

DEVELOPMENT OF PROBLEM-BASED LEARNING MODEL LEARNING MODULE TO IMPROVE MATHEMATICAL COMMUNICATION AND CURIOSITY OF GRADE 5 STUDENTS

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Abstract

This study aimed to examine the development process, outcomes, and impact of Problem-Based Learning (PBL) modules designed to enhance fifth-grade elementary students' mathematical communication skills and curiosity in arithmetic. The research was conducted at SDN 2 Cepiring and SDN 5 Cepiring, located in Cepiring District, Kendal Regency, with fifth-grade students as the sample. A development research design was employed, incorporating both qualitative and quantitative analyses. Qualitative data were analyzed through validation assessments of the module, syllabus, and lesson plans, while quantitative data were analyzed using t-tests and simple linear regression. The validation results from expert reviewers indicated that the module, syllabus, and lesson plans each received an average score of 3.812, equivalent to 95.3%, which falls under the "Very Good" or "Very Feasible" category. The module's effectiveness was further supported by post-test results, where the control group achieved an average score of 66.11, while the experimental group attained a higher average of 79.85. The t-test analysis yielded a t-value of 5.501 with a significance level of 0.000, indicating a statistically significant difference ($p < 0.05$) and confirming the module's effectiveness in improving students' mathematical communication and curiosity. Additionally, the N-Gain analysis revealed a modest improvement of 17.83% in the control group (from a pre-test average of 59.07 to a post-test average of 66.37), compared to a substantial gain of 60.40% in the experimental group (from 58.23 to 75.23). These findings affirm that the developed PBL module is effective in enhancing students' learning outcomes in mathematics.

Keywords: *Module; Problem-based learning model; mathematical communication and curiosity*

Abstrak

Tujuan penelitian ini untuk mengetahui proses, hasil dan pengaruh pengembangan modul pembelajaran *Problem based learning* (PBL) untuk meningkatkan kemampuan komunikasi matematika dan *curiosity* siswa materi berhitung pada siswa kelas V SD. Penelitian ini dilakukan di SDN 2 Cepiring dan SDN 5 Cepiring Kecamatan Cepiring Kabupaten Kendal. Sampel yang digunakan adalah siswa kelas 5. Penelitian ini menggunakan metode pengembangan. Analisis data dilakukan dengan menggunakan analisis kevalidan modul, silabus dan RPP, sedangkan analisis kuantitatif dengan uji t dan regresi linier sederhana. Hasil validasi modul dari validator diperoleh rata-rata 3.812ig 95.3% yang berada pada kategori sangat baik atau Very Worth. Hasil validasi silabus dari validator diperoleh rata-rata 3.812 atau sama dengan 95.3% yang berada pada kategori sangat baik

atau Very Worth. Hasil validasi RPP vdari validator diperoleh rata-rata 3.812 atau sama dengan 95.3% yang berada pada kategori sangat baik atau Very Worth. Keefektifan modul mendapatkan rata-rata data hasil belajar (pos test) kelas kontrol sebesar 66.11 sedangkan rata-rata hasil belajar (post test) kelas eksperimen sebesar 79.85. Dan dari hasil perhitungan dengan uji t diperoleh $t_{hitung} = 5.501$ dengan signifikan 0.000, karena tingkat sig $0.00 < 0,05$ maka kesimpulan penggunaan modul efektif untuk meningkatkan komunikasi matematika dan coriusity siswa. rata-rata data hasil pre test kelas kontrol sebesar 59.07 dan rata-rata hasil post test kelas control sebesar 66.37 dengan N-Gain peningkatan 17.83%. Sedangkan kelas eksperimen dengan rata-rata pre test 58.23 dan rata-rata hasil post test 75.23 sehingga terjadi peningkatan (N-Gain) 60.40%. Jadi dapat disimpulkan bahwa modul efektif untuk meningkatkan hasil belajar siswa.

Kata kunci: Modul; Model pembelajaran problem-based learning; komunikasi matematika dan *curiosity*

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Introduction

Enhancing the quality of Indonesia's human resources is an essential and continuous endeavor, with education playing a central role in this process. Improving educational quality requires sustained and multifaceted efforts, such as updating the curriculum, enhancing teacher competencies through professional development programs, providing adequate infrastructure and learning facilities, supplying necessary equipment and learning tools, and incorporating effective instructional aids. Among the various subjects taught in schools, mathematics has consistently been perceived as one of the most challenging for students, from elementary levels through to higher education. This persistent difficulty is largely due to the cumulative nature of mathematics; conceptual understanding at early stages significantly affects comprehension at more advanced levels. Mathematics is inherently hierarchical and systematically structured, involving logical reasoning, symbolic representations, and abstract thinking, all of which contribute to its complexity for many learners.

