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The Effect of the Missouri Mathematics Project Learning Model on Students' Mathematical Communication Ability

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Abstract

Mathematical communication is one of the most important mathematical abilities that students must learn. Students' ability to communicate mathematical concepts orally or in writing is known as mathematical communication ability. Therefore, this research aims to determine how the Missouri Mathematics Project (MMP) model affects students' mathematical communication ability. With the Nonequivalent Control Group Design, The quantitative research method and type used in this research is experimental. Purposive sampling is a technique used for sampling which Busana_1 is an experimental class of the control class KKKR_2The research instrument used was a test. The data analysis in this study used parametric tests. The results of this research show that the class. $\text{Busana}_1$is an experimental class that has a higher value when juxtaposed with KKKR_2 the class analysed with descriptive analysis. The results of the hypothesis were obtained based on the t-test that it $t_{hitung} = 9{,}987 > t_{tabel} = 1{,}66$ was significant. Thus, it is rejected $0{,}162 < 0{,}05 H_0$and H_1 accepted, it is proven that the influence of the Missouri Mathematics Project (MMP) model on students' mathematical communication ability is obtained.

Keywords: Communication ability; Learning; Missouri Mathematics Project.

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1. Introduction

Education is a program comprising various elements to achieve goals Zetriuslita (2022). Mathematics is of great importance in the field of education. Based on Ismah & Sundi (2018), mathematics is a fundamental aspect of education taught to students nationally and globally. Based on Kadarisma (2016), many people benefit from learning mathematics. In conclusion, mathematics is rightly recognised as a critical element of education, benefiting individuals and societies globally. However, a holistic approach that integrates teaching with other disciplines may enhance its effectiveness and address broader educational goals.

Based on the Regulation of the Minister of Education and Culture Number 58 of 2014, the mathematics learning outcomes are developing understanding and ability to solve problems, the ability to analyse and communicate ideas, the use of properties and patterns in reasoning, the ability to think, explain the correlation between mathematical concepts, as well as attitudes and behaviours that show appreciation for the practical application of mathematics in real life. In line with the *National Council of Teachers of Mathematics* (NCTM), effective communication skills in mathematics are an important aspect of students' overall mathematical proficiency. Here are references that support the stated opinion about mathematics learning outcomes and their alignment with the NCTM standards: Boaler (2016) Discusses the importance of communication and reasoning in fostering mathematical understanding. Cai & Hwang (2020) Highlight the role of communication in mathematics education for developing proficiency. National Council of Teachers of Mathematics (2014) Outlines strategies for effective teaching, including reasoning, problem-solving, and communication. Leong & Tan (2016) Explore how reasoning and communication aid in problem-solving. Rittle-Johnson, Schneider, and Star (2015) Emphasize the importance of connecting mathematical concepts for deeper understanding. Niss and Højgaard (2019) Examine the development of competencies, including communication and reasoning. Santos-Trigo & Camacho-Machín (2014). Focuses on the problem-solving aspect of mathematics education. Wang & Chiang (2019). Highlights using reasoning and patterns in computational approaches to mathematics. Goos, Stillman, and Vale (2017) Discuss real-world applications of mathematics and the importance of reasoning and communication. Swan & Burkhardt (2014) Focus on designing activities to enhance communication and reasoning in mathematics.

Based on NCTM (2000), effective mathematical communication involves skilful organisation and explanation of mathematical concepts clearly and logically, as well as the ability to evaluate and articulate mathematical ideas in a meaningful way critically. Based Astiswijaya (2020) Mathematical communication skills are students' proficiency in communicating mathematical concepts orally and in writing and understanding, interpreting, and explaining mathematical language, symbols, and notation. Based Nofrianto (2017)Students' mathematical communication skills can be seen as their capacity to transmit the knowledge they have acquired through interactions in real-world situations or in the classroom environment where communication occurs. Mathematical communication is not merely a skill to enhance learning; it is integral to the discipline of mathematics itself. By emphasizing the ability to articulate and critique mathematical ideas, educators can empower students to develop a deeper understanding of concepts, work collaboratively, and apply their knowledge effectively in various contexts. Communication transforms mathematics from an abstract field into a dynamic, interactive, and impactful study area.

