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UNDERSTANDING THE CONCEPT OF PYTHAGORAS IN JUNIOR HIGH SCHOOL STUDENTS USING PMRI

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ABSTRACT

This research aims to determine students' conceptual understanding using the PMRI learning approach with the context of cotton rope in the Pythagorean theorem material on students' conceptual understanding in class VIII SMP NEGERI 2 Pagaralam. The obstacle faced by students in studying the Pythagorean Theorem is a lack of understanding of the basic concepts in the Pythagorean theorem material. One method that can strengthen understanding of concepts in learning mathematics is Indonesian Realistic Mathematics Education (PMRI). The research method used was experimental using a control group Pre-test - Post-test design. This research involved 2 classes, namely the experimental and control classes. Data collection techniques include observation and tests, the analysis techniques used are documentation, observation and tests. Based on test data analysis, the average student score in the experimental class was 78.8, while the control class had a score of 72.50. From the research results, students' conceptual understanding was found to be better using PMRI with comparison results in the experimental class being better than in the control class.

Keywords: Understanding The Concept, Pythagoras, PMRI

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PRELIMINARY

The Pythagorean Theorem is a mathematical rule that states that in a right triangle, the sum of the squares of the lengths of two perpendicular sides is equal to the square of the lengths of the hypotenuse, also known as the hypotenuse. This theorem was expressed by Pythagoras, an ancient Greek mathematician and philosopher. In a right triangle, there is a statement that the square of the length of the hypotenuse is equal to the sum of the squares of the lengths of the other sides. In the learning process, many students have difficulty understanding the concept of the Pythagorean Theorem. This theorem requires in-depth understanding and high precision to be understood and applied correctly in solving problems (Surakhmad, 1972). However, in reality students' mastery of concepts and use of formulas is still very lacking. The cause of students' lack of understanding of

mathematics is students' tendency to memorize concepts rather than focus on the process of understanding the concepts in depth (Ramadhany & Prihatnani, 2020).

According to Naisunis et al., (Friantini et al., 2020), the difficulties faced by students in understanding concepts are caused by a lack of understanding of the purpose or meaning of the questions and also students' difficulties in identifying relevant equations. One of the obstacles students face in studying the Pythagorean Theorem is a lack of understanding of the basic concepts or prerequisites related to the theorem (Hamalik, 2013). Therefore, it is important for students to have good comprehension skills, especially in understanding concepts related to the Pythagorean Theorem. A student is considered to have understood a mathematical concept if he is able to explain the concept using his own words (Ilma et al., 2021). Mathematics is a science that has an important role in human life. Mathematics helps in developing a person's thinking abilities in understanding relationship patterns, thought patterns, art and language, thus making the thinking process easier (Khoerunnisa et al., 2020). According to the Ministry of National Education, understanding concepts is one of the important mathematics skills that students are expected to achieve in learning mathematics. This includes the ability to demonstrate understanding of the mathematical concepts being studied, explain the relationships between these concepts, and apply concepts flexibly, accurately, efficiently and appropriately in a variety of situations. Understanding concepts is considered to be the core of every subject in the curriculum, which involves the way students understand information and use it in real world contexts, in line with the concept and implementation of the independent curriculum (Soedjadi, 2000).

According to Law no. 20 of 2003, Part 1 Article 1, curriculum is defined as a set of plans and arrangements concerning objectives, content, learning materials, and methods used as a guide in implementing learning activities to achieve certain educational goals. This curriculum does not limit the ways of learning that can take place inside or outside of school, and also encourages teacher and student creativity in the learning process (Manalu et al., 2022). Students can achieve learning goals if learning activity planning is designed well. This means that educators play an important role in designing learning activities in the classroom (Ilma et al., 2021). In the process of understanding learning, concrete elements are still needed where students use real situations or contexts as a starting point to start the process of rediscovery. This aims to enable students to understand mathematical concepts in a more in-depth and structured manner (Fitriani & Yuliani, 2016). To

implement the concepts and principles of an independent curriculum, an effective learning approach is needed in the teaching and learning process.

