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Development of Mathematics e-Modules based on PjBL STEM on Materials Constructing Flat Side Spaces to Improve Mathematical Communication Ability of Junior High School Students

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ABSTRACT

Online learning, especially in mathematics, requires e-mathematical modules based on PjBL STEM on flat-sided geometry, to strengthen mathematical communication skills. The purpose of this study is to produce an appropriate PjBL STEM-based mathematics e-module to support online learning. Development research contains 4-D models, namely Define, Design, Develop, and Disseminate. The research was conducted at SMPN 2 Sawahan with two classes, namely VIII A (Control Class) and VIII B (Experimental Class). The results showed: 1) the PjBL STEM-Based Mathematics e-Module met the validity criteria, the average validation score was 94% in the "very valid" category, and the practicality criteria obtained from the student response questionnaire sheet achieved a score of 62% in field trials with the practical category, and the effectiveness criteria were tested using a t-test to meet the specified criteria, the post-test value of the experimental class was 4.75 greater than the control class and p-value = 0.015 <0.05, meaning that there was a significant difference in student learning outcomes. in the experimental class and the control class. 2) The improvement of students' mathematical communication skills can be seen after using the developed e-Module. This can be seen from the results of the normalized gain test with an average N-Gain score of 0.63 (medium level interpretation). Proving that the developed e-Module can improve students' communication skills. Based on the results of the study, it was concluded that the PjBL STEM-based Mathematics e-Module developed by researchers could improve students' mathematical communication skills and was suitable for use in learning.

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1. INTRODUCTION

Over the past two years, the whole world has been hit by an outbreak, namely the Covid-19 pandemic. (Saleh & Mujahiddin, 2020) This pandemic has an impact on various fields, including in the field of education, especially universities as the answer to the challenge. During the Covid-19 pandemic, learning is carried out online and offline. In the implementation of online and offline learning, schools use teaching materials in the form of printed modules. The use of the module was chosen during the implementation of online learning, because it met the criteria as a medium for independent teaching materials. Most of the modules used for learning are printed modules which tend to be informative, have simple pictures and contain practice questions. (Lestari, 2019) The module used has not been fully able to support students' understanding of the material being studied, because the presentation of the material in the module is too concise so as to allow underprivileged students to improve their mathematical communication skills. (Setyansah & Lusiana, 2020) The form of literacy and training using technology can be a solution to face the challenges of online learning during the Covid-19 pandemic .

Online learning requires the adjustment of teaching materials, including learning modules for students. Existing modules can be innovated in the content or presentation method. In accordance with the opinion (Puspitasari, 2019) hich states that the print module can be developed into an interactive computer-based module. So when entering this digital era, the learning process must also adapt to technological developments, namely by innovating from print modules to more practical electronic modules. It is intended that students can easily study the module independently. In addition, it is necessary to consider the interactivity element of the module, so that students can interact like face-to-face learning because in the implementation of online learning students cannot discuss with friends or teachers directly so that this can affect their mathematical communication skills. Though communication is the most important thing in the learning process, especially learning mathematics. Without communication, the mathematics learning process is difficult to develop. According to (Wahyudin, 2012) communication really supports students to understand new mathematical concepts.

Based on the results of observations at SMPN 2 Sawahan, it shows that the level of students' mathematical communication skills is still low. This is evidenced from the results of the pretest in the form of description questions to determine the mathematical communication skills of class VIII SMPN 2 Sawahan. The results of the pretest showed that the level of students' mathematical communication skills was still low. Students' low mathematical communication skills can be seen in students' answers when solving math problems. The results of observations on student answers indicate that students have not been able to write solutions using mathematical terms and notation appropriately, have not been able to present their opinions in a structured manner and students have not been able to interpret mathematical ideas in other forms, such as pictures or equations. Mathematical communication is needed by students to understand mathematical concepts in order to be able to use the correct mathematical language in expressing the ideas they have. The low mathematical communication ability of students causes students' mathematics learning outcomes to be low. The low mathematics learning outcomes of students can be seen from the average value of mathematics lessons in the even mid-semester assessment in 2021/2022 of 71.96 which has not met the Minimum Completeness Criteria (KKM) set for mathematics learning, which is 75. Therefore, Teachers must be able to carry out learning with an effective approach that can adapt to the conditions of the Covid-19 pandemic. The application of an effective approach can improve mathematical communication skills and student learning outcomes.

A learning process can run well depending on the learning approach taken. The approach that can improve students' mathematical communication skills is the STEM approach. STEM is an approach that connects four disciplines which include, science, technology, engineering and mathematics. In the learning process, the STEM approach is able to train students cognitively, skills, affectively, and is not only taught theory but also taught practice so that students can experience real learning in the learning process. The learning model used during STEM-based learning is STEM Project Based Learning (PjBL).

