI elementary school students in Lentera Harapan schools, Indonesia. This study was conducted using a quantitative approach by distributing five test items to 54 students. Instruments are tested valid and reliable. The results found that mathematical communication, critical thinking and problem-solving skills has positive effect on the understanding of mathematical concept.

Keywords: Mathematical Communication Skills, Mathematical Critical Thinking Skills, Problem Solving Skills, Mathematical Concept Understanding

Introduction

Sarwanto (2021), Nadia (2014), Maria, (2020), and Komariyah, (2018) agreed that mathematics, mother of sciences, is taught to children from an early age. Because it affects children's abilities to think critically, logically, and systematically. Ginanjar (2019) argued elementary school students need to learn mathematical concepts to develop their ability to think creatively, logically, critically, analytically, and systematically. In addition, according to Rusdawati (2019), understanding concepts that are formed from an early age will help students in forming knowledge that will be learned at higher level.

Understanding of mathematical concepts is influenced by many factors. Some students' internal factors are ability to think, motivation, health, learning style. Whereas students' external factors are family, community environments in Unaenah (2019). According to Helma (2017), mathematical understanding is an abstract thinking process using critical reasoning, the ability to solve problems and communicate mathematically, as well as the ability to use mathematical concepts and patterns in everyday life.

In current situation, students' ability to understand mathematical concepts in Indonesia tends to be low. This is indicated by the difficulty students face in solving mathematical questions that are slightly altered from the example teacher has given in Unaenah (2019). Students who cannot solve math problems indicate that they have not been able to understand mathematical concepts thoroughly stated by Radiusman (2020). Based on these problems, the purpose of this study is to examine the effect of mathematical communication, and critical thinking skills on grade VI students' problem-solving skills of mathematical concepts at Lentera Harapan School, Indonesia.

Literature Review

A. Mathematical Concept Understanding

Mathematical concept understanding means grasping the basic principles, definitions, and operations associated with that concept. It involves knowing what the concept is about, how it works, and being able to perform basic calculations or operations related to it. It is important for students to know the procedure for solving problems. It can be the basis for students to focus on rules or procedures in solving mathematical problems in Tailor (2016). It can speed up to solve the problem. Hanifa (2016) argued that there are three characteristics of a person having a good understanding of concepts. They are the ability to do translation, the ability to interpret and the ability to extrapolate.

B. Mathematical Communication Skills

According to Yati (2019), mathematical communication is one of the abilities in a person's cognition. It is the ability to convey and explain mathematical ideas appropriately. Mathematical communication can also be interpreted as a skill to explain mathematical concepts to others orally and in writing in Hodiyanto (2017). Mathematical communication skills help students to process and form the meaning of mathematical concepts so that they can be used to associate concepts with one another and explain the concepts in Sammon (2017).

Nurhasanah (2019) stated that the criteria for a person to have good mathematical communication skills are such as having the ability to interpret, solve, and write down problems and the process of solving the problems faced appropriately and systematically. Furthermore, NTCM (2003) argued that there are four criteria in measuring a person's communication skills, namely communicating thoughts in a sequence and clearly to peers and teachers, being able to use mathematical language to explain concepts, being able to use mathematical thinking through the communication process, and being able to analyze mathematical thinking appropriately. In conclusion, to have good communication skills, it is necessary to look at the following indicators, namely (1) Composing and connecting his mathematical thoughts through communication, (2) Communicate thoughts sequentially and clearly to peers and teachers.

C. Mathematical Critical Thinking Skills

Siswanto (2020) explained that mathematical critical thinking is the ability to analyze, process, and integrate received information so that it can provide logical and relevant conclusions. According to Fasha (2018). It shapes students' readiness to think at a more difficult and abstract level. Anugraheni (2018) stated that children can develop their mathematical critical thinking skills from an early age and can be formed in any mathematics learning planning at the elementary school level.

Ridlo (2020) proposed that the criteria in measuring a child's mathematical critical thinking skills are: (1) can provide a simple explanation, (2) can make a basic decision, (3) can conclude information, (4) can provide further explanation. Siswono (2020) and Facione (2015) agreed that there are six indicators of critical thinking, namely (1) interpretation consisting of categorization, decoding, signification, and clarifying a meaning, (2) analysis which is the ability to identify, examine, and analyze arguments or ideas, (3) evaluation which means an ability to assess the arguments given, (4) conclusion, meaning students have alternative thoughts and can draw a logical conclusion, (5) Explanation which means being able to state the results of thoughts using the right methods and procedures, (6) Regulation which means the ability to provide appropriate results and make appropriate assessments of procedures. Therefore, a person can be said to have good mathematical critical thinking skills if he or she can identify and formulate the problem, analyse information based on given data, provide conclusions from existing information.