In mathematics learning, a student who already has a mathematical understanding is also required to communicate it, so that his understanding can be understood by others, namely by communicating ideas, strategies, and mathematical solutions both in writing and orally. The ability to communicate is also one of the process standards listed in the principles of mathematics learning stated by the National Council of Teachers of Mathematics (NCTM) (2000). Based on the results of preliminary observations in class, it is known that in mathematics lessons, students' ability to solve mathematical communication problems is still low. This is indicated by students not being able to provide correct and clear arguments about the questions they answer in story-based questions. Students' courage in conveying their ideas and opinions is still lacking. To reduce the occurrence of things like this, students need to be accustomed to communicating their ideas to others orally and in writing according to

their interpretation. Written communication ability indicators are arranged based on three abilities, including: writing (written text), which is explaining ideas or solutions to a problem or picture using one's language; drawing (drawing), which is explaining ideas or solutions to mathematical problems in the form of pictures; and mathematical expression (mathematical expression), which is stating problems or everyday events in the language of mathematical models. In other words, mathematical communication skills are needed to convey mathematical ideas correctly.

In addition to the use of the Problem-Based Learning Model, the use of innovative teaching materials is very necessary, because existing teaching materials (books, literature) are still monotonous and less interesting to students. Learning modules must attract students to study them. According to Indriyanti (2010), a module is a strategy for organizing learning materials containing sequencing, which refers to the creation of a sequence of presentation of learning materials, and synthesizing, which refers to efforts to show learners the relationship between facts, concepts, procedures, and principles contained in the learning materials.

According to Belawati (2003), modules serve important functions in the learning process. They act as foundational sources of information by presenting core content that can be further developed. Modules also function as student guides, supplementary teaching materials enriched with communicative illustrations and photographs, instructional tools for teachers, and sources of student practice activities. The implementation of a problem-based learning (PBL) model using expert-validated modules can help address communication challenges and stimulate curiosity in mathematics among fifth-grade elementary school students. This module-based PBL approach begins with the presentation of real-world problems that must be solved, leading students to discover new concepts and connect them with prior knowledge. The learning process is monitored through feedback provided in the module, which encourages students to engage in self-assessment. This problem-solving emphasis is intended to enhance students' cognitive abilities, particularly in communication and curiosity. Additionally, experimental activities included in the module are designed to cultivate students' observational skills, their ability to prepare materials, analyze results, draw conclusions, and present findings, thus fostering their communication competencies. Such activities are also expected to nurture scientific attitudes and deepen students' curiosity toward arithmetic concepts.

This study aims to achieve three primary objectives. First, it seeks to explore the development process of a Problem-Based Learning (PBL) module aimed at enhancing fifth-grade elementary students' mathematical communication skills and curiosity toward arithmetic content, while ensuring the module fulfills the criteria of validity, practicality, and effectiveness. Second, the study intends to evaluate the outcomes of the developed PBL module in terms of its validity, practicality, and effectiveness in improving students' abilities to communicate mathematical ideas and foster curiosity in learning arithmetic. Third, the research aims to investigate the influence of the PBL module on students' mathematical communication skills and their level of curiosity regarding arithmetic topics, thereby

providing evidence of the module's pedagogical impact within the elementary school context.

Research Methods

The development of module-based learning media to improve mathematical communication and curiosity in this study is included in product-oriented development in the form of learning modules. This study uses a research and development approach method (Research and Development), namely the process of developing and validating this learning module product. Based on the opinion above, it can be concluded that research and development in education and learning is a research model that aims to develop and validate products in the form of interesting and innovative learning modules to improve and develop the quality of education and learning effectively and efficiently. In this study, not all stages were carried out considering the time and costs available. The stages in the research include: 1) Research and information collection, 2) Planning, 3) Product design development, 4) Product validation, 5) Operationalizing revised products, 6) Distribution and implementation). In this study, the population was grade V students of SD Negeri 2 Cepiring, Cepiring District, Kendal Regency. A sample is a portion of an object taken from the entire object being studied and is considered to represent the entire population (Notoatmojo, 2003). In this study, the research sample was all members of the population as samples.