In mathematics learning, students' mathematical communication abilities are still lacking. This aligns with Natawijaya's research, which Aden (2011) quoted, students with poor communication and numeracy abilities face several challenges when learning math. Data *Trends in International Mathematics and Science Study* (TIMSS) 2015 stated that mathematics learning in Indonesia is mostly focused on developing initial ability, with little attention paid to applying mathematics to real-world situations and delivering mathematical ideas. According to Astiswijaya (2020), mathematics students' communication ability can be achieved if the learning process takes place through two-way communication. However, when applied in the classroom, teacher learning is often only carried out unilaterally by the teacher, and one-sided learning results in fewer students sharing their thoughts and ideas about mathematics. Based on an observation by Sukman (2017), at State Junior High School 2 Salatiga, most of the students experienced difficulties in solving story problems accurately. Students still often have difficulty writing down information, showing symbols, and working on problems obtained from their beloved questions. This condition can be seen from the test scores of 58 students, which shows that most students still have moderate mathematical communication ability. Based on Izzati & Suryadi (2009), students' mastery of mathematical communication ability is still low because, so far, there has not been much focus on this field of mathematics learning.

This condition is in accordance with what I have experienced during the Field Education Practice Lecture (FEPL) at Pekanbaru 4 State Vocational High School, where most students have difficulty solving this math problem. Students have difficulty incorporating symbols, drawings, graphs, and curves into mathematical models. Only when an example resembles a problem that students work on during the learning process can they find a mathematical model. Students need the help of teachers to answer math problems. Thus, the teacher-centred learning model still dominates the learning process. In addition, students have difficulty completing daily test questions while working on them. These difficulties are the inability to write down the steps systematically, the inability to write down the answers themselves, and the inability to connect various mathematical concepts with answering daily test questions.

This learning model makes students solve difficulties by imitating the teacher's solution when discussing math problems and examples. The student does not investigate and perfect his mathematical concepts. Students cannot develop their mathematical ideas. The student has never solved a math problem before. In addition, after learning these concepts, students will find it difficult to apply them to actual difficulties or non-routine problems. This is why students struggle with mathematical communication ability when studying the subject.

Maximum efforts are needed to help children master mathematics lessons; the planned learning goals can be achieved in the end. Teachers must be able to create learning that increases students' proficiency in expressing ideas, thoughts, and concepts derived from mathematical principles. This model is related to mathematics learning. One of the learning strategies that can help students communicate more mathematically is the *Missouri Mathematic Project* (MMP).

Teachers and students can take the initiative to participate proactively during the learning process by using *the* Missouri *Mathematics Project* (MMP) as a model for learning mathematics. The role of the teacher in the *Missouri Mathematics Project (MMP) learning process technique is the role of the* facilitator; students actively discover concepts during the project development phase. After understanding this idea, which is easy to understand and endure, students will easily apply their knowledge to convey mathematics. Afterwards, students collaborate (by following *the Missouri Mathematics Project* (MMP) process, controlled practice) to complete an assignment in which they help each other understand the subject matter. Students will compose answers, try to find the right solution, and talk more about math.

Based Suryati & Putri (2023) Here are the advantages of using the Learning model *Missouri Mathematic Project* (MMP): 1) The relatively strictly regulated use of time ultimately results in much material delivered to students. 2) There are many practical questions and project assignments; in the end, students will learn to communicate from various kinds of questions. 3) Modelling This learning model has its own appeal because of its emphasis on collaborative learning.

Thus, my research aims to see "The Influence of *the Missouri Mathematics Project* (MMP) Learning Model on Students' Mathematical Communication ability". The novelty of the research lies in applying the Missouri Mathematics Project to a distinct and increasingly prioritised area of mathematics education—mathematical communication ability. By linking a proven instructional model to this specific competency, the study not only fills a gap in the existing literature but also provides actionable insights for improving mathematics instruction in ways that prepare students for future collaborative, communicative, and applied mathematical tasks.

