

Problem-Based Learning Assisted by GeoGebra to Improve Students' Mathematical Understanding

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ABSTRACT

This study aimed to develop teaching materials to improve the mathematical understanding of the Pythagorean theorem material by using the development of teaching materials through the GeoGebra-assisted Problem Based Learning (PBL) approach. This study uses the Borg & Gall model's research and Development (RnD) development method with the Borg & Gall model. The researchers collected data through observation, questionnaires, interviews, and tests of mathematical understanding abilities. The population in this study was 80 students of Madrasah Tsanawiyah class VIII, with 30 students in a limited trial and 50 students in a broad trial. Data is processed using descriptive and inferential statistics. This research produced a teaching material with a Problem Based Learning approach assisted by Geogebra software on the Pythagorean theorem material and indicates that there is an increase in students' mathematical understanding abilities after being given learning using GeoGebra-assisted PBL approach teaching materials.

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1. INTRODUCTION

Mathematics is an essential science for us to learn. Mathematics is born from the facts in human life, then applied back into daily life, and becomes a supporting science for various other disciplines (Isrokatun, Hanifah, Maulana, & Suhaebar, 2020). Mathematics has been taught from elementary school to college. But the problem is that mathematics is still seen as a problematic and tedious field of study. One of the most challenging materials for students in high school is the Pythagorean theorem material. It is the part where students are often mistaken in distinguishing the hypotenuse (hypotenuse) from other triangle sides and comparing the sides of the corresponding right triangles. Many students do not understand the Pythagorean theorem concept taken from the square area. In this material, students begin to be required to practice their ability to understand concepts and examine where the Pythagorean theorem formula comes from.

Mathematical understanding is the goal of a mathematics learning process. Mathematical understanding as a goal means an ability to understand concepts, distinguish several separate concepts, and the ability to perform calculations meaningfully on broader situations or problems. So that the ability to understand mathematics is a strength that must be considered and treated functionally in the process and objectives of learning mathematics; moreover, the students can only gain mathematical understanding through learning with understanding. According to Hewson and Thorley (Ernawati, 2003), understanding is a conception that students can digest or understand to understand what is meant, find ways to express these conceptions and explore related possibilities. It is not easy to understand something, let alone understand mathematics. The School Mathematics Study Group (Sumarmo, 1987) details aspects of understanding behaviour: knowing mathematical concepts, laws, principles, and generalizations, changing mathematical forms into other mathematical forms, and following an explanation. Polya (Sumarmo, 1987) suggests four levels of understanding law, namely: first, a mechanical understanding where one can remember and apply a law correctly, second an inductive understanding where one can try out the law in simple cases and believe that the rule applies in a similar case, the third rational understanding where one can prove the law, and fourth intuitive understanding where one has convinced of the truth of the law without a doubt. According to Alfeld (2004), if someone understands mathematics, he can do the following: Explain mathematical concepts and facts in terms of more straightforward concepts and facts; Easily make logical connections between different facts and concepts; Recognize the connection when you encounter something new (inside or outside of mathematics) that's close to the mathematics you understand; Identify the principles in the given piece of mathematics that make everything work.

