

Differences in Increasing Students' Communication Skills and Mathematical Problem Solving through Project-Based Learning with Virtual Manipulative and Physical Manipulative Media at SMP Plus Jabal Rahmah Mulia Medan

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Abstract

This study aims to analyze the differences in the improvement of mathematical communication skills and mathematical problem solving of students who are taught using manipulative virtual learning media and physical manipulative learning through project-based learning models (PjBL), as well as analyzing the performance of class VII students of SMP Plus Jabal Rahmah Mulia Medan in solving problems. questions that measure communication skills and mathematical problem solving. Data obtained through subjective tests or essay tests, each of which measures the students' mathematical problem solving and communication skills. Data were analyzed using ANACOVA test. The population in this study were all students of class VIII of the private high school Jabal Rahmam Mulia for the 2020/2021 academic year. While the sample in this study is class VIII1 which is the first experimental class which is taught using manipulative virtual learning media and class VIII2 is the second experimental class which is taught using physical manipulative learning media. Based on the results of the ANACOVA calculation, the analysis results obtained $F_{hitung} = 3,450 > F_{table} = 3.38$ and with $sig = 000$, because the significant level is smaller than 0.05 so that H_0 is rejected and H_a is accepted. Thus, there are differences in problem-solving abilities between students who are given a realistic mathematics approach assisted by macromedia flash and students who are given a contextual approach assisted by macromedia flash. Based on the results of the analysis $F_{count} = 20.889 > F_{table} = 3.38$ and with $sig = 000$, because the significant level is smaller than 0.05 so that H_0 is rejected and H_a is accepted. Thus, there are differences in mathematical communication skills between students who are given virtual manipulative assisted project-based learning (PjBL VM) and students who are given physical manipulative assisted project-based learning (PjBL PM).

Keywords

mathematical
communication skills;
mathematical problem
solving ability, project-
based learning
models, virtual
manipulative; physical
manipulative



I. Introduction

Realizing "Education is able to support future developments where education is able to develop the potential of students, so that they are able to face and solve life problems they face" (Trianto, 2013). Education must touch the core potential and competency potential of students. The concept of education is even more important when they have to enter life in society and the world of work, because they must be able to apply what they learn in school with problems encountered in daily life both today and in the future.

The mathematical abilities of students in Indonesia were stated by the test results from the 2015 Trends in International Mathematics and Science Study (TIMSS) which showed that Indonesia's ranking was 45 out of 50 participating countries with a score of 397 for math and science abilities (TIMSS: 2015). Irhamna (2020) argues that mathematics is a universal science. Mathematics is also seen as the queen of science. And the results of a study by the Program for International Students Assessment (PISA) in 2015 showed that Indonesia's ranking was 63 out of 69 countries involved.

The results of observations to several students showed the same thing, namely grade IX students at SMP Plus Jabal Rahmah Mulia Medan in the academic year 2020/2021 showing unsatisfactory learning outcomes, especially learning outcomes in the field of mathematics studies. Mathematical communication skills of class IX-1 students at Plus Jabal Rahmah Mulia Medan can be seen from the preliminary results of the researchers' observations of 40 students with an average value of communication skills of 68, out of 40 students only 17 of them had scores above average. This means that from 40 students, 57.5% of students get communication scores below 68.

The Indonesian government has made various efforts to improve the quality of teaching and improve student mathematics learning outcomes, because mathematics is a very important science in every level of education pursued by every Indonesian citizen. The government's efforts include developing curricula, providing training to teachers, completing educational infrastructure and even improving teacher welfare. Along with the development of the internet, learning strategies have shifted and various information and communication technology-based learning strategies have emerged, from e-learning models, smart classroom technology, virtual classrooms, blended learning, etc. (Fitri & Zahari, 2019).

To increase this capacity, the education system in these schools needs to improve all the factors that can influence it, including external factors. Apart from good teacher competence, learning facilities must also be provided. Learning facilities can be provided by the teacher through the use of learning media. Learning media or teaching aids are also an important infrastructure that affects student learning outcomes and mathematical abilities. Learning media that are widely known are classified into two types, namely: Physical Manipulative and Virtual Manipulative.