2. Methods

The research used is quantitative. Based Ibrahim (2018) This research intends to explore the impact of the treatment and understand the potential consequences it may cause. The research used is quantitative, with a non-equivalent control group design. In this design, a control group was obtained that was completely unable to control external variables that might affect the performance of experimental activities sugiyono (2015)This design emphasises that the experimental and control classes are not randomly selected. Teachers who recommend based on student grades aforementioned cause this condition. The research design wears a pretest to see the initial abilities of students, both in the experimental class and in the control class.

The population in this research is class X Pekanbaru 4 State Vocational High School, while the sample is part of the population that is already taken from a certain point of view. Hasnunidah (2017). This sampling uses the following techniques: Purposive Sampling, which is where $Busana_1$ is the experimental class is the control class $KKKR_2$. Musfiqon (2016) said the technique was purposive sampling. It was carried out by considering the individuals being investigated. In this experimental class, there were 37 people, while in the control class 37 people. In the control class, model discovery learning was used. Experimental class wear Learning Model Missouri Mathematics Project (MMP)

Data collection methods include tests, observations, and documentation. Descriptive and inferential analysis are also used in the data analysis process. Sugiyono (2016) stated that the analysis. Moreover, inferential analysis was used in this research. Descriptive analysis provides information about data on communication skills results during the learning process. Lestari (2017) defines inferential analysis as a statistic that examines sample data and treats the results as a population. To conduct the t-test, the results of the student's communication ability score must be obtained early. After that, tests must be carried out on normality and homogeneity. With the SPSS 22 for Windows application, t-tests were conducted for an inferential data analysis approach. One of the most popular applications for statistical data is SPSS.

The indicators of mathematical communication skills used in the research are: 1). Connecting real objects, images, and diagrams into mathematical ideas. 2). Presenting mathematical ideas and relations orally or in writing with real objects. 3). Expressing everyday events in mathematical language or symbols. 4). Presenting and making mathematics questions that have been studied. One example of a question by the indicator of connecting real objects, images, and diagrams into mathematical ideas above is as follows the diagram below shows data on the number of class X students at Surabaya State High School from 2015 to 2021.

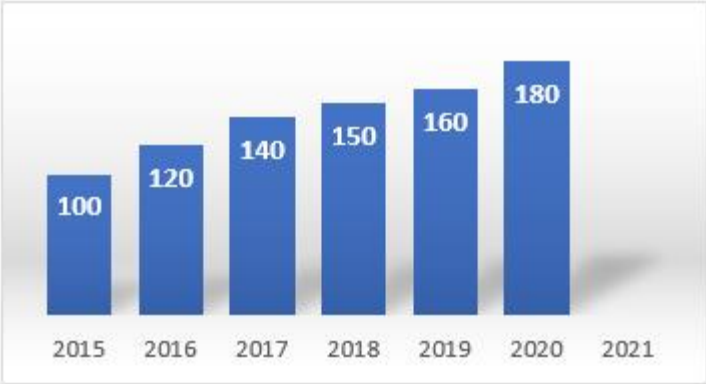

Figure 1 Diagram of Data in the Class X Students

If the number of female students in grade X in 2015 and 2020 were 55% and 40% of the total students in those years, respectively, can it be concluded that the number of female students in 2015 was greater than in 2020? Explain!

3. Results and Discussion

3.1. Results

The following results are based on pretests-posttests regarding students' mathematical communication ability. A descriptive analysis of the average mathematical communication ability of students is carried out in the following table:

Table 1 - Pretest Result Data

Descriptive Analysis	Pretest	
	Experiment $(BUSANA_1)$	Control $(KKKR_2)$
Number of students	37	37
Total value	1524	1362
Average	41,18	36,81
Highest score	67	63
Lowest score	6	11

Based on Table 1 above, the number of experimental students is 37 students, while the number of control class is 37 people. The high value in the experimental class is 67, while the high value in the control class is 63. In the experimental class, the average is 41.18, while in the control class, the average value is 36.81. So, it is concluded that the average value of the experimental class pretest is higher when compared to the control class. In this experimental class, the gender is female, and the control class is male. Because there is a gender difference, this condition can affect the average value.