Understanding ability is one of the essential mathematical abilities to have from an early age. Understanding is defined from the word understanding Sumarmo in Octamela et al., (2019). The degree of understanding is determined by the degree of the interrelationship of an idea, procedure, or mathematical fact that is understood thoroughly if these things form a network with high linkages. According to Rosali (2019), mathematical understanding has a vital role because if students do not have basic mathematical abilities, students will have difficulty learning more advanced mathematical concepts. In line with Pitaloka (2012), besides being one of the goals of learning mathematics, the understanding ability can also help students memorize formulas and correctly understand the meaning of learning mathematics. Therefore, the ability to understand mathematics is essential. According to the Ministry of National Education, the importance of understanding mathematical concepts is seen in the first objective of learning mathematics (Indonesia, P. M. P. N. R, 2015). The mathematical concepts explain and apply concepts or logarithms in a flexible, accurate, efficient, and precise way in problem-solving. In general, indicators of mathematical understanding include: recognizing, understanding, and applying mathematical concepts, procedures, principles, and ideas (Sumarmo, 2010). KillPatrick and Findell (Andjung, 2004) suggest that indicators of mathematical understanding include: firstly, the ability to restate the concepts that have been studied; secondly, the ability to classify objects based on whether or not the requirements that make up the concept are met; thirdly the ability to apply concepts algorithmically; the fourth ability to provide examples of the concepts being studied; the fifth ability to present concepts in various forms of mathematical representation; the sixth ability to relate multiple internal and external mathematical concepts; and the seventh ability to develop necessary or sufficient conditions for a concept. The indicators used to measure students' mathematical understanding abilities in this study are indicators of mathematical understanding abilities according to Zarkasyi (2015), 1) identifying, making examples and not examples, 2) translating and interpreting the meaning of symbols, tables, diagrams, pictures, graphs, and mathematical sentences, 3) understand and apply mathematical ideas, and 4) make an exploration or thought. The importance of understanding students is stated by Santrock (Hendriana, H., Rohaeti, E. E., and Sumarmo, 2017) that understanding the concept is a crucial aspect of learning. Likewise, mathematical understanding is an essential foundation for thinking in solving mathematical problems and real-life problems.

The results of the 2018 PISA study ranked Indonesia down compared to the 2015 PISA results. This 2018 study assessed 600,000 15-year-old children from 79 countries every three years. The study

compared each child's math, reading, and science performance. For the mathematics category, Indonesia is ranked 7th from the bottom (73) with an average score of 379 (Tohir, 2019). Based on qualitative descriptive research that Lanya (2017) has carried out, it shows that the ability to understand the concepts of junior high school students is low. It can be seen from the seventh-grade students of SMPN 4 Pamekasan who cannot state the definition of comparison using their language. Supported by research results by Fajar et al. (2019), the understanding of mathematical concepts of SMP Negeri 17 Kendari students in class VIII shows the category of the high level of mathematical understanding as much as 3%, moderate as much as 10%, and low category as much as 87% with exploratory, descriptive research methods. With these conditions, it is seen that mathematical understanding skills need to be trained from an early age.

In addition to developing and determining appropriate teaching materials, a teacher must choose the right approach or learning model so that students feel the meaning of the material they are learning. One of them is the Problem Based Learning (PBL) approach. PBL learning is an approach to learning students work on authentic problems to compile their knowledge, develop inquiry and thinking skills, develop independence, and develop self-confidence (Kurniawanti & Rizal, 2019). The presentation of authentic problems aims to make students closer to mathematics. Students can understand the benefits of mathematics in everyday life and provide meaningful experiences that cause motivation and curiosity to increase learning, ultimately improving their mathematical understanding. PBL approach is one approach in learning that helps students to develop student activities in learning. The characteristics of the PBL approach, according to Arends in Riyanto (2014), consist of the existence of concrete problems or problems that exist in the community, existing problems must be made as attractive as possible so that students are motivated in learning, the PBL approach emphasizes collaborative, communicative and cooperative learning (team), in applying the PBL approach learning resources are not only taken from one learning source. The PBL approach prioritizes independent education (active students), the solutions obtained by students are communicated in front of the class. The PBL approach emphasizes problem-solving in the learning process. The steps of the PBL approach used by the researcher are quoting from Hosnan (2014), suggesting the stages in the PBL approach, namely, student orientation to problems. The teacher explains the learning objectives, describes the necessary logistics, motivates students to participate in the selected problem-solving activities, and organizes students to learn. The teacher helps students define and manage learning tasks related to the problem and guides individual or group experiences. The teacher encourages students to collect appropriate information, conduct experiments to explain, solve issues, and develop presenting work. The teacher assists students in planning and preparing relevant outcomes such as reports, videos, and models and helps share assignments with friends, analyze and evaluate the problem-solving process. Teachers help students to reflect or assess their investigations and the processes they use.