The Laboy-Rush PjBL model (Afriana et al., 2016) is a recommended model to be applied in the 2013 curriculum by emphasizing four STEM disciplines. The syntax of the PjBL STEM model that is applied during learning includes 5 stages, namely, Reflection, Research, Discovery, Application and Communication. The STEM approach in the field of science can be applied in the form of linking mathematical problems with students' daily lives. In the field of technology, you can use appropriate technology such as Geogebra to solve problems related to Constructing Flat Side Space. In the engineering field, it can be applied in finding solutions to solve the problem of Constructing Flat Side Space. And in the field of mathematics, skills are needed to analyze and interpret data calculations mathematically.

The STEM approach can be an innovative approach and can be used when learning mathematics because it is able to create problem-based learning in everyday life. As it is known that the STEM approach is currently playing an important role in the world of education in the digital era to remain able to keep up with competition in the global economy (Arnila et al., 2021). The results of the study (Sulistiyono et al., 2021) stated that STEM learning was more effective for improving student learning outcomes during the Covid-19 pandemic than learning that did not use the STEM approach. The results of the study (Herlina et al., 2021, Sukmagati, 2019) state that the use of STEM-based e-modules is proven to be effective in the learning process and can improve student learning outcomes. So, this is the background for researchers to develop a Mathematics e-Module based on PjBL STEM which will be applied to the material for Constructing Flat Sided Space. The material for Constructing Flat Sided Space was chosen because in this material students have not been able to master it well, this is evidenced by the students' daily test scores (UH) and the low pretest scores.

2. METHODS

The research conducted is a type of research and development (Research and Development). According to (Sugiyono, 2019) R&D is a research method used to produce certain products and test the effectiveness of these products. The suggested teaching material development model according to Thiagarajan in (Sugiyono, 2019) is the 4-D model. In this study using a 4-D model consisting of 4 stages, namely, define, design, development and dissemination. Activities at the define stage include front end analysis, concept analysis and analysis of learning objectives. Activities at the design stage include the preparation of instruments and the initial design of the PjBL STEM-Based Mathematics e-Module. The preparation of the instrument consists of an e-Module validation sheet, a validation sheet for learning outcomes test questions, student response questionnaire sheets and learning outcomes test questions. Activities at the development stage include expert validation, stage 1 revision, test instrument validation, small group trials, large group trials, data analysis of the practical results of e-modules, data analysis of the effectiveness of e-modules and analysis of the results of improving mathematical communication skills. And activities at the dissemination stage include the dissemination of teaching materials in the form of e-Modules based on PjBL STEM that have been developed. However, the distribution carried out was limited to the scope of the SMPN 2 Sawahan school environment because of limited time, costs and the implementation of the distribution of teaching materials was still at the pilot stage.

This research was conducted at SMPN 2 Sawahan. The research subjects taken were class VIII students of SMPN 2 Sawahan, Madiun Regency for the Academic Year 2021/2022 which consisted of 2 classes, namely class VIII A and class VIII B by setting class VIII A as the control class and class VIII B as the experimental class.

Determination of the sample in this study using simple random sampling technique. Simple random sampling is a sampling technique that is carried out randomly without regard to the strata that exist in the population (Sugiyono, 2019). The researcher used a simple random sampling technique because the members of the population were considered homogeneous. Therefore, the trial design of this study used a true experimental design method of Pretest-Posttest Control Group Design. In this design, there were two groups, the first group (experimental) was given treatment (X) and the second group (control) was not treated (X). However, both the experimental and control groups were given a pretest first to find out whether there was a difference between the experimental group and the control group in the initial state. Furthermore, the experimental group was given treatment (X) using teaching materials in the form of e-Mathematics Module based on PjBL STEM while the control group was not given treatment using teaching materials in the form of e-Module Mathematics based on PjBL STEM. Then, after the experimental group was given treatment, both the experimental group and the control group were given a posttest and then the results were observed to see a comparison between the experimental class and the control class.

The instruments used in this study were the e-Module Mathematics instrument validation sheet based on PjBL STEM to measure the level of validity of the developed teaching materials, student response questionnaire sheets to measure the practicality of the developed teaching materials and learning outcomes test questions to measure the effectiveness of the developed teaching materials. developed teaching materials. As for the data collection techniques using observation techniques, questionnaires / questionnaires and student learning outcomes tests.

To test the suitability of teaching materials using the Mathematics e-Module based on PjBL STEM, it is necessary to analyze the data after conducting limited trials and field trials which include:

1. Analysis of the Validity of Teaching Materials

To determine the validity of teaching materials, the following criteria can be used (Akbar, 2013).