In addition to causing gaps in mathematical ability, differences in Gender also affect the way a person learns mathematics. "The interplay between gender, social, and cultural dimensions greatly influences how we think about mathematics education." Keitel (1998)According to Keitel, social, cultural, and gender issues impact mathematics learning. Diverse gender differences will also give rise to very different brain morphologies and personalities, which in turn results in different ways of learning. Men learn best when the focus is on hands-on activities such as laboratory work, design, assembly, and so on when communication (both verbal and non-verbal) is minimal or non-existent. On the other hand, women prefer to learn through methods and approaches related to communication, including presentations, speaking, writing, lectures, and informal conversations by Amen (2018).

In addition to the results of the pretest, the results of the posttest that have been carried out in the control class and the experiment can also be obtained; in the end, a descriptive analysis can be carried out. on the average score on students' mathematical communication skills shown in the table below:

Table 2 - Posttest Result Data

Descriptive Analysis	Posttest	
	K. Experiment ($BUSANA_1$)	**K. Control ($KKKR_2$)**
Number of students	37	37
Total value	3080	2215
Average	83,24	59,86
Highest score	97	88
Lowest score	61	37

Based on Table 2 above, the comparison between the experimental and control classes shows that the experimental class has 37 students, with the highest score of 97 and an average score of 83.24. Meanwhile, the control class also consisted of 37 students, with the highest 88 and an average score of 59.86. In terms of statistics, it can be seen that the results of the experimental class posttest exceed the results of the control class posttest. Thus, it can be concluded that the students in the experimental class showed superior mathematical communication skills compared to the students in the control class.

Conversely, to prove that the Missouri Mathematics Project (MMP) learning model has a better influence on learning, a comparison of pretest and posttest data will be carried out, followed by an inferential analysis.

Table 3 - Pretest Normality Test Experimental Class and Control Class

Class		Shapiro-Wilk		
		Statistics	**Df**	**Sig.**
Learning Outcomes	Experimental classes	.982	37	.813
	Control Classes	.974	37	541

*. This is a lower bound of the true significance
a.liliefors significance correction

From the results obtained in Table 3, the Shapiro-Wilk significant value was obtained for the pretest value in the experimental class for $> 0,05$ ($0,813 > 0,05$). the pretest value of the control class, it can be concluded that this variable is actually distributed normally $> 0,05$ ($0,541 > 0,05$).

Table 4 - Homogeneity Test Pretest Experimental and Control Class

Levene statistic	df_1	df_2	**Sign.**
.054	1	72	.816

According to Table 4 above, the sign value means the value. So, the initial ability variance between these experimental and control classes is homogeneous. $0,813 > 0,05$ ($0,816 > 0,05$).

Table 5 - Normality Test Posttest of Experimental and Control Classes

Class		Shapiro-Wilk		
		Statistics	**Df**	**Sig.**
Learning Outcomes	Experimental classes	.962	37	.228
	Control Classes	.949	37	.089

*. This is a lower bound of the true significance
a.liliefors significance correction

Based on Table 5 above, it was obtained that the significant value of Shapiro-Wilk for the posttest of the experimental class was greater than 0.05 (0.228 > 0.05) (0.089 > 0.05). After that, the significant value of Shapiro-Wilk for the control class posttest was greater than 0.05 (0.089 > 0.05). In the end, the conclusion of the normally distributed variance was drawn.

Table 6 - Homogeneity Test Posttest of Experimental and Control Classes

Levene statistic	df_1	df_2	Sign.
.1993	1	72	.162

Based on Table 6 above, it is obtained that the significant value is 0.162, where the value). 0,05 (0,162 $>$ 0,05 Therefore, the data from the posttest class, namely the experimental and control classes, are homogeneous.