This instrument is a mathematical communication ability test. This test is given individually and aims to measure mathematical communication ability. The assessment of test results is carried out by the guidelines used in scoring mathematical communication ability. This non-test instrument consists of several forms that are adjusted to the steps in the development research. There are two types of non-test instruments used, namely interviews and questionnaires. Interviews are used during the preliminary study by interviewing mathematics teachers and several fifth-grade students regarding the initial conditions of students and the use of textbooks during learning. The second instrument, namely the questionnaire, is used at several stages of the research. This questionnaire uses a Likert scale with four answer choices that are adjusted to the research stage and the purpose of the questionnaire.

Data collection techniques are a strategic step in research, namely, to obtain data. The data collection techniques used in this study are observation and interviews. The instrument used to obtain data in this study is a questionnaire. This data is used to determine the feasibility of the product being developed. The questionnaire in this study will be given to 2 validators, namely media experts, material experts, and questionnaires for students.

Data were analyzed using a descriptive percentage test using the following formula (1)

$$P = \frac{S}{N} \times 100\% \quad (1)$$

P = component presentation

S = total score of research result components

N = maximum score

The percentage data results will be converted based on the following criteria:

Table 1 Expert Validation Assessment Criteria

Persentase	Kriteria
81%-100%	Very Worth
61%-80%	Worth
41%-60%	Quite Decent
21%-40%	Less Worthy
0%-20%	Not Feasible

Data Analysis

This t-test analysis is to determine the level of effectiveness of the Problem Based Learning (PBL) learning model based on independent learning with the arithmetic operation material module. To compare learning outcomes before (pre-test) and after learning (post-test) between the experimental class with the PBL learning model based on the module with lecture learning, it can be tested using a one-sided test (Sugiyono, 2015:315) (2).

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}} \quad (2)$$

with $dk = n_1 + n_2 - 1$

$\bar{X}_1$ = sample mean 1

$\bar{X}_2$ = sample mean 2

s_1 = sample standard deviation 1

s_2 = sample standard deviation 2

s_1^2 = sample variance 1

s_2^2 = sample variance 1

n = number of samples

t count > t table, H_a accepted

t count < t table, H_o accepted

Testing is also done with the help of SPSS Statistics with an independent sample test analysis. The decision-making criteria are based on the comparison of Significance values (Sig.), namely, if Sig. > 0.05, then H_0 is accepted; otherwise, if Sig. < 0.05, then H_0 is rejected.

Results and Discussion

Research and Information Gathering

This research and information gathering stage includes problem analysis, curriculum analysis, analysis of relevant theoretical studies and research, and needs analysis. Problem analysis: Based on the observation results, it is known that to support the learning process, textbooks and Student Worksheets (LKS) published by one of the publishers are used and are also supported by reading books in the library but in limited numbers. The description of the material in the textbooks and Student Activity Sheets (LKS) used by students is

incomplete, the description of the material is only in outline, there is no clear explanation of the concept that can be understood by students, even though mathematics material requires a lot of conceptual understanding. In addition, the provision of examples in the form of explanations or images is very lacking, coupled with the appearance of images that are unclear and less attractive.

Next, an analysis of the needs of the study object is carried out and the preparation of learning tools such as teacher's handbooks, syllabuses and RPPs is carried out. Furthermore, the development of learning tools is carried out according to needs. Based on the needs analysis, it is expected that researchers can contribute to teaching and learning activities in schools, especially for fifth grade elementary school students, especially in terms of improving mathematical communication and curiosity. Fifth grade students of Elementary School 2 Cepiring, Cepiring District, Kendal Regency have different characteristics because student input comes from almost all elementary schools in Cepiring District, Kendal Regency, and its surroundings.

The average input quality is quite good. From the results of initial observations, the mathematics subject scores are quite good. However, it needs to be improved, especially in terms of mathematical communication and curiosity. The fourth-grade teacher who teaches comes from a young generation with a different teaching style. Because it is still easy, it is still energetic and likes new things in making changes in the teaching and learning process, especially in the use of teaching media such as the use of laptops and LCDs. The next step is to formulate learning objectives; the results of task analysis and concept analysis will be used as a reference for formulating specific learning objectives stated in behavior as an elaboration of basic competencies. Indicators of learning achievement are compiled by researchers based on the development of the curriculum at the educational unit level.