One method that can strengthen understanding of concepts in mathematics learning is Indonesian Realistic Mathematics Education (PMRI). In PMRI, students start by understanding concepts from real situations before developing them into more general or abstract concepts (Rahayu, 2017). PMRI is a mathematics learning approach that is rooted in real experiences or contexts that students have experienced, emphasizing process skills, discussion, collaboration and argumentation between fellow students. This approach makes the student the center of learning rather than the teacher. Based on the findings of previous studies related to the PMRI approach (Widyastuti & Pujiastuti, 2014), Research shows that learning mathematics using the PMRI approach has a positive impact on students' understanding of concepts. Research by Dyah et al., (2013) shows that (1) students who take part in learning with the PMRI model achieve learning outcomes that meet standards, (2) the ability to understand mathematical concepts of students who take part in learning with the PMRI model is superior to those who take part in learning with the expository model, and (3) students those who took part in learning with the PMRI model were more active than those who took part in learning with the expository model.

The relationship between understanding concepts in the Pythagorean Theorem material and applying the PMRI approach is in the research of Hutajulu & Lexbin, (2016), in this research, the development of LKPD in the context of guava fruit using the PMRI approach to football material has met the validity criteria based on self-evaluation and expert observation, as well as practical criteria based on the results of questionnaire recapitulation at the one-on-one, small group and field test stages. Some of the challenges students face in understanding concepts include difficulties in understanding right triangles, applying the Pythagorean Theorem, recognizing various types of triangles, and using the Pythagorean Theorem in everyday life situations (Ana & Nusantara, 2019). To overcome this problem, a learning design was carried out by analyzing learning barriers, which resulted in a learning design that could anticipate students' difficulties in understanding concepts in the Pythagorean Theorem material. In research by Prihaswati et al., (2023), the use of woven mats can increase interest in understanding concepts. In Munir & Sholehah (2020) research, to show the effectiveness of the PMRI approach with the context of tumpeng rice in learning cone volume material in class XI, learning outcomes showed a significant increase.

Understanding concepts is a crucial element in the learning process (Santrock, 2011). Understanding concepts greatly influences students' interest in the learning process (Holf & Sascha, 2019) and problem solving (Barmby et al., 2014). NCTM (Bartell et al., 2013) says that understanding concepts is the main goal in learning mathematics. A similar opinion was expressed by Ilma et al. (2021), in mathematics, there is a hierarchical structure where understanding new topics requires a solid understanding of previous concepts, so students need to connect new information with previously held knowledge. Mathematics is a field of knowledge where understanding of concepts is developed gradually (Beatty, 2011).

The PMRI approach is a learning approach that emphasizes students' active involvement in the learning process in class, enabling them to build their own understanding of mathematical problems (Idris & Silalahi, 2016). According to Mohammad Haryono, with the PMRI approach, students are more facilitated in understanding and accepting mathematics learning better (Izzati & Sholikhakh, 2021). There are three key principles in PMRI according to Gravemeijer (Arikunto, 2020), namely: guided re-invention, didactical phenomenology, and self-developed models. In the PMRI approach, students' daily circumstances are used to increase their enthusiasm, involvement and understanding of learning materials (Sari et al., 2018). Therefore, researchers chose cotton rope as one of the contexts for learning the Pythagorean theorem because it is concrete and known to students, so it not only makes their understanding easier but also makes learning more interesting, fun and meaningful for students (Widiawati. et al., 2018).

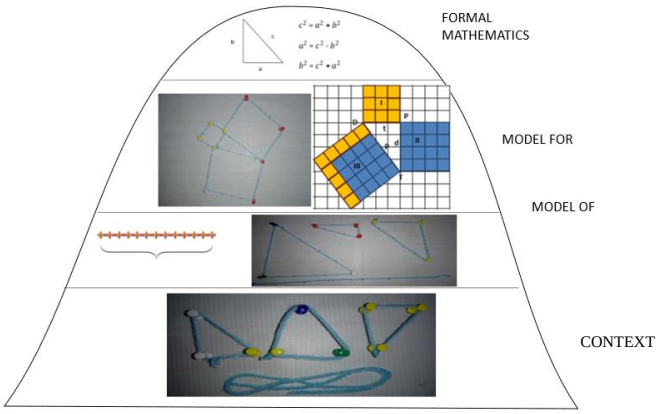

Figure 1. ***Iceberg***

Based on this explanation, research was then carried out which aimed to determine students' conceptual understanding after implementing mathematics learning using the PMRI approach with the context of cotton rope in the Pythgaoras theorem material on the

concept understanding ability of class VIII students. If understanding of a concept increases, it is hoped that students' competency abilities will also increase.