Table 7 - T-test

		f	Sig	t	Df	Sig.(2 tailed)
Posttest results	Equal variances assumed	1.993	.162	9.987	72	.000
	Equal variances not assumed			9.987	68.35	.000

Based on the table above, it can be concluded that $\mathrm{t_{hitung}}$ =9,987 where there is a significant 5% and a degree of freedom. (DK) with a score of 72; in the end $n_1 + n_2 - 2$ $\mathrm{t_{tabel}}$ it is worth 1,66. Therefore tu $\mathrm{t_{hitung}}$ 9,987 $>$ $\mathrm{t_{tabel}}$ 1,66. Then H_0 rejected and H_1 accepted. These findings show that students in the experimental class have stronger mathematical communication abilities than those in the control class. It can be concluded that the Missouri Mathematics Project (MMP) learning model positively impacts the development of mathematical communication skills in the experimental class.

3.2. Discussion

Findings from descriptive and inferential research analyses provide evidence to support this conclusion. Based on post-test data, it can be seen that the experimental class obtained an average score of 83.24, compared with the control class, which obtained an average score of 59.86. This condition shows that the initial ability of the experimental class is superior to that of the control class, which can be seen from the higher average score in both pretest and post-test assessments. These findings show that students in the experimental class have stronger mathematical communication skills than those in the control class. It can be concluded that the Missouri Mathematics Project (MMP) learning model positively impacts the development of mathematical communication skills in the experimental class. The references align with the findings of this study and provide evidence supporting the impact of the Missouri Mathematics Project (MMP) and similar structured learning models on mathematical communication skills. These references include studies on problem-solving, cooperative learning, and the development of communication in mathematics education, examines how academic dialogue fosters mathematical understanding, explores the role of instructional methods in enhancing communication, advocates for real-world application and understanding in mathematics, discusses factors influencing achievement, including cooperative learning models, and highlights the impact of cooperative learning on communication skills in mathematics (Boaler, 2016; Cai & Hwang, 2020; NCTM, 2014; Leong & Tan, 2016; Rittle-Johnson, Schneider & Star, 2015; Niss & Højgaard, 2019; Swan & Burkhardt, 2014; Johnson, Johnson & Holubec, 2018; Hattie, 2009; Sfard, 2001; Freudenthal, 1973; Polly & Orrill, 2012; Kilpatrick, Swafford & Findell, 2001; Mercer & Howe, 2012; Zwiers & Crawford, 2011; Wood & Turner-Vorbeck, 2001; Cobb, Stephan, McClain & Gravemeijer, 2001; Evitts, 2004; Resnick, Asterhan & Clarke, 2015; Meyer & Turner, 2002).

This condition is in accordance with research by Rosyid & Umbara (2018), which found that students who participated in the Missouri Mathematics Project learning model experienced an improvement in mathematical communication skills better than students who participated in traditional learning. Students can gain a better understanding, interpretation, and evaluation of mathematical concepts and the ability to convey mathematical concepts through the Missouri Mathematics Project.

Based on Apriyani (2023), students' mathematical communication capacity has increased drastically due to the Missouri Mathematics Project (MMP) paradigm. This condition is because students have used the Missouri Mathematics Project (MMP) learning and followed the application procedures in learning mathematics. Based on research, students showed increased activity and participation in applying the Missouri Mathematics Project (MMP) learning paradigm from the first day of the meeting to the last day. Students are trained to improve their mathematical communication skills through the Missouri Mathematics Project (MMP) process of review, development, controlled practice, group work, and assignments. The results of inferential statistical analysis of posttest scores were obtained. $t_{hitung}\ 9{,}987 > t_{tabel}\ 1{,}66$ In the end H_0 rejected and H_1 accepted. This condition means that the mathematical communication ability of students in the experimental class is better than in the control class. The influence on the mathematical communication ability of students in class X of State Vocational High School 4 Pekanbaru was experimented with the Missouri Mathematics Project (MMP) learning model.