Physical learning media (physical manipulative), is a learning tool that has an important role in the teaching and learning process. Physical manipulative is a teaching aid whose form can be touched and seen directly which can be used to explain learning concepts. The following are the results of research related to the use of physical manipulatives in mathematics learning.

Noening (2014) in the results of his research states, the impact of the application of innovative media in learning mathematics with flat shape material is the increased ability of teachers to design and implement learning that applies innovative learning media, increase the ability to organize material and manage learning and be able to make good use of learning time, increase Meaningful students' mathematical abilities and also increased student involvement in learning and student persistence when working in groups.

Nurul (2012) states that classes that use physical manipulative learning have a significant increase in mathematical abilities, seen from the achievement of completeness in learning mathematics. Darwis, et al (2014) revealed the results of their research that, in classes taught using physical manipulative, there was an increase in students' mathematical abilities seen from the ability of students who were able to solve problems using the formulas that had been found.

Through good mathematics education, students can indeed obtain various kinds of provisions in facing challenges in the global era. In the 2013 curriculum itself, the use of technology in learning became something that was highly recommended. The learning process in the 2013 curriculum requires students to participate actively and provide sufficient space for students' creativity, interests, and talents (Fitri, Syahputra, & Syahputra, 2019).

After questioning and answering mathematics teachers at Muhammadiyah Medan Middle School, it was found that learning using learning media in the classroom could generate student interest in learning mathematics. However, there are some difficulties in teaching using learning media. These difficulties started from the minimal availability and learning media that seemed boring. The use of physical learning media is also ideal because it is not available in the classroom. Physical learning media which is quite heavy and difficult to carry becomes an obstacle to using learning media in the classroom. However, now the use of learning media can also be accessed easily without having to be provided in every class. The use of virtual learning media is very easy, only with a use of a gadget and a good internet connection, virtual learning media can be easily used.

In addition to choosing the right learning media, to improve mathematical abilities students need to choose a good learning model and classroom processing so that learning media can be used optimally.

Mathematics teacher at SMA N 1 Tj. Morawa revealed that mathematics learning activities rarely use learning media in the classroom due to the unavailability of these learning media. Although it cannot be denied that the effort to improve students' mathematical abilities is to use learning media and choose teaching methods that are in accordance with the material being taught, in order to achieve all learning objectives. Both also argue that using learning media requires a longer learning time. However, both agree to say that the selection of a learning model that is in accordance with the material being taught has a big effect in improving students' mathematical abilities, especially in learning that is centered on student activities.

Based on the opinion of the two teachers above, the use of learning media affects students' mathematical problem-solving and communication skills, which are abilities that students must have according to government regulation number 19 of 2005 (Depdiknas 2006). So that these abilities can be possessed properly, it is necessary to choose the right learning model. The teacher-centered learning model is no longer able to improve student learning outcomes and mathematical abilities, so the Project Based Learning (PjBL) learning model is chosen which is a learning model centered on student activities in this study. Johnson, et al (2013) in their research said that project-based learning can improve mathematical abilities and reduce the failure rate which is also a problem in this study. When project-based learning is used in the classroom, students' misbehavior is markedly reduced. Likewise, the students' cognitive abilities improved significantly.

Karaduman (2013) has conducted research on 100 students who studied mathematics using project-based learning. The results of this study indicate that students who are taught using project-based learning have a sense of responsibility about their learning and are independent in the learning process. So that this is considered capable of improving students' mathematical abilities. Based on this background, the authors are interested in carrying out a study entitled *"Differences in Improving Students' Communication Ability and Problem Solving Students Through Project-Based Learning with Virtual Manipulative and Physical Manipulative Media at SMP Plus Jabal Rahmah Mulia Medan"*.