Table 1. Validity Criteria

No.	Validity Criteria	Validity Level
1	85,01%-100,00%	Very valid, or can be used without revision
2	70,01%-85,00%	Fairly valid, or usable but need minor revision
3	50,01%-70,00%	Less valid, suggestions are not used because they need major revisions
4	01,00%-50,00%	Invalid, or should not be used

Teaching materials using PjBL STEM-based Mathematics e-Modules are declared valid if the combined validity results show results more than 70% (Akbar, 2013).

2. Practical Analysis of Teaching Materials

he data analyzed to determine the practicality of teaching materials using the Mathematics e-Module based on PjBL STEM were obtained from student response questionnaires. Student response questionnaire using the Guttman scale with the checklist method. The Guttman scale is used to measure the attitudes, opinions and perceptions of a person or group of people about social phenomena (Sugiyono, 2019). The instrument in the questionnaire is a statement, the answers to each item use the Yes-No answer category. To determine the practicality of teaching materials, the following criteria can be used (Akbar, 2013).

Table 2. Practical Criteria

No.	Practical Criteria	Practical Level
1.	81,00 % - 100,00%	Very practical
2.	61,00 % - 80,00 %	Practical
3.	41,00 % - 60,00 %	Less Practical
4.	21,00 % - 40,00%	Not Practical
5.	00,00 % - 20,00 %	Very Impractical

3. Analysis of the Effectiveness of Teaching Materials

To determine the effectiveness of teaching materials using the e-Module Mathematics based on PjBL STEM, it can be determined from the difference in the average posttest scores in the experimental class and the control class using the t-test. Before carrying out the t-test, there are prerequisites that must be carried out, namely conducting a normality test and a homogeneity test. For normality test, a data is said to be normal if the significance level is > 0.05 while if the significance level is < 0.05 then the distribution is not normal. For the homogeneity test, a data is said to be homogeneous if the significance level is > 0.05 while if the significance level is < 0.05 then the data is not homogeneous. After knowing that the data is normally distributed and homogeneous, then a hypothesis test is carried out. Hypothesis testing was carried out by testing the independent sample test on the posttest value of the experimental class and the control class. For hypothesis testing, if the significance value is less than 0.05 ($p < 0.05$), then there is a significant difference in the posttest score in the experimental class and the control class.

4. Analysis of Mathematical Communication Ability

To determine the increase in students' mathematical communication skills, the normalized gain test (g) was used which was developed by Hake. In addition to using the normalized gain test, the increase in students' mathematical communication skills was obtained from the analysis of the results of working on student learning outcomes test questions which contained three indicators of mathematical communication skills, namely stating the situation into a mathematical model (pictures, tables, diagrams, mathematical relations/expressions) and solving them, complete a mathematical model according to the form of the image given, compose questions from the image given and answer them. Sundayana in (Sugiyono & Widjanarko, 2017) formulates and categorizes the normalized gain test developed by Hake as follows:

$$\text{Normalized Gain (N-Gain) }/(g) = \frac{(Post-test\ Score)-(Pre-test\ Score)}{(Ideal\ Score)-(Pre-test\ Score)}$$

The following is the normalized gain category (g) modified by Sundayana in (Sugiyono & Widjanarko, 2017).

Table 3. Criteria for Increasing Mathematical Communication Ability

No.	Normalized Gain (N-Gain)	Interpretation
1.	-1,00 ≤ g ≤ 0,00	There is a decrease
2.	g = 0,00	Permanent
3.	0,00 < g < 0,30	Low
4.	0,30 ≤ g < 0,70	Currently
5.	0,70 ≤ g ≤ 1,00	High

3. FINDINGS AND DISCUSSION

The product developed in this research is the PjBL STEM-based Mathematics e-Module. The results of the research that has been carried out are described as follows.

1. *Define*

Based on the results of observations, the following data were obtained. a) Mathematics teaching materials used by teachers and students during online and offline learning are still conventional, namely using print modules. b) The average PTS score obtained does not meet the KKM set for mathematics learning, which is 75. c) The students' mathematical communication ability is still low, this is evidenced by the pretest score in the form of description questions on the Flat Sided Space Building material. From the problems that have been described, it can be used as a reference in the preparation of the developed e-Module.

2. *Design*

PjBL STEM-based Mathematics Module. The PjBL STEM-based math e-module contains elements of text, videos, images that can attract students' attention so that students can be active in learning and the e-Module is equipped with the Geogebra application which aims to make students more technologically literate so they can keep up with the times.

Figure 1.