Researchers apply learning models to the Missouri Mathematics Project (MMP) in the experimental class. Missouri Mathematics Project (MMP), based on Putra (2017) It is a structured learning model that teachers can use to help students develop through exercises that provide freedom and opportunities to think individually and in groups, as well as the ability to apply. their own understanding to work independently in the seatwork. At the beginning of the student meeting, the student was inactive and unable to interpret and evaluate the controlled exercises in the learning materials, which still looked confusing. However, in the next meeting, students began to learn actively in groups and individually. Learning model Missouri Mathematics Project (MMP) can Help students connect previously learned mathematical ideas to solving problems and exercises mathematically. This condition will positively impact students' mathematical communication skills and relate the concepts learned to solving a problem according to the procedure.

The control class used the learning model Discovery Learning. This teacher is only a supervisor who usually fails to detect problems and misunderstandings between the teacher and his students. Further, Khasinah (2021) Learning Model Discovery Learning This makes learners often have difficulty forming opinions, making predictions, or drawing conclusions, and using this model is time-consuming. This condition will cause students to be more likely to get bored quickly, not listen to explanations, and even not pay attention when the teacher explains. This condition will also impact students' mathematical communication, as seen in the posttest results.

The following is a snippet of the results of the post-test on students' mathematical communication ability as follows:

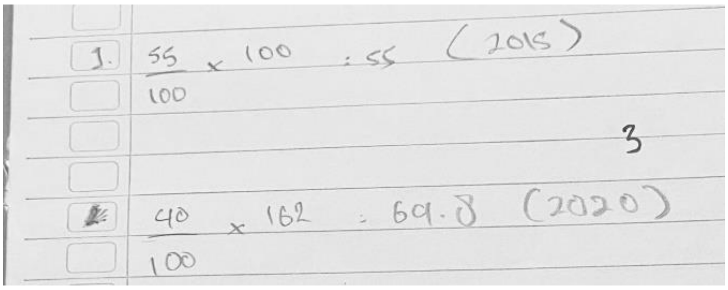

Figure 2 Indicators Connect Images Into Mathematical Ideas

In the snippet of the student's answer above, it can be seen that the student's mistake, in general, is still wrong in solving problems in accordance with the procedure in working on story problems and obtaining errors in the operation of work on number 1. Based on the answers above, students can generally write down how to solve question number 1 correctly and correctly. However, the student made a mistake in that the student did not write a conclusion at the end of the problem-solving.

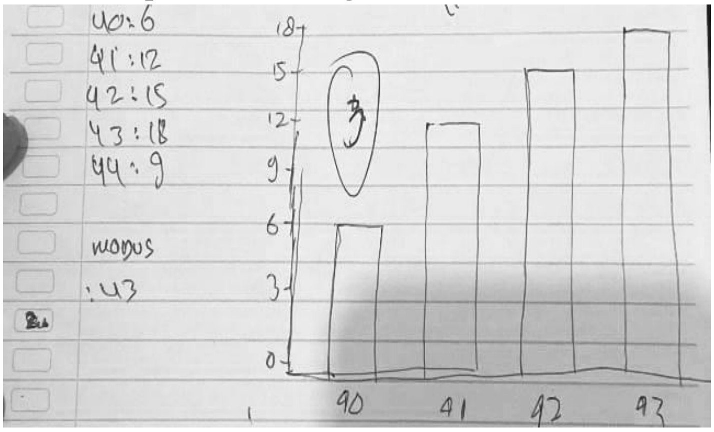

Figure 3 Indicators Explain Ideas in Writing with Pictures

Based on the results of question number 2, students still make mistakes when solving the problem. Namely, they do not draw a bar diagram at a weight of 44 kg, but they do it untidily.