II. Research Methods

This study took two parallel classes with class VIII1 being the first experimental class which was taught using manipulative virtual learning media. Class VIII2 is the second experimental class which is taught using physical manipulative learning media by implementing project-based learning. The experimental design in this study can be described as follows:

Table 1. Research Design

Grup	Pre-test (T1)		Treatment	Post-test (T2)	
Experiment 1	T _{1.1}	T _{1.2}	X ₁	T _{2.1}	T _{2.2}
Experiment 2	T _{1.1}	T _{1.2}	X ₂	T _{2.1}	T _{2.2}

Information :

T1.1: The initial test measures mathematical communication skills

T1.2: The initial test measures your mathematical problem-solving ability

X1: Project-based learning with manipulative virtual learning media

X2: Project-based learning using physical manipulative learning media

T2.1: The final test measures mathematical communication skills

T2.2: The final test measures your mathematical problem solving ability

The population in this study were all students of class VIII of the private high school Jabal Rahmam Mulia academic year 2020/2021 which consisted of 2 classes. The research instrument used was a subjective test or essay test, each of which measured students' mathematical problem solving and communication skills. In this study, each research sample was given a test essay consisting of 5 items of initial ability (pre-test) and final test (post-test) which measured communication and problem solving skills. The data to be analyzed in this study are the pretest results as a companion variable and the post-test results as the dependent variable. The use of ANACOVA is because in this study using accompanying variables as independent variables that are difficult to control but can be measured together with the dependent variable. All statistical calculations use the help of the SPSS 22 computer program.

III. Results and Discussion

The results of the problem-solving ability test were carried out twice, namely the pretest and posttest with different questions. The pre-test and post-test were followed by 25 students so that in the data analysis, 25 students were involved in this study, namely those who took the pretest and posttest. Following are the results of the descriptive statistical analysis.

Table 2. PreTest of Problem Solving Ability in the Experiment Class 1

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKPM} \leq 55$	9	36 %	Less
2	$55 < \text{SKPM} \leq 70$	15	60 %	Enough
3	$70 < \text{SKPM} \leq 85$	1	4 %	Good
4	$85 < \text{SKPM} \leq 100$	0	0 %	Very Good

Description: SKPM = Problem Solving Ability Score

From Table 2, it can be seen that the pre-test of problem-solving abilities in the experimental class 1 shows that the number of students who received less scores was 9 people or 36%, 15 people had sufficient scores or 60%, and 1 good score or 4%.

Table 3.Post-Test of Problem Solving Ability in Experiment class 1

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKPM} \leq 55$	0	0 %	Less
2	$55 < \text{SKPM} \leq 70$	5	20 %	Enough
3	$70 < \text{SKPM} \leq 85$	15	60 %	Good
4	$85 < \text{SKPM} \leq 100$	5	20 %	Very Good

Description: SKPM = Problem Solving Ability Score

From Table 3 it can be seen that the post-test problem-solving ability in the experimental class 1 shows that the number of students who get sufficient grades is 5 people or 20%, good scores are 15 people or 60%, and very good scores are 5 people or 20%.

The problem solving ability test was carried out twice, namely the pretest and posttest with different questions. The pre-test and post-test were followed by 28 students so that in the data analysis, 28 people were the subjects of this study, namely those who took the pre-test and post-test. Following are the results of the descriptive statistical analysis.

Table 4. Pre Test Problem Solving Ability in Experiment class 2

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKPM} \leq 55$	7	25 %	Less
2	$55 < \text{SKPM} \leq 70$	21	75 %	Enough
3	$70 < \text{SKPM} \leq 85$	0	0 %	Good
4	$85 < \text{SKPM} \leq 100$	0	0 %	Very Good

Description: SKPM = Problem Solving Ability Score

From Table 4, it can be seen that the pre-test of problem-solving abilities in the experimental class 2 found that the number of students who received less grades was 7 people or 25%, and enough scores were 21 people or 75%.