METHODS

The method used in this research is experimental. The experimental method is a way of teaching, where students carry out an experiment on something, observe the process and write down the results of the experiment (Khaeriyah et al., 2018). Desain yang di gunakan pada penelitian ini adalah *Control Group Pre-test – Post-test.*

Table 1. *Control Group Pre-test – Post-test*

E	O_1	X	O_2
C	O_3	X	O_4

(Arikunto, 2020)

The sample in this study consisted of two classes, the first class, namely VIIIG, consisting of 31 students as the experimental class, and class VIIIH, 30 students as the control class. The research uses data collection techniques, namely observation and tests. The test used is a written test with five essay questions, which follow the concept understanding skills guidelines. The evaluation criteria for students' skills in understanding concepts have been summarized in table 2.

Table 2. Evaluation Criteria Percentage of Students' Concept Understanding Ability

Indicator	Description	Student responses to questions	Score
Restating a Concept	The student's ability to re-express what was communicated to him in this material, namely regarding the Pythagorean theorem	Blank answer	0
		There is the ability to restate a concept but incorrectly	1
		Restating an incomplete concept	2
		Restates a concept correctly but incompletely	3
		Restate a concept completely and correctly	4
Classifying objects according to certain properties (according to the concept)	Students are able to group objects according to their properties	Blank answer	0
		There is the ability to classify objects according to certain properties in accordance with the concept but is wrong	1
		classifying objects according to certain properties according to the concept is incomplete	2
		classify objects according to certain properties in accordance with the concept correctly but incompletely	3
		classify objects according to certain properties in accordance with the concept correctly and completely	4

Give examples and non-examples of a concept	Students are able to distinguish between examples and non-examples of the material being studied	Blank answer	0
		There is the ability to provide examples and non-examples of a concept but it is wrong	1
		Provides examples and non-examples of a concept but is incomplete	2
		Provide examples and non-examples of a concept correctly but incompletely	3
		Provide examples and non-examples of a concept correctly and completely	4
Apply concepts or algorithms to problem solving	Students can solve problems using formulas	Blank answer	0
		There is the ability to apply concepts or algorithms to solve problems but they are wrong	1
		Apply concepts or algorithms to problem solving but are incomplete	2
		Apply concepts or algorithms to solve problems correctly but incompletely	3
		Apply concepts or algorithms to solve problems correctly and completely	4

RESULTS AND DISCUSSION

The researcher carried out the learning process using the PMRI approach to the Pythagorean theorem material, when the learning was carried out the researcher provided motivation so that students were more active in carrying out learning activities for class VIII.G using the PMRI approach as an experimental class, while class VIII.H which was the control class received treatment Conventionally, at the first meeting, an initial test is carried out. The test questions are in the form of 5 essay questions covering the material of the Pythagorean theorem.

The researcher gave test questions in the form of 5 description questions. Where researchers direct students to work on questions independently and honestly to find out whether there is a difference in understanding the concepts of students who use the PMRI approach in the cotton rope context and those who use conventional learning methods. The indicators for understanding mathematical concepts in this research are restating a concept, classifying objects according to certain properties, giving examples and non-examples of a concept, applying concepts or algorithms to problem solving. After completing the pretest questions, the researcher then divided the students into 5 groups, then distribute LKPD and cotton rope to groups of students and then explain the material on the Pythagorean theorem. In order to attract students' attention and remind them of the material, the researcher asked students questions:

Researcher : "Who knows, what is the meaning of the Pythagorean theorem?"
Student 1 : "Ma'am, the Pythagorean theorem is a theorem that explains the relationship between side lengths in right triangles"
Researcher : "Yes, the answer is correct, is there anyone else who can answer?"
Student 2 : "Yes ma'am, the Pythagorean theorem states that the sum of the areas of the squares attached to the legs of a right triangle is the same as the area of the squares attached to the hypotenuse."
Researcher : "Your answer is very correct, does anyone know what the hypotenuse is in a right triangle?"
Student 3 : "I am ma'am, the hypotenuse of the triangle is the hypotenuse ma'am."
Researcher : "Yes, that's right."

From the conversation above, the researcher knows that the students understand little of the material. The researcher explains the Pythagorean theorem material in everyday life and explains the Pythagorean formula and gives examples that are found in everyday life, for example the roof of a house, a ladder attached to the wall of a house, and a tree that the ladder is leaning against and many more.

Figure 2. Students Observe The Learning Context of Cotton Rope

Figure 3. Students Use The Context of Cotton Rope

In the picture above, students are given the context of cotton rope, where students play with rope and are directed by the researcher for students to make triangles from the cotton rope. Students shape the cotton rope into various triangle shapes as seen in the picture below.