According to Gunantara et al. (2014), the PBL approach is suitable for all subjects, including mathematics. This is in line with research conducted by Kurniawanti and Rizal (2019), which shows that the application of the PBL model can improve student learning outcomes on the Pythagorean theorem material in class VIII SMP Negeri 18 Palu in the learning process. The learning approach will run more optimally when combined with the help of technology, one of which is the PBL-based GeoGebra software. GeoGebra (Hohenwarter, Hohenwarter, Kreis, & Lavicza, 2008) is dynamic mathematics software that combines geometry, algebra, and calculus to learn mathematics. This software was developed for learning mathematics in schools by Markus Hohenwarter at the University of Florida Atlantic. In addition, GeoGebra is a software that helps students or teachers do assignments or learn mathematics related to geometry, algebra, tables, graphs, statistics, and calculus. GeoGebra software is very suitable to be applied to Pythagorean theorem material. The results of research show this by Fitriyani and Sugiman (2014), who succeeded in developing the Pythagorean theorem Theorem learning tool with the IDEAL approach assisted by GeoGebra. Regarding achievement and motivation to learn mathematics with data acquisition, as much as 83.33% of students achieved the specified KKM, and 87.5% of students had high motivation to learn mathematics. Thus, from the various descriptions that the author has put forward, they are relevant to this research regarding the development of

teaching materials through the GeoGebra-assisted Problem Based Learning (PBL) approach to improve the mathematical understanding of the Pythagorean theorem material for MTs students. This research is essential for researchers to do to overcome some problems in online learning. In addition, this research can contribute to teaching staff by upgrading teaching materials.

2. METHODS

The research method used is Research and Development (R&D), which is used to develop specific products, and test their effectiveness (Sugiyono, 2015). This research development model uses the Borg & Gall model (Sukmadinata, 2010), which consists of 10 steps, namely 1) research and data collection; 2) planning and development of teaching materials; 3) validation of teaching materials; 4) improvement of initial teaching materials; 5) limited trial of teaching materials; 6) revision of advanced teaching materials; 7) extensive testing of teaching materials; 8) revision of final teaching materials; 9) product trial; 10) revision of teaching materials that have been refined with the following explanation.

Research and data collection

Borg & Gall (Sugiyono, 2015) explained that this stage is a systematic process to determine goals, identify discrepancies between reality and desired conditions, including literature review, class observations or observations, and prepare initial reports. Interviews were conducted with teachers at MTs Al Mubarak Batujajar, MTs Terpadu Albidayah, and MTs Asih Putera. The preliminary study results in this research are used as the basis for determining the product design of the teaching materials developed and guiding the learning process.

Planning and development of teaching materials

Borg & Gall (Arifin, 2012) explained that this stage includes formulating special abilities and objectives to determine the order of materials and small-scale trials. At this stage, the researcher prepares the design of teaching materials and research plans. The research plan includes outputs and achievement targets, objectives, problem formulation, test subjects, budget requirements, timelines, and stages of implementation. In addition, researchers conducted discussions with some experts as a form of small-scale trials regarding the development plan to be carried out. The researcher collects the necessary materials and components at this stage, such as learning materials, software installations, and design components. Then the researchers began to carry out the initial development of teaching materials according to the designs that had been prepared. At this stage, the initial development has been made in teaching materials that can already be used.

Validation of teaching materials

Borg & Gall (Arifin, 2012) explained that this stage was carried out with model or product design experts respondents. This activity is carried out to review the initial product provide input for improvement. In the development model by Borg & Gall, this stage is part of the initial product trial. Still, this study's validation stage is at a separate stage to produce better teaching materials when conducting trials. The trial was carried out in 3 stages, namely limited, broad, and product.

Improvement of teaching materials

Borg & Gall (Sugiyono, 2015) explained that this stage was carried out based on the initial validation results. The validation results obtained qualitative information about the program or product being developed. At this stage, the researcher evaluates and improves teaching materials based on both qualitative and quantitative validation results.

Limited trial of teaching materials

Borg & Gall (Sukmadinata, 2010) explained that after revising and improving the initial teaching materials, the next step was to test the teaching materials. The trial was carried out in 3 stages: limited, broad, and product, with revisions after each trial.

At this stage, the researcher conducted limited teaching materials to students studying the material in the teaching materials. The trial was carried out by carrying out the teaching and learning process in the classroom using these teaching materials. The subjects used were 30 students of class VIII-B at MTs Terpadu Albidayah Cangkorah.