D. Mathematical Problem-Solving Skills

According to Bariyyah (2021), mathematical problem-solving skills are the abilities to identify problems, search and select various alternative solutions and make decisions in solving all the problems at hand. NTCM (2003) claimed that there are characteristics of a student who has mathematical problem-solving skills, namely (1) can apply various problem-solving strategies, (2) can use mathematical concepts in different situations, (3) can build new knowledge from the problem-solving process carried out, (4) can reflect on the problem-solving process. Polya (2004) also explained that there are four characteristics in measuring a person's problem-solving skills, namely: understanding the problem correctly, compiling problem-solving steps, taking steps to solve the problem correctly, double-checking every information and calculations made. In this research the indicators of problem-solving skills are mathematical communication skills and mathematical critical thinking skills.

Methodology

A. Instruments Design

Three independent variables are going to be measured. They are Mathematical communication skill (X_1), Mathematical Critical Thinking Skill (X_2), and Mathematical Problem-Solving Skills (X_3). One dependent variable called Mathematical Concept Understanding (Y). These independent variables are measured by using three instruments called Mathematical Communication Skill, Mathematical Critical Thinking Skill, and Mathematical Problem-Solving Skills. These instruments are constructed through a test instrument that consisting of five essay questions. The dependent variable is measured by averaging all mathematics test score within that semester. Design of the three Instruments are shows at Table I for X_1, Table II for X_2 and Table III for X_3. Score on brackets on each item indicates the maximum score on that item if students answer correctly.

TABLE I: MATHEMATICAL COMMUNICATION SKILLS INSTRUMENT

Indicators	Description	Numbers
Composing and connecting his mathematical thoughts through communication	Students can identify as well as compile existing information in writing for use in work steps	1a (20) 1b (20)
Communicate thoughts sequentially and clearly to peers and teachers	Students can communicate in writing the correct sequence of solving given math problems	3a (30) 4a (30)

TABLE II: MATHEMATICAL CRITICAL THINKING SKILLS INSTRUMENT

Indicators	Description	Question numbers
Formulate a problem from the questions given	Students can write down the questions asked from the questions correctly	2a (20) 2b (20)
Analyze information based on data, idea, and concepts	Students can write down everything they know about the problem correcly	3b (20) 4b (20)
Provide conclusions from existing information	Student can write the conculation of the problem solving	5 (20)

TABLE III: PROBLEM SOLVING SKILLS INSTRUMENT

Indicators	Description	Question numbers
Mathematical communication skills	Student can write the problem correcly	1a (10), 1b (10) 3a (15), 4a (15) 2a (10), 2b (10)
Mathematical critical thinking skills	Students can identify the right operations to solve the problems	3b (10), 4b (10) 5 (10)

B. Population and Sample

This research was conducted in elementary schools in Tangerang Regency. The population of this study was 57 grade VI elementary school students in two classes. However, at the time of data was collected, the number of samples became 54 students because three students from class B were absent due to illness. The complete data in this study was tabulated at Table IV. and Descriptive data are tabulated at Table V.

C. Validity and Reliability of Instruments

The three instruments should be tested whether they are valid and reliable. Validity and reliability test of Mathematical communication skills instruments is shown at Table VI. The standard correlation for 54 respondents with confidence interval 95% is 0.27 then it can be concluded that the instruments are valid and reliable. Other instruments, Mathematical critical thinking skill, and Mathematical problem-solving skills are found valid and reliable with Cronbach alpha equals to 0.68, and 0.83 respectively.

TABLE IV: EXPERIMENT DATA

Resp	X_1	X_2	X_3	Y	Resp	X_1	X_2	X_3	Y
1	52	57	54	64	28	87	100	93	100
2	90	73	82	68	29	67	77	72	60
3	67	77	72	70	30	58	52	55	50
4	58	52	55	40	31	46	72	59	52
5	52	77	64	68	32	43	67	55	50
6	85	70	78	66	33	33	73	53	80
7	24	32	28	48	34	54	78	66	100
8	80	67	73	74	35	93	70	82	76
9	100	100	100	72	36	93	100	97	92
10	100	60	80	60	37	66	62	64	68
11	75	83	79	42	38	58	77	68	88
12	100	100	100	100	39	100	100	100	95
13	59	42	50	68	40	68	48	58	50
14	38	67	53	44	41	100	90	95	100
15	10	47	28	48	42	40	40	40	68
16	69	68	69	100	43	77	93	85	72
17	67	77	72	72	44	37	57	47	68
18	100	80	90	100	45	48	83	66	68
19	65	27	46	78	46	31	72	51	65
20	100	100	100	78	47	100	100	100	78
21	59	72	65	68	48	85	90	88	66
22	37	47	42	68	49	63	93	78	78
23	58	62	60	70	50	90	93	92	100
24	67	87	77	74	51	66	75	70	72
25	90	83	87	78	52	75	53	64	78
26	73	100	87	70	53	80	87	83	52
27	77	73	75	72	54	53	87	70	70