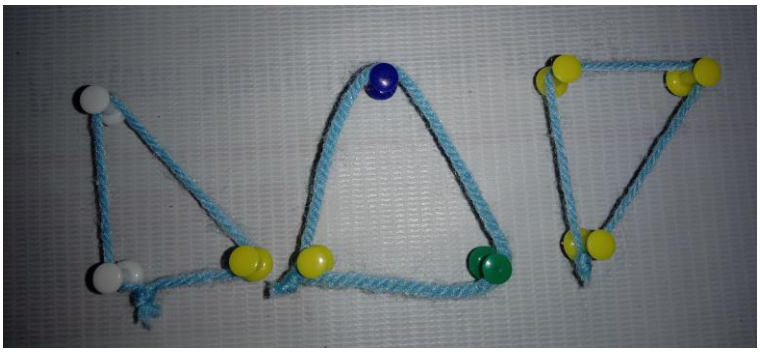

Figure 4. Various Triangular Shapes

Figure 4. Students Measure The Length of The Cotton Rope

Next, after students have finished making a triangle on cotton rope, students discover that the triangle used in the Pythagorean theorem is a right triangle. Then students make a conclusion on a right-angled triangle to measure the length of the triangle.

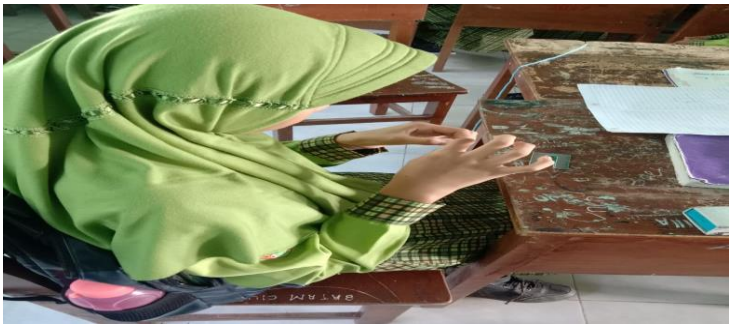

Figure 5. Students Make Knots On Cotton Rope

In Figure 5, a group of students using learning media, when implementing learning using the context of cotton rope, students were able to carry it out well, even though there were obstacles as in group 1, which can be seen in the conversation below:

Student 1 : "Ma'am, I want to ask, in activity 1, how do you move the square pieces, ma'am?"
Researcher: "Okay, to move the square pieces, the first step is to first draw a right triangle and make a square on each side of the right triangle. If so, then how many squares are there in the triangle and move it to the biggest square . ”
Student 2 : "So ma'am, first draw a right triangle and then make a square, okay ma'am?"
Researcher: "Yes, that's right, how many squares must be made?"
Student : "3 ma'am, small medium and large square."
Researcher: "That's right, where is the big big square located?"
Student : "On the hypotenuse of the triangle, ma'am."
Researcher: "That's right, is there anything else you want to ask?"
Student : "No ma'am."
Researcher: "Please continue."