Revision of advanced teaching materials

This stage is a further revision and improvement of teaching materials based on the results of a limited trial, the results of the limited trial, which in the form of responses, followed up by revising and improving the teaching materials, both visually and the material.

Extensive trial of teaching materials

Borg & Gall (Sugiyono, 2015) explained that the trial results more broadly involved a larger group of subjects to determine the product's success in achieving goals and gathering information.

At this stage, the researchers conducted extensive trials of teaching materials to several different students to obtain responses to use and assess the ability of teaching materials at this stage in achieving learning objectives and information. The schools taken were MTs Nurul Falah Cimahi and SMP Al-Qur'an Al-Hasanat Eltahfidh Karawang, with 50 students, where each school consisted of 25 students.

Revision of final teaching materials

At this stage, researchers make improvements again based on the results of extensive trials that have been carried out. The improvement is carried out by being oriented to the success of the teaching materials in achieving goals, outcomes, and achievement targets.

Product trial

Borg & Gall (Arifin, 2012) explained that after product improvement, a trial of the enhanced product would be conducted to determine the effectiveness of the developed product. Tests were carried out in a broader group.

At this stage, the teaching materials developed are teaching materials that are ready to be used in further learning. Then the researchers conducted further testing using a mathematical understanding ability test and a questionnaire to test the effectiveness of the teaching materials.

Revised teaching materials that have been refined

Borg & Gall (Sugiyono, 2015) explained that this stage is a revision of the final product, based on suggestions in field trials. The purpose of this stage is to determine whether a product developed is ready for use in schools without involving the presence of researchers or product developers. At this stage, the development of teaching materials enters the final phase, and the final product has been perfected. This finalization is carried out through the last revision of teaching materials based on suggestions, input, and evaluations in the final test. The data obtained is then processed to review and analyze the effectiveness of the teaching materials so that the final results of the development can be obtained.

Data collection techniques using interviews, observations and questionnaires (questionnaires). The data analysis test used is descriptive qualitative analysis, which describes the results of the development of the product. The research conducted will produce a final product in the form of mathematics teaching materials with the Geogebra-assisted Problem Based Learning approach on the Pythagorean theorem material. Scoring in validation using the criteria of Nisa & Agung (2014), which is presented in Table 1.

Table 1 Expert validation rating scale

Category	Value Weight
Very good	4
Well	3
Not good	2
Very Not Good	1

Furthermore, the formula used in each question uses the following formula Anas (2015).

$$P = \frac{f}{N} \times 100 \%$$

Information:

P: Percentage figures from questionnaire data

N: The maximum number of scores

f: The number of scores obtained

The next step is calculating the numbers from the percentage of questionnaire data obtained, which is matched with Table 2 (Sedarmayanti, Hidayat, & Syarifudin, 2002).

Table 2 Validation Criteria

Score	Criteria
80% < P ≤ 100%	Very Worthy
60% < P ≤ 80%	Worthy
40% < P ≤ 60%	Decent enough
20% < P ≤ 40%	less worthy
0% ≤ P ≤ 20%	Very Less Worthy

The method used in product testing is an experimental method with a design in the form of pretest-posttest Control Group Design. This study involved two groups, namely the experimental and control groups. All groups were given a pretest and posttest of mathematical understanding as well as questionnaires and interview guidelines. The experimental group received online learning using teaching materials with a PBL approach assisted by GeoGebra software as a treatment. The control group received online learning with a scientific approach called ordinary learning.

The population in the product trial was MTs students in West Bandung Regency, with the selected sample being two groups of eighth-grade students from MTs Al Mubarak Batujajar. The assessment of instrument items refers to the scoring guidelines listed in table 3 below, namely:

Table 3 Rubric for Giving Mathematical Comprehension Ability Test Scores

Score	Answer Criteria and Reason
4	Complete, clear, and correct mathematical explanation
3	The mathematical explanation is almost complete and correct, but there are some errors.
2	Explanations mathematically make sense, but are only partially correct, paint a picture but are incomplete, and model mathematically correctly but incorrectly in order to arrive at a solution.
1	Few of the picture explanations or mathematical models are correct.
0	No answer or misinterpreted.

