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Translational Representation in Understanding Pythagorean Theorem Reviewed from Student Learning Styles

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Abstract
This study aims to describe the translations of representation in understanding Pythagorean's theorem from the perspective of students' learning styles. Representation has an important role in mathematics learning. Representation as a means of understanding concepts and mathematical thinking and revealing the understanding of concepts. The method in this study is qualitative. The subjects of this study came from 85 mathematics students from the State Islamic University of Mataram. The selection of subjects was selected based on the results of a learning style questionnaire with the categories of visual learning style, auditory learning style, and kinesthetic learning style. The data collection technique used a learning style questionnaire, a Pythagorean theorem test instrument and a task-based interview. This study has proven that students have successfully solved Pythagorean theorem problems because they are able to carry out the translation process from verbal to visual representation and from visual to symbolic. This indicates that understanding concepts and the ability to change information in various forms of representation have a great influence on success in solving mathematical problems.

Keywords: learning styles; representational translation; pythagorean theorem

Abstrak
Penelitian ini bertujuan untuk mendeskripsikan translasi representasi dalam memahami teorema pythagoras ditinjau dari gaya belajar mahasiswa. Representasi mempunyai peran penting dalam pembelajaran matematika. Representasi sebagai sarana dalam memahami konsep dan berpikir matematis serta mengungkap pemahaman konsep. Metode dalam penelitian ini adalah kualitatif. Subjek penelitian ini berasal dari 85 orang mahasiswa tadris matematika dari Universitas Islam Negeri Mataram. Pemilihan subjek dipilih berdasarkan hasil angket gaya belajar dengan kategori gaya belajar visual, gaya belajar auditori, dan gaya belajar kinestetik. Teknik pengumpulan data menggunakan angket gaya belajar, instrumen tes teorema pythagoras dan wawancara berbasis tugas. Penelitian ini telah membuktikan bahwa mahasiswa berhasil menyelesaikan soal teorema pythagoras karena mereka mampu melakukan proses translasi dari representasi verbal ke visual dan dari visual ke simbolik. Hal ini mengindikasikan bahwa pemahaman konsep dan kemampuan untuk mengubah informasi dalam berbagai bentuk representasi sangat berpengaruh terhadap keberhasilan dalam memecahkan masalah matematika.

Kata kunci: *gaya belajar; translasi representasi; teorema pythagoras*

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Introduction

Mathematics is one of the most important sciences in the world of education and daily life (Gustinawati et al., 2020; Khoerunnisa & Sari, 2021). Mathematics is one of the sciences that studies concepts that allow students to be actively involved in finding concepts, applying concepts, and being able to solve mathematical problems (Pauweni et al., 2022). Mathematics is a subject that is considered difficult in terms of understanding and solving problems (Nugraha, 2023). Not only students, but students also experience the same thing. One of the materials in mathematics subjects that is considered difficult is related to Pythagorean's theorem (Prayekti, 2019).

The Pythagorean theorem is one of the important materials because it is often used in daily life, such as in distance measurement, development design, sports, photography, and cinematography (R. D. Putri & Kartini, 2023). In the material of the Pythagorean theorem, it can be seen that representation is an important thing for students to have in learning mathematics. Because representation can help understand mathematical concepts or solve problems related to mathematics.

Representation is a means of understanding concepts and mathematical thinking as well as revealing the understanding of concepts. Abdullah stated that the concept of representation is one of the psychological terms used in mathematics learning to explain important phenomena about thinking (Abdullah, 2014). Mathematical representations are expressions of mathematical ideas displayed by students as models or substitute forms of problem situations. To find out the relationship between representations, a translation process is needed (Mundy, 2000).

Translation is a cognitive process in transforming information contained in one form of representation into another form of representation (Rahmawati et al., 2017). Translational representation is a process that converts a representation that is presented into another form of representation (Sari & Susanah, 2023). The process of translating representation as a model of real-world problems into abstract concepts and symbols (Rahmadian et al., 2019). The process of representation translation is important for building information connections to achieve successful problem-solving and mathematical understanding.