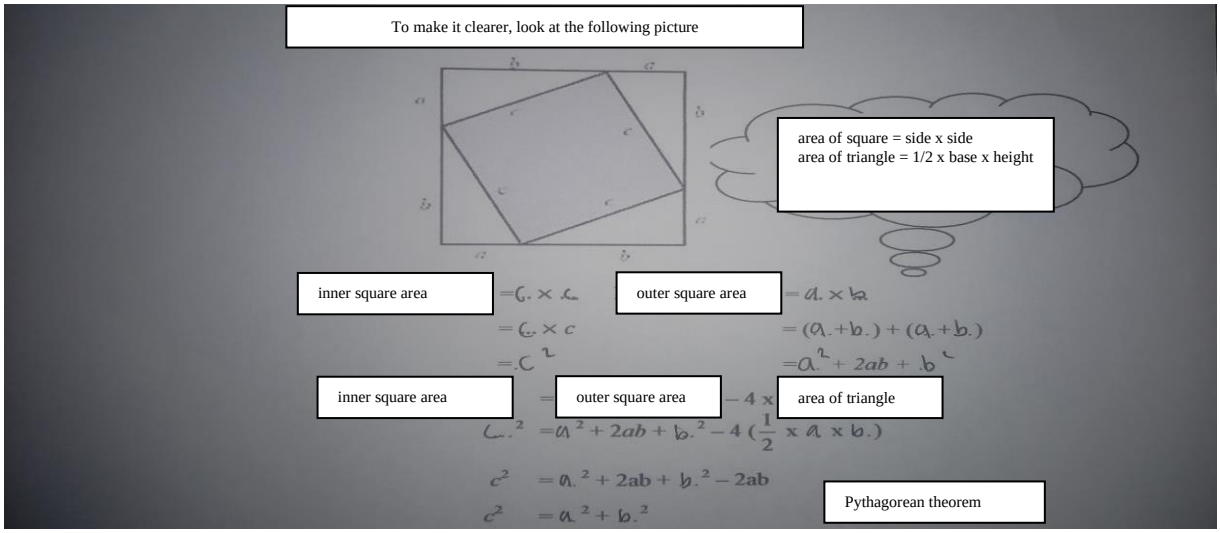

Figure 6. Answers on student LKPD

Figure 7. Groups Experiencing Difficulties

The researcher went around again to observe and ask other groups whether anyone was still experiencing learning difficulties.

Researcher: "What about this group, do you have any questions?"
Student 1 : "Ma'am, I want to ask, in activity 2, how do you calculate the units on the sides of a triangle, ma'am?"

Researcher: "Okay, I will answer a question from one of your friends, please pay attention after you make a conclusion on each side of the triangle and form a square, right...? So, counting the units on each square on the side of the triangle is how to count the vertices that you have made on each side of the triangle."
Student 2 : "So ma'am, we have to make a conclusion first so we can calculate the units of the sides of the triangle."
Researcher: "Yes, that's it, make a knot first and determine the units."
Student : "Okay ma'am"
Researcher: "Does anyone want to ask any more questions?"
Student : "No ma'am"
Researcher: "Please continue"

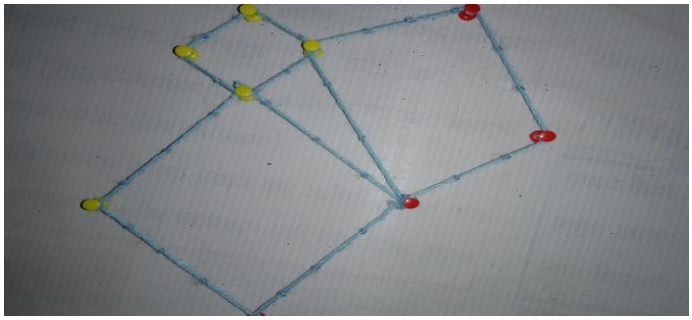

Figure 8. Form The Pythagorean Theorem Using Cotton String

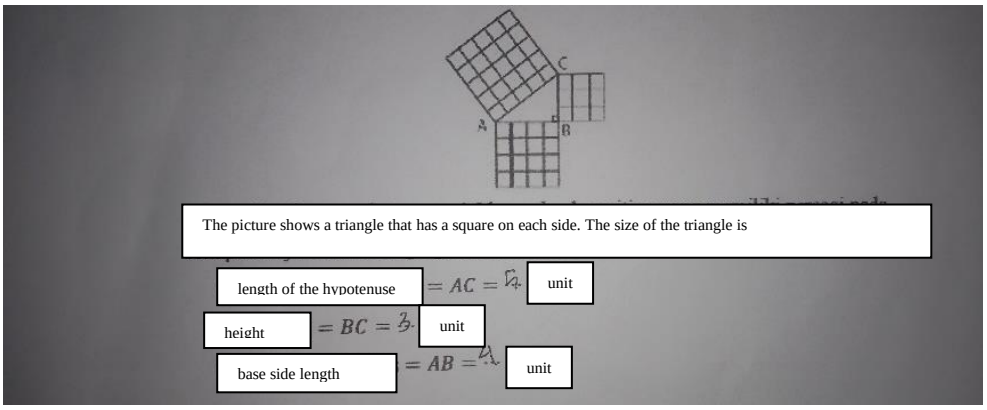

Figure 9. Answers in LKPD

It can be seen that there are some students who do not understand the stages in solving questions. After being explained by the researcher, finally the students were able to solve the problems on the LKPD as seen from the students' answers in picture number 5. And it can be seen that one of the other groups was still having difficulty solving the questions. After being explained by the researcher, the students finally recalled the material that had previously been briefly explained to solve the problems in the LKPD.