Source: Cai, Jane, dan Jakabcsin dalam Hidayat (2013:25)

Then the calculation of n-gain is carried out to determine the increase in students' mathematical understanding abilities. The following is the calculation of normalized gain according to Hake (Nurfauziah, 2012) as follows:

$$\text{Gain Ternormalisasi } (g) = \frac{\text{Skor tes akhir} - \text{skor tes awal}}{\text{skor maksimum ideal} - \text{skor tes awal}}$$

The level of normalized gain scores, according to Meltzer (Faizah, 2019), is grouped into three categories as shown in table 4 below, namely:

Table 4 N-Gain Interpretation Classification

The magnitude of the N-gain	Interpretation
$0,70 \leq \text{N-Gain} \leq 1$	High
$0,30 \leq \text{N-Gain} < 0,70$	Currently
$0 \leq \text{N-Gain} < 0,30$	Low

3. FINDINGS AND DISCUSSION

The development of this research resulted in a mathematics learning module with a Geogebra-assisted Problem Based Learning approach on the Pythagorean theorem material. Based on the research and development that has been carried out following the Borg and Gall research procedures, there are ten research steps. The first stage is research and data collection; the problems in the field are in learning mathematics, students still find it challenging to understand the material (Umam, 2019) and feel bored, so that students are passive in the learning process (Mulyani, 2016), educators also have not used materials teaching that makes students interested (Putra & Pamungkas, 2019). The potential is that school facilities are adequate and students already have laptops, so the authors use them to develop GeoGebra-assisted teaching materials.

From the results of observations and interviews, the results obtained in the form of a summary as follows:

1. Teachers still have difficulties overcoming students whose mathematical abilities are relatively low, especially when students consider problematic materials, one of which is the Pythagorean theorem material.
2. The solution used to overcome these difficulties is that students are required to memorize the Pythagorean theorem formula without understanding the concept.
3. The teaching materials often used are in the form of books from the government but are not yet fully effective in overcoming the difficulties experienced due to the varying levels of students' mathematical abilities.
4. ICT-based teaching materials are still rarely used due to the limited use of ICT-based teaching materials and supporting infrastructure.
5. During the Covid-19 period, learning was carried out remotely and online, either entirely or partially, but encountered various obstacles such as limited learning time. Not all students had online learning tools, inadequate networks, and limited internet quota, so learning became less effective.
6. The media used in online learning are Google Meet, Whatsapp, Youtube, Google Form applications, and physical media such as assignment books and material summaries. Still, the media and teaching materials used are less effective and make it difficult for students to understand the learning materials.

The second stage is product planning which uses student worksheets as teaching materials in which there are Problem Based Learning steps consisting of (1) orienting students to problems, (2) organizing students to learn, (3) guiding individual and group investigations, (4) develop and present the work, (5) analyse and evaluate, then in the investigation step. The researcher inserts an action to investigate the problem with the help of GeoGebra software with clear instructions.

After the product has been designed, the thing to do is assess experts. The evaluation of these experts is carried out so that the products developed achieve the desired goals (Zakiy, Muhammad, & Farida, 2018). Design validation on this teaching material was tested by three expert validators, two material experts, and one media expert. The expert validation assessment analyzed three aspects,

namely aspects of content feasibility, graphic feasibility, and language feasibility. The validation test results by material experts are presented in Figure 1.

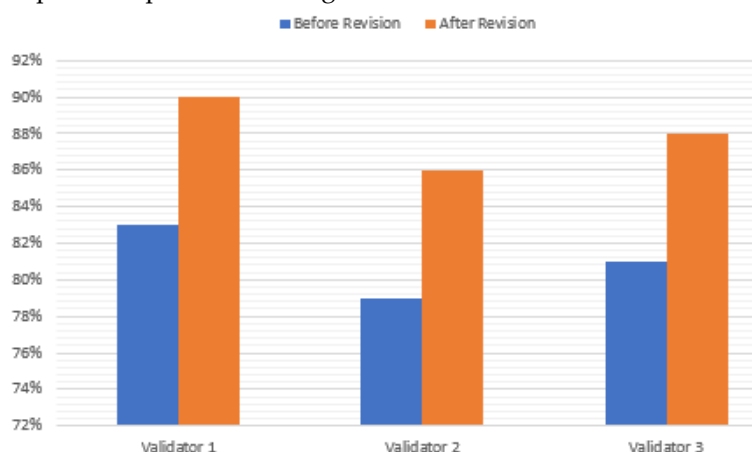


Figure 1 Expert validation results

Based on Figure 1, the results obtained from the validation of experts before the improvement received an average of 81% with the "Fair" criteria. While the results obtained after the improvement obtained an average validation of 88% with the criteria "very feasible."