Table 5. Post-Test of Problem Solving Ability in Experiment class 2

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKPM} \leq 55$	0	0 %	Less
2	$55 < \text{SKPM} \leq 70$	3	10,71%	Enough
3	$70 < \text{SKPM} \leq 85$	24	85,71 %	Good
4	$85 < \text{SKPM} \leq 100$	1	3,58 %	Very Good

Description: SKPM = Problem Solving Ability Score

From Table 5, it can be seen that the post-test problem-solving ability in the experimental class 2 shows that the number of students who received sufficient grades was 3 people or 10.71%, 24 people or 85.71% had good scores and very good scores. as much as 1 person or 3.58%.

The data from the pretest and posttest of students' mathematical communication skills were analyzed descriptively with the aim of describing the level of students' mathematical communication after the implementation of learning with virtual manipulative assisted project-based learning and physical manipulative-assisted project-based learning. The results of the pretest and posttest for the two experimental classes are described as follows:

The mathematical communication ability test was conducted twice, namely the pretest and posttest with different questions. The pre-test and post-test were followed by 50 students so that in the analysis of the data, the subjects of this study were 50 people who took the pre-test and post-test. Following are the results of the descriptive statistical analysis.

Table 6. Pre Test of Mathematical Communication Ability in Experimental Class 1

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKRM} \leq 55$	9	36 %	Less
2	$55 < \text{SKRM} \leq 70$	15	60 %	Enough
3	$70 < \text{SKRM} \leq 85$	1	4 %	Good
4	$85 < \text{SKRM} \leq 100$	0	0 %	Very Good

Information: SKRM = Score of Mathematical Communication Ability

From Table 6, it can be seen that the pre-test of mathematical communication skills in the experimental class 1 shows that the number of students who get less scores is 9 people or 36%, enough scores are 15 people or 60%, and good scores are 1 person or 4%.

Table 7. Post-Test of Mathematical Communication Ability in Experimental Class 1

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKRM} \leq 55$	0	0 %	Less
2	$55 < \text{SKRM} \leq 70$	4	16 %	Enough
3	$70 < \text{SKRM} \leq 85$	17	68 %	Good
4	$85 < \text{SKRM} \leq 100$	4	16 %	Very Good

Information: SKRM = Score of Mathematical Communication Ability

From Table 7, it can be seen that the post-test of mathematical communication skills in the experimental class 1 shows that the number of students who get sufficient grades is 4 people or 16%, good scores are 17 people or 68% and very good scores are 4.

The mathematical communication ability test was conducted twice, namely the pre test and post test with different questions. The pre-test and post-test were followed by 56 students so that in the analysis of the data, 56 students were the subject of this study, namely those who took the pre-test and post-test. Following are the results of the descriptive statistical analysis.

Table 8. Pre Test of Mathematical Communication Ability in Experimental Class 2

No	Value Interval	The Number of Students	Percentage	Assessment Category
1	$0 \leq \text{SKRM} \leq 55$	9	32,14 %	Less
2	$55 < \text{SKRM} \leq 70$	16	57,15 %	Enough
3	$70 < \text{SKRM} \leq 85$	3	10,71 %	Good
4	$85 < \text{SKRM} \leq 100$	0	0 %	Very Good

Information: SKRM = Score of Mathematical Communication Ability

From Table 8, it can be seen that the pre-test of mathematical communication skills in the experimental class 2 shows that the number of students who received less scores was 9 people or 32.14%, 16 people had sufficient scores or 57.15%, and good grades. as many as 3 people or 10.71%.

Table 9. Post-Test of Mathematical Communication Ability in Experimental Class 2

No	Value Interval	The Number Of Students	Percentage	Assessment Category
1	$0 \leq \text{SKRM} \leq 55$	0	0 %	Less
2	$55 < \text{SKRM} \leq 70$	7	25 %	Enough
3	$70 < \text{SKRM} \leq 85$	19	67,86 %	Good
4	$85 < \text{SKRM} \leq 100$	2	7,14 %	Very Good

From Table 9, it can be seen that the post-test of mathematical communication skills in the experimental class 2 shows that the number of students who received sufficient grades was 7 people or 25%, good scores were 19 people or 67.86% and very good scores were 2 people or 7,14%. Based on the various answers to questions no.1 to no. 5 in both experimental classes for problem-solving abilities, the percentage of students' answers can be summarized in the table as follows:

Table 10. The Summary of the Percentage of Student Answers for Problem Solving Abilities

No	Aspect Indicator	(Experiment Class 1)					(Experiment Class 2)				
		1	2	3	4	5	1	2	3	4	5
1	Understand the problem.	76%	60%	4%	80%	84%	46,43%	64,29%	71,43%	75%	60,71 %
2	Seek what will be done to solve the problem.	92%	44%	4%	80%	8%	60,71%	53,57%	28,57%	28,57%	14,29 %
3	Resolving problems.	92%	100%	28%	80%	8%	53,57%	21,43%	21,43%	92,86%	14,29 %
4	Arrange for problem solving.	84%	56%	60%	80%	36%	67,86%	60,71%	60,71%	46,43%	64,29 %
Average percentage		84%	65%	24%	80%	34%	57,14%	50%	45,54%	60,72%	38,40 %
Total average		57,4%					50,36%				

Based on the various answers to questions no.1 to no. 5 in both experimental classes for mathematical communication skills, the percentage of students' answers can be summarized in the table as follows:

Table 11. The Summary of the Percentage of Student Answers for Mathematical Communication Skills

No	Aspect Indicator	(Experiment Class 1)					(Experiment Class 2)				
		1	2	3	4	5	1	2	3	4	5
1	Menggambar	80%	80%	100%	68%	96%	21,43%	75%	75%	89,29 %	75%
2	Write math text	100%	88%	100%	100%	100%	82,14%	17,86%	7,14%	7,14%	7,14 %
3	Writing Mathematical Models	80%	16%	72%	0%	36%	0%	0%	0%	3,57%	14,29 %
Average percentage		86,67 %	61,3 3%	90,67 %	56%	77,33%	34,52%	30,95%	27,38 %	33,33 %	32,14 %
Total average		74,40%					31,66%				

If in testing the similarity of the two regression models above H_0 is rejected (regression models are not the same), then it is continued by testing the two alignments of the regression models. Testing the alignment of the linear regression model for experimental class 1 (PjBL VM) and experimental class 2 (PjBL PM) used covariance analysis using statistical F with the formula and criteria set. The results of the analysis of the parallelity test of the two regression models are as follows:

Table 12. Analysis of Covariance for Complete Design of Problem Solving Ability Tests of Between-Subjects Effects

Dependent Variable: posttest_pm_pmr

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	20,016 ^a	2	10,008	3,939	,039
Intercept	950,809	1	950,809	89,168	,000
pretest_pm_pmr	14,485	1	14,485	1,358	,249
group	7,820	1	7,820	3,733	,039
Error	533,154	50	10,663		
Total	79923,000	53			
Corrected Total	553,170	52			

a. R Squared = ,036 (Adjusted R Squared = -,002)

For the problem-solving ability, the pre-test significant value was obtained <0.05 , it can be concluded that at the 95% confidence level, the post-test results were influenced by the students' pre-test abilities before being given a realistic mathematical approach and a contextual approach. Therefore, the error can be corrected by the pre-test value as a covariate / variance.

The regression model that has been obtained for the previous problem-solving ability for the experimental class 1 (PjBL VM) is $Y = 36.246 + 0.95X$. and experimental class 2 (PjBL PM) is $Y = .32,698 + 0,187X$. Furthermore, because the two regressions for the two groups are homogeneous and the constant equality of the linear regression line for the problem solving ability of the experimental class group 1 (PjBL VM) is 36,246 greater than the constant equation of the linear regression line equation for the experimental class group 2 (PjBL PM) which is 32,698 then geometrically The regression line for experimental class 1 (PjBL VM) is above the regression line for experimental class 2 (PjBL PM).