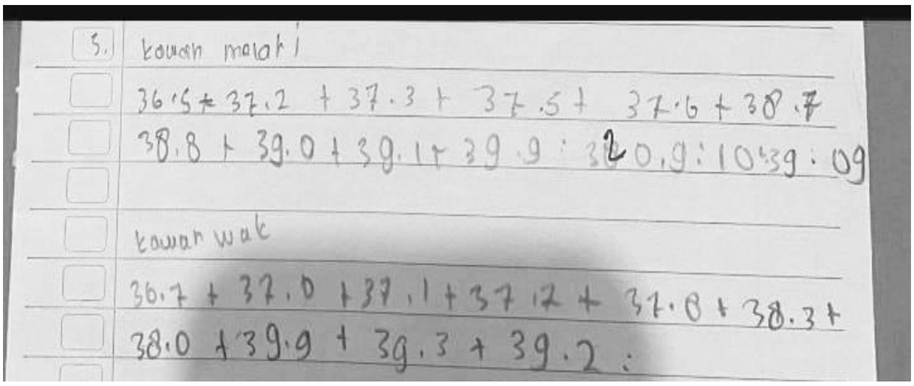

Figure 4 Indicators Declare Day-to-Day Events

Based on the student's answer to question number 3, the student's answer was not correct. This condition is caused by the student considering the problem difficult to do and not understand. As a result, the student could not answer the teacher's questions correctly.

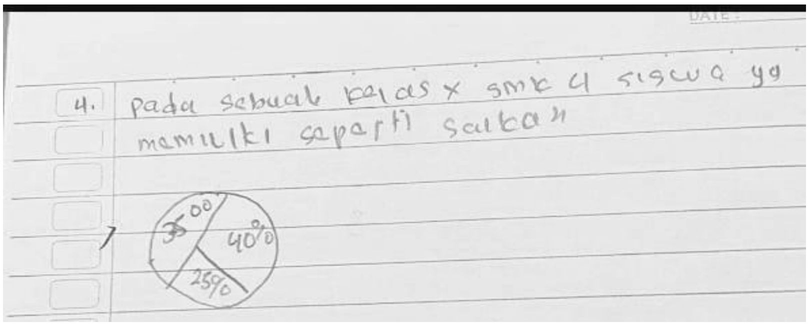

Figure 5 Indicators Explain and Make Questions

In answer number 4, students do not answer questions according to the criteria and cannot interpret ideas or express mathematical language or symbols. As for the students of the experimental class, it can be seen from the snippet of the answer as follows:

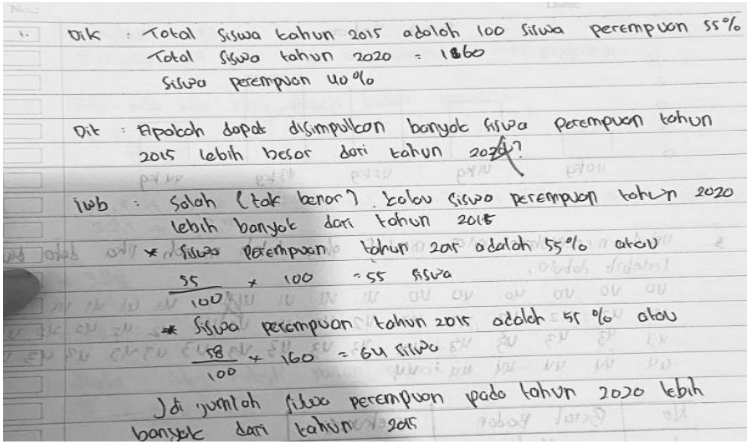

Figure 6 Indicators Connect Images to Mathematical Ideas

From the response of the experimental class, it can be seen that the students are able to answer question number 1 correctly and correctly. This condition is caused by the ability of students to connect to the idea of applying mathematical concepts, write conclusions in answers correctly, and write down all known facts asked to be written.

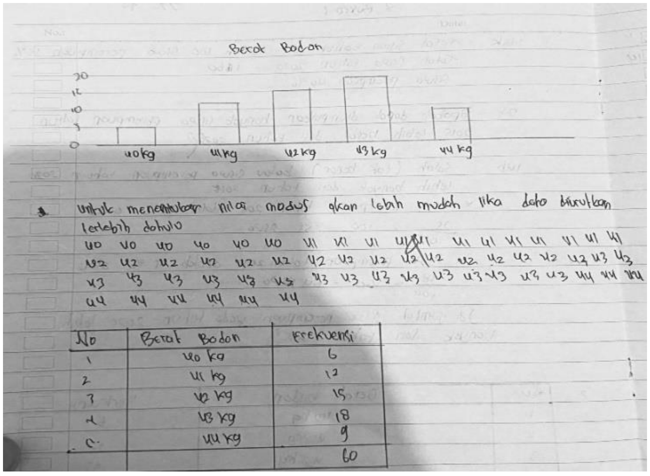

Figure 7 Indicators explain ideas in writing through images

For answer number 2, students are able to solve problems by writing down what they know, and students can take pictures of the math problems; in the end, students are said to be able to solve this practice problem completely and accurately. This condition also allows students to explain mathematical ideas through writing and pictures.