This is also reinforced by research conducted by previous researchers that showed that the teaching materials developed were eligible (Azizah, Amri, & Ikashaum, 2021). The novelty of this research with previous research is that mathematics teaching materials with a GeoGebra-assisted Problem Based Learning approach on Pythagorean theorem material have a very feasible category in the validation test by material and media experts. The feasibility of this teaching material indeed cannot be separated from experts' guidance, input, and advice.

After the teaching materials have been validated and revised according to the input and suggestions of the validator, the researcher is ready to conduct the product trials of the teaching material product. The teaching materials are prepared to conduct product trials. Product trials are done to ensure that teaching materials are based on student responses. The response was enthusiasm and interest in mathematics teaching materials with the GeoGebra-assisted PBL approach. The results are presented in Table 5.

Table 5 Extensive Trial Results

No	School	Percentage (%)
1.	SMP Al-Qur'an Al-Hasanat Eltahfidh Karawang.	81 %
2.	MTs Asih Putera	79 %
3.	MTs Nurul Falah	84 %
Percentage average (%)		81 %
Criteria		Very Interesting

Based on Table 5 above shows that it obtained an average percentage of 81% in the wide trial with the "Very Interesting" criteria. This is supported by previous research, which also obtained interesting criteria in the trials conducted (Octariani and Rambe, 2018). The novelty contained in this study with previous research is that the development of this teaching material has a very interesting category.

The following is a preview of the product before and after the revision.


Topik : Teorema Pythagoras

Kompetensi Dasar

3.6 Menjelaskan dan Membuktikan Teorema Pythagoras dan Identifikasi Tripel Pythagoras

Indikator

3.6.2 Menentukan Rumus Pythagoras untuk Segitiga Siku-Siku yang Diketahui Panjang Sisi-Sisinya



Kelompok :

Nama Anggota Kelompok :

1. 3.

2. 4.

Kelas :

Petunjuk:

- ✦ Bacalah setiap perintah dari LKS ini dengan teliti dan terurut.
- ✦ Siapkan aplikasi Geogebra.
- ✦ Lengkapi dan jawablah setiap pertanyaan pada LKS dengan cara berdiskusi dengan teman kelompokmu, apabila mengalami kesulitan bertanya pada guru.



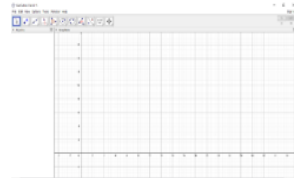
Aktivitas Pembelajaran PBL berbantuan Software Geogebra

Organisasi untuk Belajar

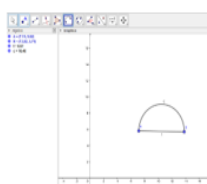
1. Bacalah permasalahan tersebut dengan jelas
 2. Pada kegiatan ini, kalian akan dibimbing untuk dapat menemukan Teorema Pythagoras melalui konsep luas persegi pada aplikasi *Geogebra* dengan mengikuti petunjuk pada LKS berikut dan screenshot pekerjaan yang sudah kalian lakukan sesuai arahan.
 3. Dari pengamatanmu terhadap masalah pada Konteks 1 buatlah beberapa pertanyaan.
- Contoh:
Bagaimana cara mendapatkan tinggi sisi depan tenda yang berbentuk segitiga sama kaki?

Penyelidikan

1. Bukalah aplikasi *geogebra* sehingga muncul tampilan seperti berikut!



2. Hapuslah grid supaya memudahkan kita untuk menggambar "klik kanan > grid"
3. Gambarkan segitiga siku-siku melalui bantuan setengah lingkaran.
Tools Line > Segmen > buat satu garis melalui dua titik > Tools Circle with Center Through Point > klik dua titik yang dibuat tadi sampai muncul gambar seperti berikut.