(a) (b) (c)

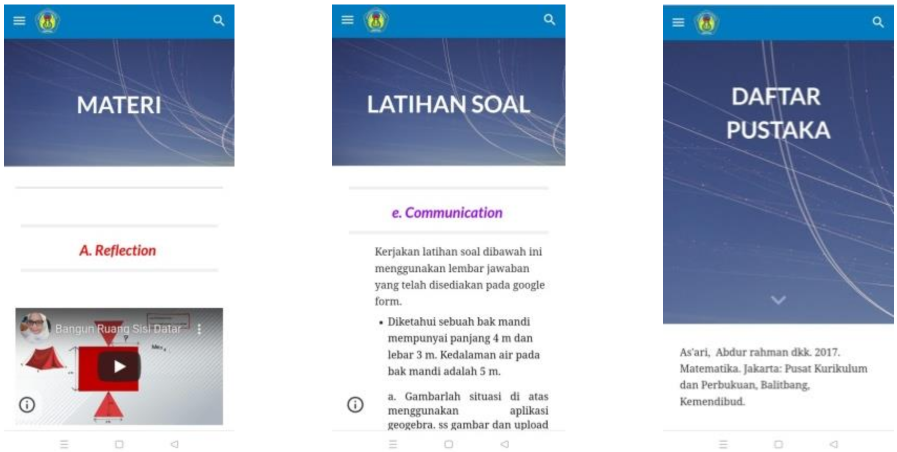
Figure 1. are (a) the cover design of the PjBL STEM-based Mathematics e-Module designed by the researcher according to the material and level that will be used for research; (b) STEM simulation which aims to make students know the explanation of each stage of PjBL STEM used in the e-Module. PjBL STEM stages consist of Reflection, Research, Discovery, Application, Communication; (c) Instructions for e-modules aim to make students know the steps that must be taken in using e-modules.

Figure 2.

(d) (e) (f)

Figure 2. are (d) the table of contents aims to make it easier for students to know the content contained in the Mathematics e-Module based on PjBL STEM; (e) The basic competence aims to make students know the basic competencies that must be achieved in the material for Constructing Flat Sided Space, while the competency achievement indicators aim as a guide for teachers to develop materials, design learning activities and as a guide in designing and evaluating learning outcomes; (f) The concept map aims to make students know the relationship between each material that is summarized.

Figure 3.



(g) (h) (i)

Figure 3. are (g) Materials containing the syntax of the PjBL STEM model on the Flat Side Space Building material, which consists of Reflection, Research, Discovery, Application, Communication; (h) The practice questions contain questions that students must do using google form, then after doing the work students can immediately check the results of their work; (i) The bibliography contains reference sources for the preparation of the developed e-Module.

3. *Development*

After the design stage, the next stage is the development stage. The results obtained at the development stage are described as follows.

(1) Analysis of the Validity of the Mathematics e-Module based on PjBL STEM

The instrument validity test in this study involved 3 validators to validate the PjBL STEM-based Mathematics e-Module and 2 validators to validate learning outcomes test questions. Validation of STEM-based e-Modules on the material of Constructing Flat Sided Space for class VIII SMPN 2 Sawahan was carried out by learning strategists, design experts and content experts. Mathematics based on PjBL STEM on flat-sided geometry to improve the mathematical communication skills of junior high school students. The results of the analysis of the validation of the Mathematics e-Module instrument based on PjBL STEM and the validation of learning outcomes test questions are described as follows:

Table 4. Results of the Analysis of Mathematics e-Modules based on PjBL STEM

No.	Assessment Component	Validator			Average Percentage of Components
		1	2	3	
1.	Content Eligibility	100%	100%	100%	100%
2.	Language	100%	100%	100%	100%
3.	Presentation	100%	100%	100%	100%
4.	Grapichs	100%	50%	75%	75%
5.	Characteristics of e-Modules	100%	83%	100%	94%
Total Empirical Score (Tse)		23	20	22	
Total Expected Score (TSh)		23	23	23	
Validity Percentage (V)		100%	87%	96%	
Combined Presentation			**94%**		

Based on the research conducted, it can be seen that for the results of the final analysis of the validation of the Mathematics e-Module based on PjBL STEM, the average percentage of combined validation results is 94%. This shows that the results of the final analysis of the PjBL STEM-based Mathematics e-Module are included in the very valid criteria and there is no need for revision as shown from the combined percentage which is in the interval of 85.01%-100%.

Table 5. Result of Pretest Question Validation Analysis

No.	Research Field	Validator 1	Validator 2	Average Percentage of Realms
1.	Substance	100%	100%	100%
2.	Contruction	80%	80%	80%
3.	Language	100%	100%	100%
Total Empirical Score (Tse)		26	26	
Total Expected Score (TSh)		28	28	
Validity Percentage (V)		93%	93%	
Combined Presentation		93%		

Based on Table 5, it can be concluded that the pretest learning outcomes test questions developed by the researchers met the very valid criteria which were in the interval 85.01%-100.00% and were worthy of being tested on students.