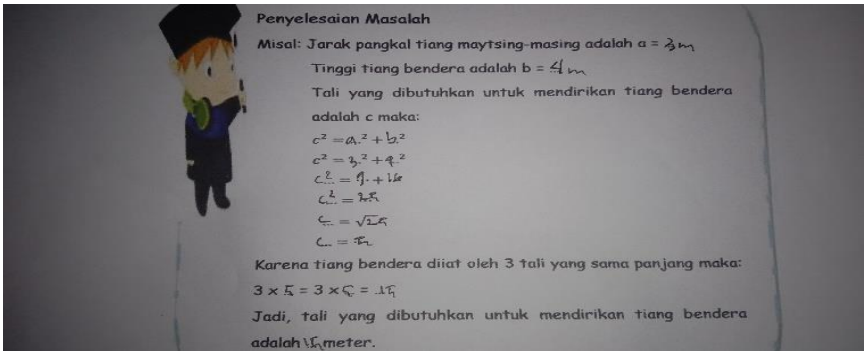

Figure 10. Answers in LKPD

It can be seen in Figure 10 that students can solve the problems stated in the LKPD well.

Figure 11. Students Solve Problems on LKPD

In Figure 11, after students have finished understanding the stages of the material in the researcher's explanation. Next, students can continue to answer evaluation questions. There are 4 evaluation questions that meet the indicators of students' conceptual understanding. To answer these questions, students work on the LKPD and discuss with their groups to get the correct answer.

At the end of the meeting, a posttest was carried out to determine students' understanding of the PMRI approach. From the students' answers in the final test, it can be seen that they were able to answer each question well, thanks to the learning carried out at the previous meeting.

Based on the discussion above, data from observations and tests can be analyzed. The observation results show indicators of students' understanding of concepts during learning using the PMRI approach, the average percentage can be seen in the following picture.

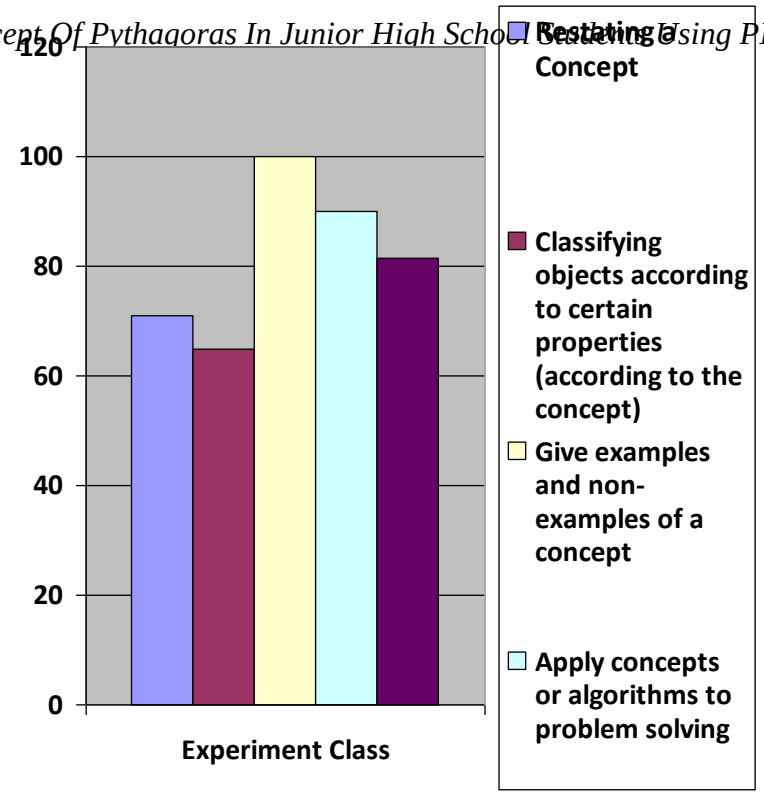

Figure 12. Concept Understanding Observation Data

In Figure 12, students' abilities are presented based on observation sheets from observations at meetings. The overall average ability of students to understand concepts is 81.5%, which means high. This means that students understand the concept during the process of learning the Pythagorean theorem through the use of PMRI. Thus, it can be said that learning using PMRI influences students' understanding of concepts in learning, especially regarding the Pythagorean theorem material.