Screenshot Hasil Pekerjaamu Disini

Figure 3 Product results before revision

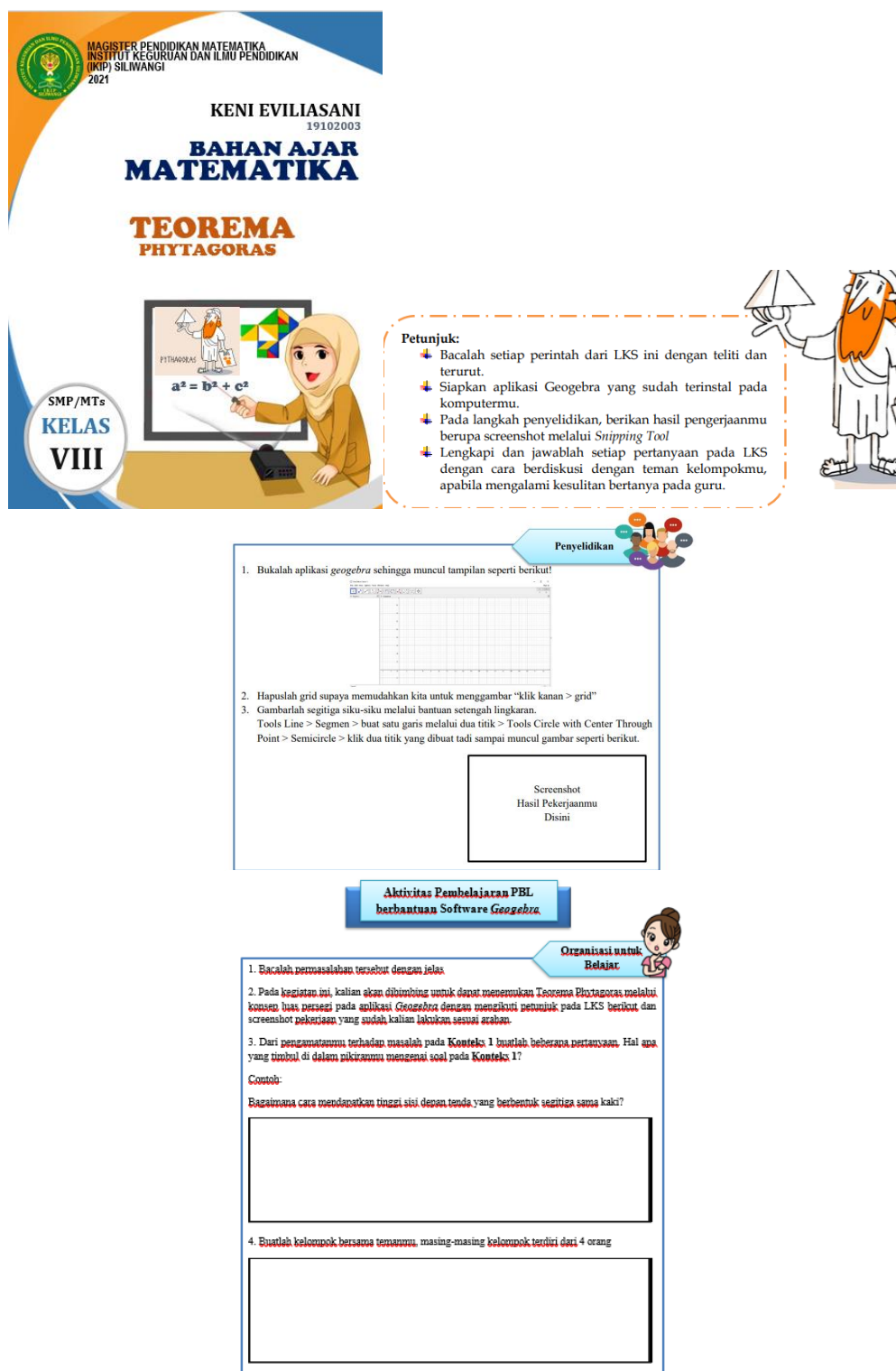


Figure 4 Product results after revision

Before the revision, it can be seen in Figure 2 that the cover of teaching materials still uses the words of student worksheets. At the stage of organizing students, there is no column provided to find out the steps of student learning. In addition, at the investigation stage, some pictures are exemplified by the teacher, so the thing that is feared is that students copy and paste the existing results. At the same time, after the revision, an appropriate cover has been made. In Figure 3. the product after the

revision shows that the proper coverage has been given and the column provided to answer the student organizing step. The pictures made by the teacher at the investigation stage have been deleted.