Planning

The development of a Problem-Based Learning (PBL) learning module to improve students' mathematical communication skills and curiosity in arithmetic material for fifth-grade elementary school students is made through the development steps that have been prepared. This module is made using the Microsoft Office PowerPoint 2013 application with the help of Paint and PhotoScape v3.4 image processing applications.

Product design development

The data obtained from the preliminary study are in the form of teaching materials that will be developed into a module with a PBL learning model to improve mathematical communication and curiosity.

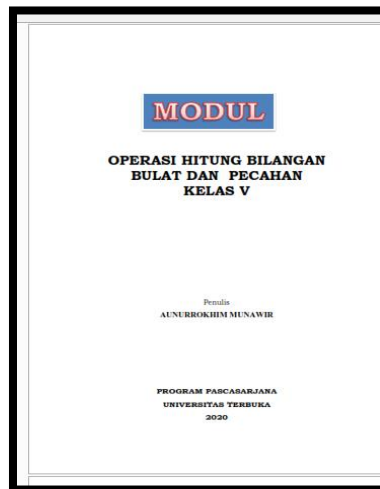


Figure 1. Initial module cover

Figure 1 displays the initial module cover that has been completed by the researcher and will then be validated by experts to be assessed as feasible or in need of revision.

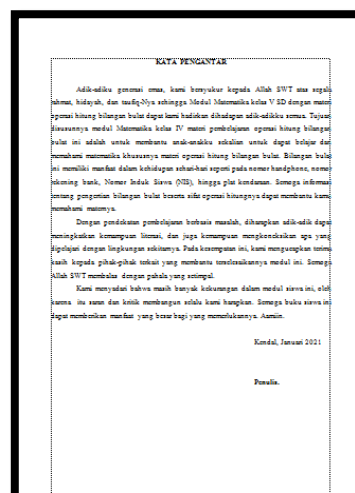


Figure 2. Initial introduction in the module

This image is a display of the initial introduction in the module, consisting of gratitude for the completion of the module, gratitude for those who have helped compile the module, and awareness of the shortcomings of the module. After completing the initial module by the researcher, revisions will be made by module experts.

DAFTAR ISI	
BILANGAN BULAT	1
KATA PENGANTAR	2
DAFTAR ISI	3
SAB I PENDAHULUAN	4
A. Latar Belakang	4
B. Deskripsi Singkat	5
C. Kompetensi dasar dan Indikator	6
D. Pen Koneksi	6
E. Matriks	6
F. Tujuan Pembelajaran	7
G. Penjabaran Pembelajaran Model	7
SAB II KEGIATAN BELAJAR	8
A. Operasi hitung Penjumlahan dan Pengurangan	10
1. Matriks Perkak	10
2. Rangkuman	12
3. Lembar Kerja	12
4. Kuis	14
B. Operasi hitung Perkalian dan Pembagian	15
1. Matriks Perkak	15
2. Rangkuman	16
3. Lembar Kerja	17
4. Kuis	19
C. Bilangan Bulat Operasi Hitung Bilangan Bulat	20
1. Matriks Perkak	20
2. Rangkuman	22
3. Lembar Kerja	23
4. Kuis	25
D. Penjabaran Bilangan Bulat	26
1. Matriks Perkak	26
2. Rangkuman	27
3. Lembar Kerja	28

Figure 3. Design of the table of contents in the initial stage module

Figure 3 is a display of the design of the table of contents in the initial stage module, which has been made as completely and in detail as possible, which will be validated by the expert validation team to see whether it needs to be revised or not for use in a wider trial.

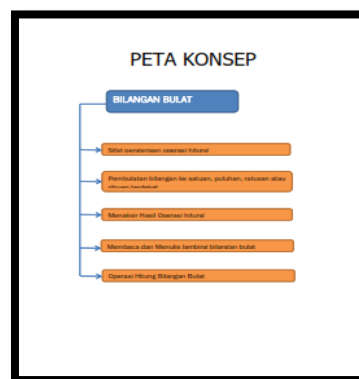


Figure 4. Appearance of the concept map design

Figure 4 shows the appearance of the concept map design in the early-stage module, that has not been validated by the expert team to assess its feasibility. The concept map here illustrates the relationship between Basic competencies and the indicators to be studied. The

appearance of the concept map design that according to the experts needs to be improved will be improved.