Table 6. Results of the Analysis of Posttest Question Validation

No.	Research Field	Validator 1	Validator 2	Average Percentage of Realms
1.	Substance	100%	100%	100%
2.	Contruction	100%	100%	100%
3.	Language	95%	95%	95%
Total Empirical Score (Tse)		55	55	
Total Expected Score (TSh)		56	56	
Validity Percentage (V)		98%	98%	
Combined Presentation		98%		

Based on Table.6, it can be concluded that the posttest learning outcomes test questions developed by the researchers met the very valid criteria which were in the interval of 85.01%-100.00% and were feasible to be tested on students.

Based on this explanation, it shows that the validity of the STEM-Based e-Module on the Material of Constructing Flat Side Space for Class VIII Students of SMPN 2 Sawahan is included in the valid category. Where this research is strengthened by the results of research (Asikin et al., 2021) which explains that the results of the validity test of STEM-based teaching materials are 88.54%. The result of the readability test of STEM-based teaching materials is 63.65%. The pretest posttest analysis shows that teaching materials can improve mathematical communication skills with an n-gain score of 0.44 which is in the medium category. STEM-based teaching materials are valid, easy to understand and effective in improving mathematical communication skills.

(2) Practical Analysis of PjBL STEM-based Mathematics e-Modules

The data analyzed to determine the practicality of the PjBL STEM-based mathematics e-Module was obtained from student response questionnaires. For the practical results of the development of Mathematics e-Module based on PjBL STEM on flat-sided geometry, it was carried out in small (limited) group trials and large group trials (field).

a. Limited Trial

The limited trial involved 6 students from class VIII B who were selected based on different cognitive abilities consisting of 2 students with high cognitive abilities, 2 students with moderate cognitive abilities and 2 students with low cognitive abilities. The following are the results of the questionnaire responses of class VIII B students in a limited trial.

Table 7. Results of the Limited Trial Student Response Questionnaire Analysis

No.	Aspect Rating Average	Aspect Percentage
1.	Appearance	57%
2.	Theory	90%
3.	Language	47%
Total Score Total per-individual		58
Total Criteria Score		90
Practicality (P)		**64%**

Based on Table.7, it can be seen that for the practical value of developing mathematical e-modules based on PjBL STEM on flat-sided geometry in small groups, 64% are included in the practical category which is in the range of 61.00% - 80.00%.

b. Field Trial

The results of the analysis of the practicality of developing Mathematics e-Modules based on PjBL STEM on flat-sided geometry in large groups (fields) can be seen in the Table. 8 following.

Table. 8 Results of Student Response Questionnaire Field Trials

No.	Aspect Rating Average	Aspect Percentage
1.	Appearance	52%
2.	Theory	83%
3.	Language	50%
Total Score Total per-individual		213
Total Criteria Score		345
Practicality (P)		**62%**

Based on Table.8, it can be seen that for the practical value of developing mathematical e-modules based on PjBL STEM on flat-sided geometry materials in the large group (field) of 62% which is included in the practical category which is in the range of 61.00% - 80.00 %.

This research is strengthened by the results of research (Febriyanti, 2018) which explains that the practical STEM-based module, based on the results of the gap test, shows the average score of 9 students is 86% in the easy-to-understand category. Based on the results of the analysis of the implementation of learning at SMK PGRI 1 Banyuwangi, it showed a score of 80 in the practical category, while learning at SMKN 1 Glagah Banyuwangi showed a score of 82 in the practical category. Furthermore, based on the results of the questionnaire analysis of student responses in the large-scale limited group test at SMK PGRI 1 and SMKN 1 Glagah Banyuwangi, it showed that the average response was 89% and 93%, respectively, with the criteria of being very interested in learning using STEM-based modules.

(3) Analysis of the Effectiveness of STEM-based PjBL Mathematics e-Modules

e-Module can be said to be effective determined from the difference in the average posttest scores in the experimental class and the control class. To analyze the data obtained from the posttest results, a statistical test is needed. The statistical test that the researcher uses is the t-test. Before carrying out the t-test, there are prerequisites that must be carried out, namely conducting a normality test and a homogeneity test.

a. Normality Test

The results of the analysis of the normality test are presented in the table. 9 following.

Table 9. Normality Test Results Posttest Values for Experimental and Control Classes

Tests of Normality

	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Post-test Results	Control Class	,096	32	,200*	,959	32	,251
	Experiment Class	,104	29	,200*	,949	29	,174

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

a. Lilliefors Significance Correction

Based on Table 9, it can be seen that the posttest data for the experimental and control classes have a sig value > 0.05, so it can be concluded that the data is normally distributed.

b. Homogenity Test

The results of the homogeneity test analysis are presented in the table. the following 10.