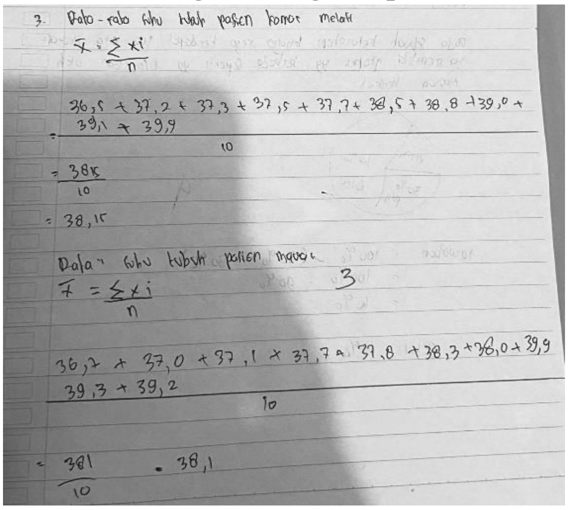

Figure 8 Indicators Declare Everyday Events

In answer number 3, students are able to solve this problem correctly by using the average formula. They can also reason questions using mathematical symbols. However, students did not state which room had a higher room temperature.

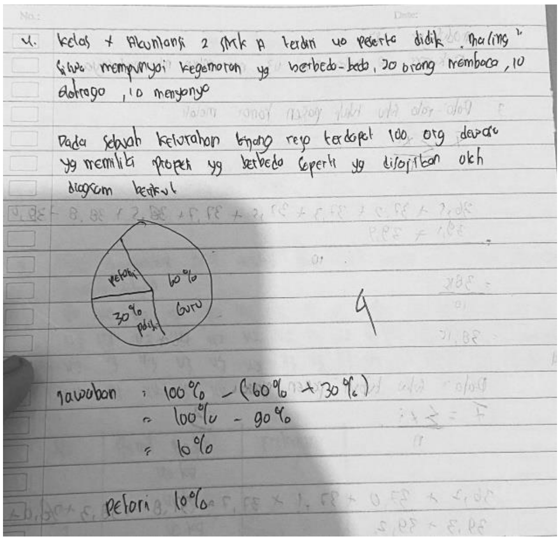

Figure 9 Indicators Explain and Create Questions

Students can answer the question correctly and correctly for the answer to question number 4. Able to formulate questions that are related to the material to be discussed in mathematics and explain common events appropriately using mathematical terminology or symbols. In addition, students can make diagrams based on questions they formulate themselves. Ask follow-up questions.

After being given the treatment, the results of the analysis of the prottest data were obtained and accepted in the end. It can be concluded that the influence of students' mathematical communication skills in the experimental class is treated with t_{hitung} 9,987 > t_{tabel} 1,66H_0 ditolakH_1 the Missouri Mathematics Project (MMP) learning model at State Vocation High School 4 Pekanbaru. The research hypothesis states that the Missouri

Mathematics Project (MMP) learning model significantly affects students' mathematical communication skills and can be accepted based on the results of data analysis.

4. Conclusions

Students' math communication can be positively influenced by using the *Missouri* Mathematics *Project* (MMP) learning paradigm through processes such as review, development, controlled exercises, seatwork, and homework. After the students completed the posttest, it was determined that the *posttest* score of the experimental class was 83.24 higher than the score of the control class. Based on the results of data analysis, it can be concluded that students' mathematical communication ability are significantly influenced by the *Missouri Mathematics Project* (MMP) learning model.

Conflict of Interest

The authors declare no conflicts of interest.

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