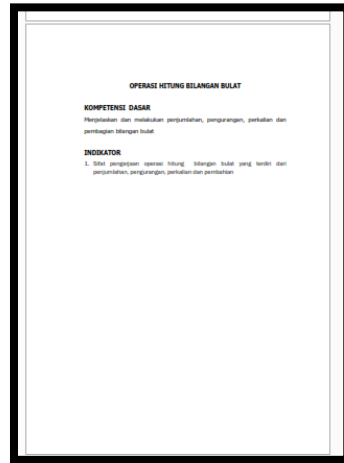


Figure 5. Core Competencies and Indicators

Figure 5 show the Core Competencies and Indicators in the initial stage module that has been completed by the researcher. Core Competencies, Basic Competencies and Indicators will be validated by validation experts to assess their feasibility.



Figure 6. The contents of the material in the initial stage module

Figure 6 shows a partial display of the contents of the material in the initial stage module that has been completed by the researcher. In the contents of the material, illustrations are provided in the form of images related to the contents of the module material. The material will then be validated by the validation team to assess the feasibility of the material. The

validated material will be revised according to the input of the validation team.



Figure 7. Sample questions in the module

This image is a display of sample questions in the module as practice for students; these questions are an indication of how students master the material. These initial stage questions have been completed by the researcher. The module also contains questions about creative thinking and curiosity. The module will also be validated first before being used in a wider-scale trial.

Module Validation

Table 2. The Result of Module Validation

Indikator	Validator		Rata-rata	%	Kriteria
	V1	V2			
1. Material	3.4	3.8	3.6	90.0%	Very Worth
2. Language and Images	3.7	3.9	3.8	95.0%	Very Worth
3. Presentation	4	3.7	3.85	96.3%	Very Worth
4. Appearance	4	4	4	100.0%	Very Worth
			3.8125	95.3%	Very Worth

Based on the data presented in Table 2, the results of the module validation conducted by expert validators yielded an average score of 3.812, equivalent to 95.3%, which falls into the "Very Good" or "Very Worthy" category. These findings indicate that the developed module is highly suitable for use in supporting the enhancement of students' mathematical communication and critical thinking skills within the context of mathematics learning.

Syllabus Validation

Table 3. The Result of Syllabus Validation

Indicator	Validator		Mean	%	Criteria
	V1	V2			
1. Identity, SK, KD	4	4	4	100%	Very Worth
2. Formulate competency achievements	4	3	3.5	88%	Very Worth
3. Identify learning materials	4	4	4	100%	Very Worth
4. Develop learning activities	4	4	4	100%	Very Worth
5. Develop an assessment system	4	3	3.5	88%	Very Worth
6. Determine time allocation	3	4	3.5	88%	Very Worth
7. Determine learning resources	4	4	4	100%	Very Worth
8. Use good and correct language	4	4	4	100%	Very Worth
			3.81	95.3%	Very Worth

Referring to Table 3, the results of the syllabus validation by expert validators show an average score of 3.812, equivalent to 95.3%, which is categorized as "Very Good" or "Very Worthy." This result indicates that the developed syllabus is highly appropriate for use and has strong potential to support the improvement of students' mathematical communication and critical thinking skills in mathematics instruction.

Table 4. Validation of Learning Implementation Plan (RPP)

Indicators	Validator		Mean	%	Criteria
	V1	V2			
1. Subject identity	4	4	4	100%	Very Worth
2. Formulation of indicators and learning objectives	4	3	3.5	88%	Very Worth
3. Learning materials	3.5	4	3.75	94%	Very Worth
4. Selection of learning model approaches	4	4	4	100%	Very Worth
5. Learning activities	3.5	3.5	3.5	88%	Very Worth
6. Selection of learning resources	4	4	4	100%	Very Worth

7. Learning assessment	3.5	3.5	3.5	88%	Very Worth
			3.750	94%	Very Worth

As shown in Table 4, the validation results of the Learning Implementation Plan (RPP) conducted by expert validators yielded an average score of 3.812, corresponding to 95.3%, which falls into the "Very Good" or "Very Feasible" category. These results suggest that the developed RPP is highly feasible for use in enhancing students' mathematical communication skills and critical thinking abilities within the context of mathematics learning.

Revision

The results of the expert revision are to improve the module in terms of material, language, presentation, and appearance, which are appropriate and need to be given practice questions for discussion.