Table 10. Result of Homogeneity Test of Posttest Values for Experiment and Control Class

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Post-test Results	Based on Mean	,313	1	59	,578
	Based on Median	,258	1	59	,614
	Based on Median and with adjusted df	,258	1	58,367	,614
	Based on trimmed mean	,291	1	59	,592

Based on Table 10, it can be seen that the posttest data for the experimental and control classes have a sig value > 0.05, so it can be concluded that the data has a homogeneous variance.

c. Hypothesis testing

After knowing that the data is normally distributed and homogeneous, a hypothesis test is carried out. Hypothesis testing was carried out with the Independent Samples Test to see the difference in the posttest scores of the experimental class using the PjBL STEM-based mathematics e-Module and the control class that did not use the PjBL STEM-based Mathematics e-Module. The results of the Independent Samples Test analysis are presented in the table. 11 and 12 below.

Table 11. Experimental and Control Class Average

Group Statistics

	Class	N	Mean	Std. Deviation	Std. Error Mean
Post-test	Control Class	32	79,94	7,392	1,307
Results	Experiment Class	29	84,69	7,479	1,389

Table 12. *Independent Samples Test Results*

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Hasil Posttest	Equal variances assumed	,313	,578	-2,494	59	,015	-4,752	1,906	-8,566	-,939
	Equal variances not assumed			-2,492	58,271	,016	-4,752	1,907	-8,569	-,935

After knowing that the data is normally distributed and homogeneous, a hypothesis test is carried out. Hypothesis testing was carried out with the Independent Samples Test to see the difference in the posttest scores of the experimental class using the PjBL STEM-based mathematics e-Module and the control class that did not use the PjBL STEM-based Mathematics e-Module. The results of the Independent Samples Test analysis are presented in the table. 11 and 12 below.

Based on Table 11, it is known that the mean value of the control class is 79.94 and the experimental class is 84.69 and in Table 12 the mean value is -4.752 (negative value), meaning that there is a tendency to increase learning outcomes, so it can be concluded that the mean posttest value of the experimental class is 4 ,75 greater than the control class and also obtained p value = 0,015 <0.05, which means that there is a significant difference in student learning outcomes in the experimental class and the control class. Therefore, it can be concluded that there is a difference in the posttest scores of the experimental class that uses the PjBL STEM-based Mathematics e-Module with the control class that does not use the STEM-based PjBL Mathematics e-Module.

From this explanation, it shows that the development of Mathematics e-Module based on PjBL STEM on flat-sided geometry is in the effective category. This research is reinforced by the results of research (Febriyanti, 2018) that the STEM-based module is considered effective based on the average N-gain score at SMK PGRI 1 Banyuwangi, which is 0.65 in the medium category. Meanwhile, the average N-gain score at SMKN 1 Glagah Banyuwangi is 0.63 in the medium category. The conclusion of this study is that STEM-based modules can be said to be valid, practical and effective, and are suitable for use in learning.

(4) Analysis of Mathematical Communication Ability

To determine the increase in mathematical communication skills of experimental class students, the normalized gain test (g) developed by Hake was used. Based on the results of the N-Gain analysis, students in small and large group trials in class VIII B experienced an increase in mathematical communication skills from the results of the pretest and posttest. The existence of an N-Gain score of 0.63 in the small group and 0.65 in the large group with a moderate level of interpretation proves that the PjBL STEM-based Mathematics e-Module can improve mathematical communication skills.

In addition to using the normalized gain test, the increase in students' mathematical communication skills was obtained from the analysis of the results of working on student learning outcomes test questions which contained three indicators of mathematical communication skills, namely stating the situation into a mathematical model (pictures, tables, diagrams, mathematical relations/expressions) and solving them, complete a mathematical model according to the form of the image given, compose questions from the image given and answer them. The following is an example of an analysis of student answers on each question in accordance with the indicators of mathematical communication skills used by researchers when correcting student answers.

The first indicator, states the situation into a mathematical model (pictures, tables, diagrams, mathematical relations/expressions) and solves them. In this indicator, students are required to write down and mention what is known and asked in the question. At the same time, students are required to use (pictures, tables, diagrams, mathematical relations/expressions) in writing down ideas when solving the problem. The analysis of the results of the first and second answers on the first indicator is as follows:

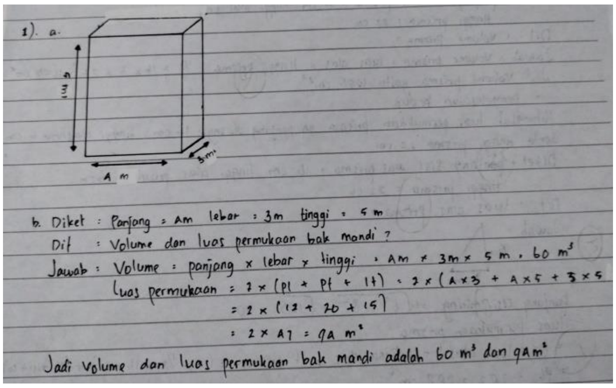


Figure 10. First Number Answer Results

Based on the results of students' answers to the first number, it was found that students could write down what they knew and were asked in a coherent manner and students described and wrote mathematical models according to the situation in question in the problem to be solved, so it was concluded that students could fulfill the first indicators of mathematical communication skills.