The next stage is the use trial using a mathematical understanding ability test to determine the students' increase in mathematical understanding skills.

Table 6 Statistical Description of Students' Mathematical Comprehension Ability

Variable	Statistics Data	Experimental Class		Control Class	
		Pretest	Posttest	Pretest	Posttest
Mathematical Ability Understanding	Mean	2,93	14,57	1,93	10,73
	%	14,65 %	72,85 %	9,65 %	53,65 %
	N	30	30	30	30
	Min score	0	8	0	5
	Max score	7	20	6	17
	Std. Deviation	2,02	3,46	1,41	2,74

Criteria: Ideal Maximum Score = 20

Based on Table 6, it is known that there is no significant difference in the average of the two classes, so it can be concluded that the standard for the mathematical understanding ability of the two classes is the same. Then the pretest and posttest data processing was carried out to test the n gain as follows.

Table 7 Test Results of Two Average N-Gain

	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	Sig. (2-tailed)
Equal variances not assumed	5,987	0,017	4,177	48,426	0,00

Based on Table 7. it is known that count = 4.177, and it is known that the value of table = 0.017. From these results, it can be seen that count table. Because count table, then 0 is rejected, and one is accepted. In other words, improving students' mathematical understanding abilities whose learning uses teaching materials using the Problem Based Learning approach with the help of GeoGebra software is better than those who use ordinary learning.

Responses to online learning using Problem Based Learning approach teaching materials assisted by GeoGebra software were obtained from student and teacher response questionnaires and interview results. It is known that the overall response of students to PBL approach teaching materials assisted by GeoGebra software is positive and indicates that the better the level of students' mathematical abilities, the more responsive to PBL approach teaching materials assisted by GeoGebra software. Then based on the results of the questionnaire, it was found that most students had an interest and enthusiasm in learning mathematics using PBL approach teaching materials assisted by GeoGebra software, were able to overcome difficulties and dared to try new things, and were able to interact online and dare to present an opinion with a reasonable interpretation dared to express opinions, which were overall with good understanding. Based on the results of student interviews, it was known that

students commented that the PBL approach teaching materials assisted by GeoGebra software was good, easy to understand, very helpful for students, and had positive and negative impacts. The advantages of this teaching material are that it makes learning easy, engaging, and easy to understand, but also conveys the drawback is that you have to have GeoGebra software installed on your laptop; in other words, you can't apply it on your cell phone. Criticisms and suggestions were also given, hoping that this teaching material could be further developed and disseminated widely.

The responses of students and teachers to online learning using PBL approach teaching materials assisted by GeoGebra software are in line with several previous studies, namely the research conducted by Padli and Rusdi (2020) regarding student responses in online learning during the pandemic. This study revealed that students' responses to online learning were generally happy, but some students still had problems with internet facilities and the costs they had to pay. Furthermore, the development of teaching materials on the Pythagorean Theorem by Putri (2017) is effective, which could be seen from the level of completeness posttest result of the student who showed that of the 34 students, there are 26 students (76%) who reached KKM.

4. CONCLUSION

Based on the results of the research presented in the previous discussion, it can be concluded that this research produced a teaching material with a Problem Based Learning approach assisted by Geogebra software on the Pythagorean theorem material and also the mathematical understanding of students whose learning using it improved better than those who used ordinary learning. The results of the feasibility test were assessed by experts, namely with very feasible criteria and in the broad trial obtained the criteria of "Very Interesting". The limitation in this study is that it is at the research stage, where the research is only up to the product test stage. Further researchers should be able to conduct development research up to the socialization stage.

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