TABLE V: DESCRIPTIVE DATA OF EXPERIMENT

Variable	**X_1**	**X_2**	**X_3**	**Y**
Minimum	10	27	28	40
Maximum	100	100	100	100
Mean	67.79	73.42	70.61	71.41
Median	66.67	74.17	71.04	70.00
Mode	100	100	100	68

TABLE VI: VALIDITY AND RELIABILITY TEST FOR MATHEMATICAL COMMUNICATION SKILLS INSTRUMENTS

Remark	1a	1b	3a	4a	X_1
Correlation	0.91	0.86	0.43	0.36	
Variance	132.73	89.85	55.33	47.81	714.83
Cronbach Alpha			0.73		

Result and Discussion

Data distribution of X_1, X_2 and X_3 are tested using Chi-square test. They are normal distribution. The frequency distribution data of X_3 is depicted in Fig. 1. The blue bar is the actual data of that interval whereas the orange bar indicates the frequency expectation data to be normal distribution. Regression analysis is used to see the effect between the three independent variables, X_1, X_2 and X_3 on dependent variable Y.

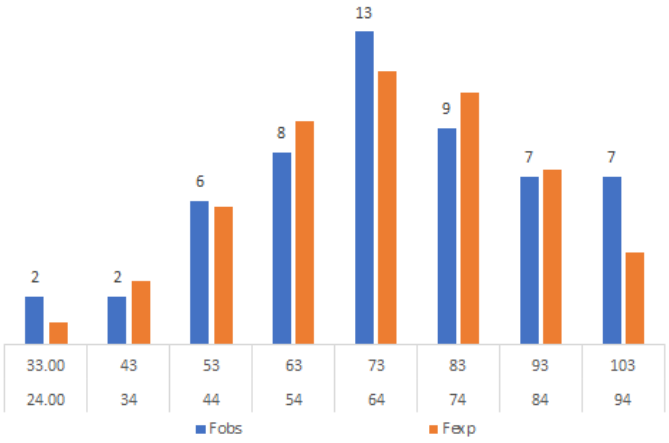

Figure 1. Students' Problem-Solving Skills Distribution

Testing for hypotheses is performed using linier regression tests. The effect of students' Mathematical communication skills on their mathematics concept understanding is stated in equation (1) and the Anova table is presented at Table VII.

$$Y = 47.13 + 0.36X_1 \quad \text{.....(1)}$$

TABLE VII: ANOVA TABLE OF MATHEMATICAL COMMUNICATION SKILLS TOWARD MATHEMATICAL CONCEPT UNDERSTANDING

	DF	SS	MS	Fcal	Sig
Regression	1	3459.16	3459.16	17.56	0.00
Residual Error	52	10243.88	197.00	-	-
Total	53	13703.04	-	-	-

It is proven that Students' Mathematical Communication skill has a positive effect on their mathematical concept understanding. The R square coefficient is 0.25. It means that Mathematical Communication skill has influence 25 % of the students' Mathematical concept understanding. This finding is also supported in Pradipta (2018). Therefore, Students' ability to communicate his or her mathematically thoughts has a positive influence on their understanding of mathematical concepts.

The result is also applied for Students' Mathematical critical thinking skill has a positive effect on their Mathematical concept understanding. The R square coefficient is 0.23. The linier regression equations is stated in equation (2).

$$Y = 41.58 + 0.41X_2 \quad \text{.....(2)}$$

This finding is also stated by Belanisa (2019). Belanisa explained that students with good critical thinking skills will be able to understand and master mathematical concepts clearly and well. These skills are used by students to analyze, process, connect that evaluate the concepts learned critically and rationally. This thinking pattern helps students understand and strengthen their understanding of mathematical concepts.

Further test has the same result that students' Problem-solving skills has positive effect on their mathematical concepts understanding. The R square coefficient is 0.30 and the regression equations is in (3).

$$Y = 37.91 + 0.47X_3 \quad \text{.....(3)}$$

Similar findings were also found by Suraji (2018). They explained that the problem-solving skills influences positively on the mastery of the concepts.

Conclusion

Based on the results of data processing and analysis, it can be concluded that mathematical communication skills, mathematical critical thinking skills, and mathematical problem-solving skills have a positive effect on the mathematical concepts understanding of grade VI elementary school students. The better students can actively communicate, think critically and logically, solve mathematical problems then the better it will help students to have better mathematical concept understanding.

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