Trial Usage

Pre-test and post-test results for the control and experimental groups. The trial of the use of the module was carried out in the experimental class, while in the control class, the learning was conventional, it show in Table 5. Before the learning was given a pre-test and after the implementation of the learning was given a post-test to see whether the use of the module was effective in improving mathematical communication and student curiosity. The following will describe the results of learning with the module and conventional learning.

Table 5. Pretest and posttest values of the experimental class and the control class

Variation	Pre-test Experiment	Posttest Experiment	Pretest Control	Posttest Control
Minimum Value	30	50	20	40
Maximum Value	80	90	80	90
Standard Deviation	14.24	9.36	13.66	11.37
Varians	50.00	40.00	60.00	50.00
Mean	58.23	75.23	59.07	66.37

Based on the results (Table 5), the pre-test experimental class, the lowest score was 30, the highest score was 80, with an average of 58.23. After learning with the module, an increase was obtained, where the lowest score being 50. The highest score was 90, with an average of 75.23.

Effectiveness Test (t-test)**Table 6. Summary of t-Test Results Data Learning outcomes (posttest)**

	Class	N	Mean	Std. Deviation	Std. Error Mean
Posttest	Experiment Class	34	79.8529	8.11707	1.39207
	Control Class	27	66.1111	11.37924	2.18994

Table 7. Independent Samples Test

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Pos test	Equal variances assumed	5.501	59	.000	13.74183	2.49810
	Equal variances not assumed	5.296	45.415	.000	13.74183	2.59493

Based on the data presented in Table 6 and Table 7, the average post-test score of the control group was 66.11, while the experimental group achieved a higher average score of 79.85. Furthermore, the results of the t-test analysis yielded a t-value of 5.501 with a significance level of 0.000. Since the p-value is less than 0.05, it can be concluded that the use of the module has a statistically significant effect and is effective in enhancing students' mathematical communication skills and curiosity in learning mathematics.

Module Effectiveness Level

The test instrument to determine the level of effectiveness of the learning module presents the analysis results in the form of averages, pre-test scores, and post-test scores. The data presented in the table indicate that the control group achieved an average pre-test score of 59.07 and a post-test average of 66.37, resulting in an N-Gain of 17.83%. In contrast, the experimental group obtained an average pre-test score of 58.23 and a post-test average of 75.23, yielding a significantly higher N-Gain of 60.40%. These results suggest that the use of the module is effective in enhancing student learning outcomes, particularly in the context of mathematical communication and curiosity.

Table 8. Summary of Learning Outcomes on a Broad Scale

Variation	Experiment		Control	
	Pre test	Post Test	Pre test	Post Test
Minimum Value	30	50	20	40
Maximum Value	80	90	80	90
Standard Deviation	14.24	9.36	13.66	11.37
Average	58.23	75.23	59.07	66.37

N-Gain	60.40%	17.83%
Description	Currently	Currently

Conclusion

The results show that the discussion in chapter IV can be concluded as follows; 1) The results of the development of the Problem based learning (PBL) learning module to improve students' mathematical communication skills and curiosity about arithmetic material for fifth grade elementary school students are included in the overall category of "Very Eligible or Valid"; 2) The results of the development of the Problem based learning (PBL) learning module to improve students' mathematical communication skills and curiosity about arithmetic material for fifth grade elementary school students are included in the effective results. This result shows that the learning results with the learning module obtained a higher average compared to the lecture model learning. Based on the results of the pre-test experimental class, the lowest result was 30, the highest score was 80 with an average of 58.23 after learning with the module, an increase was obtained where the lowest score was 50. The highest score was 90 with an average of 75.23. While in the pre-test control class, the lowest result was 20, the highest score was 80 with an average of 59.07 after learning with the module, an increase was obtained where the lowest score was 40. The highest score was 90 with an average of 66.37. Based on these results, it can be concluded that the experimental class is better than the control class. So the learning module is effective in improving mathematical communication and curiosity in grade V students. Suggestions that can be conveyed in connection with the conclusion results are 1) Learning modules based on Problem Based Learning (PBL) during this pandemic, where face-to-face meetings between teachers and students are very limited, greatly help students in mastering the subject matter, so the modules developed should not only be limited to mathematics lessons, but can be developed in other subjects. 2) The modules developed still need to be refined and developed further, especially on equivalent materials.

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