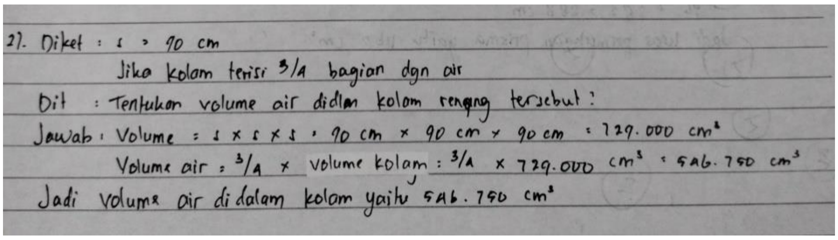


Figure 11. Number Two Answer Results

Based on the results of student answers in the second number, it was obtained that students could write down what they knew and were asked about and students wrote mathematical models according to the situation in question in a coherent way by looking for the volume of the pool first and then finding the volume if the pool was only filled with 3/4 of water, so it is concluded that students can meet the first indicator of mathematical communication skills.

The second indicator is to complete the mathematical model according to the form of the image given. In this indicator students are required to write down what ideas are used and how to solve the problem in a coherent manner according to the form of the image given in the problem. The analysis of the results of the third answer on the second indicator is as follows.

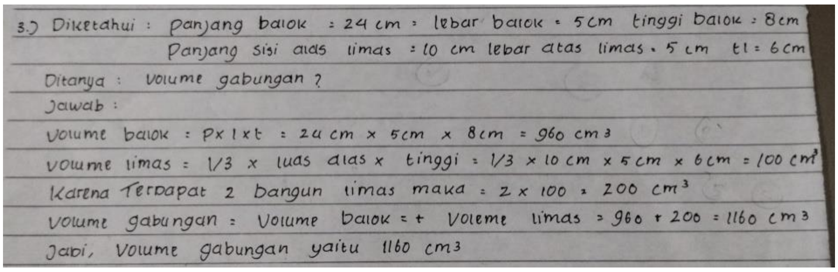

3.) Diketahui : panjang balok : 24 cm : lebar balok = 5 cm tinggi balok : 8 cm
panjang sisi alas limas : 10 cm lebar atas limas = 5 cm tl = 6 cm
Ditanya : volume gabungan ?
Jawab :
volume balok : p x l x t : 24 cm x 5 cm x 8 cm = 960 cm3
volume limas = 1/3 x luas alas x tinggi = 1/3 x 10 cm x 5 cm x 6 cm = 100 cm³
Karena Terdapat 2 bangun limas maka = 2 x 100 = 200 cm³
volume gabungan : volume balok = + voleme limas = 960 + 200 = 1160 cm3
Jadi, volume gabungan yaitu 1160 cm3

Figure 12. Number Three Answer Results

Based on the results of student answers in the third number, it was obtained that students could write down the answer ideas in a coherent manner according to the form of the image given in the problem by looking for the volume of the block, the volume of two pyramids and then looking for the combined volume. From the results of these answers, students also wrote down what was known and asked in a coherent manner so that it was concluded that students could fulfill the first and second indicators of mathematical communication skills.

The third indicator, composes questions from the pictures given and answers them. In this indicator, students are required to solve problems by compiling questions from the images presented in the questions and answering them. The analysis of the results of student answers on the third indicator is as follows.