This indicates that there are differences and in the above hypothesis there are differences in the heights of the two regression lines which are influenced by the regression constant. The height of the regression line describes student learning outcomes, namely when $X = 0$, the regression equation for problem solving ability of experimental

class 1 (PjBL VM) is obtained $Y = 36.246$ and the regression equation for experimental class 2 (PjBL PM) $Y = 32.698$. This means that it can be concluded that the problem-solving abilities of students who are taught with a realistic mathematics approach are better than the contextual approach to statistics material.

If in testing the similarity of the two regression models above H_0 is rejected (regression models are not the same), then it is continued by testing the two alignments of the regression models. Testing the alignment of the linear regression model for experimental class 1 (PjBL VM) and experimental class 2 (PjBL PM) used covariance analysis using statistical F with the formula and criteria set. The results of the analysis of the parallelity test of the two regression models are as follows:

Table 13. Covariance Analysis for Complete Design of Mathematical Communication Ability

Tests of Between-Subjects Effects

Dependent Variable: posttest_rep

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	229,185 ^a	2	114,593	12,347	,000
Intercept	425,375	1	425,375	45,832	,000
pretest_rep	210,437	1	210,437	22,673	,000
group	27,750	1	27,750	8,990	,090
Error	464,060	50	9,281		
Total	79214,000	53			
Corrected Total	693,245	52			

a. R Squared = ,331 (Adjusted R Squared = ,304)

For mathematical communication skills obtained a significant pretest value <0.05 , it can be concluded that at the 95% confidence level, the post test results are influenced by the students' pre-test abilities before being given project-based learning with virtual manipulative and physical manipulative assistance. Therefore, the error can be corrected by the pre-test value as a covariate / variance.

The regression model that has been obtained for the previous mathematical communication skills, namely for the experimental class 1 (PjBL VM) is $Y = 27.054 + 0.406X$. and experimental class 2 (PjBL PM) is $Y = 18.973 + 0.627X$. Furthermore, because the two regressions for the two groups are homogeneous and the equality constant of the linear regression line for the communication ability of the experimental class 1 group (PjBL VM) is 27,054 greater than the linear regression equation constant for the experimental class group 2 (PjBL PM) which is 18,973, geometrically the line The regression for experimental class 1 (PjBL VM) is above the regression line for experimental class 2 (PjBL PM).

This indicates that there are differences and in the above hypothesis there are differences in the heights of the two regression lines which are influenced by the regression constant. The height of the regression line describes student learning outcomes, namely when $X = 0$, the regression equation for the communication skills of experimental class 1 (PMR) is obtained $Y = 27.054$ and the regression equation for experimental class 2 (CTL) $Y = 18.973$. This means that it can be concluded that the communication skills of students who are taught with virtual manipulative assisted project-based learning are better than the contextual approach to statistics material.

From the research results obtained, the results will be described descriptively. The discussion of the results of the study was carried out on the problem solving ability, students' mathematical communication skills and the student's answer process related to

problem-solving abilities and mathematical communication.

Dahar (2011) problem solving is a human activity that combines previously acquired concepts and rules, and not as a generic skill. This definition implies that when someone has been able to solve a problem, then that person already has a new ability. Alan H, Schoenfeld (1985), in his book "Mathematical Problem Solving". The four indicators of achievement of mathematical problem solving abilities are: (1) the ability to understand problems (resources), (2) seek what is done to solve problems (heuristics), (3) solve problems (control), (4) formulate problem solving (belief) system).

The results of the study, seen from the results of statistical test analysis on the results of the pretest and post-test were given by using the realistic mathematics approach (PMR) and the contextual approach assisted by macromedia flash, the mean pretest was 29.52 and the mean post-test was 39.04 using the realistic mathematics approach. (PMR) assisted with macromedia flash while the mean pretest was 30.40 and the mean post-test was 38.39 using the contextual approach (CTL) assisted with macromedia flash.