Table 3. Test of Normality *pretest* and *posttest*

Class		Kolmogorov-Smirnov[a]		
		Statistic	Df	Sig.
understanding of concepts	Pretest VIIIG	.121	31	.200
	Pretest VIIIH	.106	30	.200
understanding of concepts	Posttest Experiment	.149	31	.076
	Posttest Control	.160	30	.049

From table 3, the pretest results for classes VIIIG and VIIIH in the Kolmogorov-Smirnov test show values of 0.200 > 0.05 and 0.200 > 0.05, indicating that the data has a normal distribution. Furthermore, the posttest results show Sig values of 0.076> 0.05 and 0.049> 0.05, so the conclusion is that the data has a normal distribution.

Table 4. Homogeneity

understanding of concepts				
	Levene Statistic	df1	df2	Sig.
Pretest	7.250	1	59	.009
Posttest	.110	1	59	.742

Based on table 4, data from the pretest results for classes VIIIG and VIIIH, the significance value is 0.009 > 0.05, indicating that the data is homogeneous in the pretest results, and also in the posttest results the significance value is 0.742 > 0.05, which also shows that the data is homogeneous.

Table 5. Independent Samples Test

		t-test for Equality of Means		
		T	Df	Sig. (2-tailed)
understanding of concepts	Equal variances assumed	5.916	57	.000

From table 5 above, it has a Sig (2-tailed) value of 0.000 < 0.05. So H0 is rejected and H1 is accepted. This means that the research hypothesis is accepted. So, it can be concluded that learning using the PMRI approach to understand concepts is superior to using conventional learning.

Next, the researcher gave five test questions in the form of description questions to students to evaluate whether there were differences in the conceptual understanding of students who used the PMRI approach and those who used conventional methods. A graph showing the percentage of indicators of student understanding of concepts between the experimental class and the control class can be seen in the following picture.

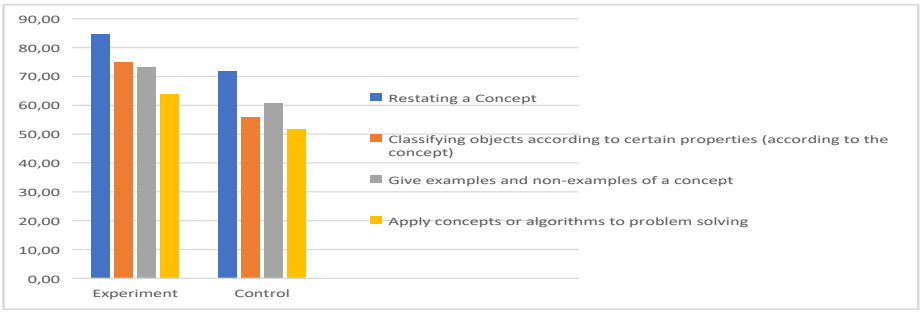

Figure 13. Percentage Graph of Indicators of Students' Concept Understanding Ability

From Figure 13, you can see the average indicator of students' conceptual understanding ability in the experimental class and control class. It can be seen that the highest indicator is classifying objects according to certain properties (according to the concept) of 75. Furthermore, the indicator restates a concept and the indicator gives examples and non-examples of a concept of 84.68. For indicators that provide examples and non-examples, it is 73.39. And the lowest indicator, namely the indicator of applying concepts or algorithms to problem solving, is 63.71.

CONCLUSION

Researchers carried out the learning process using the PMRI approach to the Pythagorean theorem material, learning for class VIII.G used the PMRI approach as an experimental class, while class VIII.H, which was the control class, received conventional treatment. The researcher gave test questions to find out whether there was a difference in students' conceptual understanding who used the PMRI approach in the context of cotton rope and those who used conventional learning methods. This research has succeeded in applying PMRI to increase students' understanding of concepts. Based on the average indicator of concept understanding, the percentage obtained, in the control class we can see that 71.67% of students are able to explain again a mathematical concept that has been studied, 55.83% of students can classify objects according to certain properties (according to the concept) , 68.83% of students can provide examples and non-examples of a concept that has been studied, 51.67% of students are able to apply concepts or algorithms in problem solving. It can be concluded that students' conceptual understanding abilities are better in the experimental class than in the control class. From the results of the independent samples test, it is known that the alternative hypothesis has a Sig (2-tailed) value of 0.000 < 0.05. So H0 is rejected and H1 is accepted. So it can be concluded that the ability to understand concepts using PMRI has a good effect. It is suggested that PMRI can be researched further at a higher level to help improve the quality of education.

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