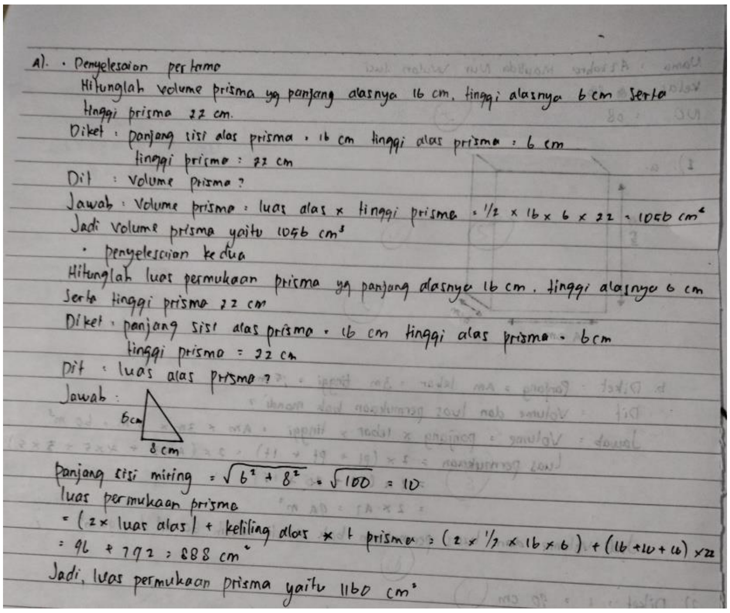

4). • Penyelesaian pertama
Hitunglah volume prisma yg panjang alasnya 16 cm, tinggi alasnya 6 cm serta tinggi prisma 22 cm.
Diket : panjang sisi alas prisma = 16 cm tinggi alas prisma = 6 cm
tinggi prisma = 22 cm
Dit : volume prisma ?
Jawab : volume prisma = luas alas x tinggi prisma = 1/2 x 16 x 6 x 22 = 1056 cm³
Jadi volume prisma yaitu 1056 cm³
• penyelesaian kedua
Hitunglah luas permukaan prisma yg panjang alasnya 16 cm, tinggi alasnya 6 cm serta tinggi prisma 22 cm
Diket : panjang sisi alas prisma = 16 cm tinggi alas prisma = 6 cm
tinggi prisma = 22 cm
Dit : luas alas prisma ?
Jawab :
6 cm
8 cm
panjang sisi miring = √6² + 8² = √100 = 10
luas permukaan prisma
= (2 x luas alas) + keliling alas x t prisma = (2 x 1/2 x 16 x 6) + (16 + 10 + 10) x 22
= 96 + 792 = 888 cm²
Jadi, luas permukaan prisma yaitu 1160 cm²

Figure 13. Number Four Answer Results

Based on the results of students' answers to the fourth number, it was found that students could arrange two questions from the pictures given in the problem at the same time students could solve them coherently. From the results of these answers, students also wrote down what they knew and asked from the questions they compiled so that it was concluded that students could fulfill the first and third indicators of mathematical communication skills.

From the explanation of the results of the analysis of students' answers to each question, it was concluded that students' mathematical communication skills could increase after using the PjBL STEM-based Mathematics e-Module because the students' answers had met the indicators of mathematical communication skills.

This research is reinforced by the results of research (Asikin et al., 2021) in their research entitled Development of STEM-nuanced textbooks to improve students' mathematical communication skills. In the study, the results of the validity test of STEM-based teaching materials were 88.54%. The result of the readability test of STEM-based teaching materials is 63.65%. The pretest posttest analysis shows that teaching materials can improve mathematical communication skills with an n-gain score of 0.44 which is in the medium category. STEM-based teaching materials are valid, easy to understand and effective in improving mathematical communication skills. The results of the study (Chalim, 2018) also showed that the mathematical communication skills of students who received PjBL STEM-based learning could achieve classical mastery and the average mathematical communication skills of students who received PjBL STEM-based learning were higher than the mathematical communication skills of students who received discovery-based learning. learning.

4. CONCLUSION

Based on the results of research, development, and research discussions regarding the development of PjBL STEM-based mathematics e-modules on flat-sided geometrical materials to improve the mathematical communication skills of junior high school students that have been implemented, the results show that STEM PjBL-based mathematics e-modules are suitable for use by teachers and students. to help the process of learning mathematics. By fulfilling the three development criteria referring to the following stages.

1. Mathematical e-Module based on PjBL STEM on the flat-sided geometry material meets the validity criteria with the average results obtained from the validation sheet reaching a value of 94% in the "very valid" category.
2. The PjBL STEM-based Mathematics e-Module on the flat-sided geometric material meets the practicality criteria obtained from the student response questionnaire sheet to the STEM PjBL-based mathematics e-module on the flat-sided geometrical material which achieved a score of 62% in field trials with categories practical.
3. Mathematical e-Module based on PjBL STEM on the flat-sided building material meets the effectiveness criteria by obtaining the posttest value of the experimental class 4.75 which is greater than the control class and also the p value = 0.015 < 0.05, which means there is a difference in learning outcomes scores students significantly in the experimental class and control class.
4. There is an increase in the mathematical communication ability of class VIII SMPN 2 Sawahan after using the STEM-based e-Module by using the normalized gain test to get an average N-Gain score of 0.63 with an average level of interpretation proving that the development of PjBL-based mathematics e-modules STEM on the material of flat side space can improve students' communication skills.

The PjBL STEM-based Mathematics e-Module on flat-sided geometry has several limitations with the following details:

1. The material in the mathematics e-Module based on PjBL STEM is limited, it only discusses the material for building flat side spaces.
2. 2. The PjBL STEM-based Mathematics e-Module cannot be printed yet.

As for suggestions for other researchers to develop similar STEM-based PjBL Mathematics e-Modules in different subjects

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