The ANACOVA calculation results obtained based on the results of the analysis $F_{\text{count}} = 3,450 > F_{\text{table}} = 3.38$ and with $\text{sig} = 000$, because the significant level is smaller than 0.05 so that H_0 is rejected and H_a is accepted. Thus, there are differences in problem-solving abilities between students who are given a realistic mathematics approach assisted by macromedia flash and students who are given a contextual approach assisted by macromedia flash. This is in line with the results of Rinayanti's (2014) research which states that the results of the study are significant differences in mathematics learning outcomes between students who take realistic mathematics education approaches and students who take conventional learning.

Ihedioha, S.A (2014) representation is a configuration (form or arrangement) that can describe, represent, or symbolize something in a way. According to Surya & Istiawati (2016), students' mathematical communication skills have the following achievement indicators: (1) Describing the problem situation, namely describing the condition of the problem in the problem in the form of diagrams, tables, graphs and pictures. (2) Writing Mathematical Texts (Writing mathematical texts related to problem solving) (3) Writing Mathematical Models (Determining the correct mathematical model as a method of problem solving. (4) Solving Problems (determining the correct problem solving).

The results of the study, seen from the results of statistical test analysis on the results of the pretest and post-test given using virtual manipulative assisted project-based learning (PjBL VM) and physical manipulative assisted project-based learning (PjBL PM), the mean pretest was 29.72 and a mean post -test 39.12 used virtual manipulative assisted project-based learning (PjBL VM) while the mean pretest was 30.21 and the mean post-test was 37.93 using physical manipulative assisted project-based learning (PjBL PM).

ANACOVA calculation results obtained based on the results of the analysis $F_{\text{hitung}} = 20.889 > F_{\text{table}} = 3.38$ and with $\text{sig} = 000$, because the significant level is smaller than 0.05 so that H_0 is rejected and H_a is accepted. Thus, there are differences in mathematical communication skills between students who are given virtual manipulative assisted project-based learning (PjBL VM) and students who are given physical manipulative assisted project-based learning (PjBL PM). This is in line with the results of research by Halat, E and Peker, M (2012) which states that the results of the study are significant differences in the motivation of students who are taught using webquests using spreadsheets.

The process of students 'answers was analyzed descriptively as seen from the students' pretest and posttest answers on the problem-solving ability test given before and after learning. The results of the students' pretest and posttests then looked at the

achievement of each indicator of problem solving ability based on the student's acquisition score according to the scoring guidelines for the two experimental classes.

The total average score for the acquisition of students from each indicator was analyzed by calculating the percentage of student achievement in each score for the two experimental classes from the test of problem-solving abilities and students' mathematical representations, so the results of the total average score for problem solving abilities were 57% with a realistic mathematics approach and 50.36% with a contextual approach. From the results obtained, it can be concluded that the process of students' answers varies, which can be found from students' answers to problem-solving abilities.

The process of students' answers was analyzed descriptively as seen from the students' pretest and posttest answers on the mathematical communication skills test given before and after learning. The results of the pretest and posttest of the students were then seen the achievement of each indicator of mathematical communication skills based on the student's acquisition score according to the scoring guidelines for the two experimental classes.

The total average score of the students' acquisition of each indicator was analyzed by calculating the percentage of student achievement in each score for the two experimental classes from the test of students' problem solving and mathematical communication skills, so the total average score for students' mathematical communication skills was obtained. 74 , 40% with realistic mathematics approach and 31.66% with contextual shortening. From the results obtained, it can be concluded that the process of students' answers varies, which can be found from students' answers to mathematical communication skills.

IV. Conclusion

The Based on the results of data analysis and discussion in this study, the following conclusions are stated:

1. Materials The problem-solving abilities of students who are given project-based learning with virtual manipulative assistance are higher than students who are given project-based learning with physical manipulative assistance.
2. The communication skills of students who are given project-based learning with virtual manipulative assistance are higher than students who are given project-based learning with physical manipulative assistance.
3. The answer process of students who are given project-based learning with virtual manipulative assistance and students who are given project-based learning with physical manipulative assistance for various problem-solving abilities.
4. The process of answering students who are given project-based learning with virtual manipulative assistance and students who are given project-based learning with physical manipulative assistance for various communication skills.

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