Translational representation is a supporting instruction to clarify the overall picture of mathematical concepts in learning. The process of representational translation is necessary to express and represent mathematical ideas to help clarify in solving problems in everyday life (Maulida et al., 2015). The representation translation process contains four stages, namely exploring the source, uncovering the source of the problem, coordinating the initial understanding, constructing the target goal of the representation, and determining the suitability of the representation (Pratiwi et al., 2023). In addition to the translation process, learning styles also have an effect on solving mathematical problems.

There is previous research related to representation translation, namely by Hanida Emilia Dewi Pertiwi et al. entitled "The Process of Student Representation Translations in Solving Statistical Realistic Problems as Numeracy Skills.". The results of his research show that in solving realistic problems there is a relationship between representational translation and numeracy ability (Pratiwi et al., 2023). Another research on the translation

process is owned by Octavina, Rizky Utami Putri, and Zukhrufurrohmah with the title "The Translation Process of Realistic Problems into Mathematical Representation of Informatics Engineering Students.". This study obtained the conclusion that the translation process of realistic problems becomes a form of mathematical representation through four stages. The initial stage is to explore the source, compile initial knowledge, build a representation target, and determine the suitability of the representation results with the source. At this stage, students can evaluate the target representation by looking at the relationship of the source representation (O. R. U. Putri & Zukhrufurrohmah, 2022). There are similarities and differences between current research and previous research. The similarity of this study is that they both want to know the process of representation translation, but The material raised in this study uses Pythagorean material. In addition, this study uses a review of learning styles where learning styles can affect the problem-solving process.

Learning styles are very important in the learning process. Learning style is the most preferred way of learning in carrying out learning activities in terms of thinking and processing and obtaining new information (Damanik, 2015). Learning style is a combination of absorbing, then organizing, and processing information (Papilaya & Huliselan, 2016). There are 3 types of student learning styles, namely 1) visual learning styles, 2) auditory learning styles, and 3) kinesthetic learning styles (Wahyuddin, 2016). Each student has a unique personality that is different from other students, so the results of the problem-solving process can also vary. Based on the above problem, this study wants to describe the translational representation in understanding the Pythagorean theorem from the perspective of student learning styles.

Method

The method used in this study is a descriptive qualitative research method, because in accordance with the purpose of this study, it is to describe how the process of representation translation in understanding the Pythagorean theorem is reviewed from the learning style of students. The type of research used in this study is a type of descriptive research. The research was conducted at the State Islamic University of Mataram with a total of 85 students. The research was carried out at the end of the even semester in the 2024 academic year. The subjects used in this study were taken based on the results of a learning style questionnaire that included the categories of visual learning styles, auditory learning styles, and kinesthetic learning styles. The subject is then selected based on the answers of students who are able to solve the problems of the Pythagorean theorem.

The main instrument in this study is the researcher himself, with supporting instruments in the form of questionnaires and test instruments. The data collection technique was carried out by providing a learning style questionnaire and a Pythagorean theorem test and conducting interviews. The learning style questionnaire is distributed through Google Forms to make it easily accessible to students. This questionnaire is distributed to find students with type categories: visual learning style, auditory learning style, and kinesthetic learning style (Wahyuddin, 2016). The Pythagorean theorem test used is a description test

of 2 questions that has been validated by one of the lecturers of the Mathematics Curriculum, by paying attention to the indicators of the Representation Translation Process.

Data analysis is carried out through the following stages: 1) Data reduction is carried out to prepare data by transcribing all collected data, such as learning style questionnaires, student answers, and semi-structured interviews. Read and analyze the entire data collected. Reduce transcribed data by simplifying, grouping, and discarding unnecessary data; 2) Data presentation is carried out by presenting research data that has been reduced and presented in the form of a series of schemes from the beginning of solving the problem to finding the conclusion of the desired result; 3) Conclusions are drawn by analyzing and discussing the collected data so that the research is valid, so as to obtain conclusions to answer the formulation of the research problem, namely how the process of representation translation in understanding the Pythagorean theorem is reviewed from the student's learning style.

There are four stages of the representation translation process that are used as a reference in this study, namely (1) exploring the source, (2) coordinating the initial understanding, (3) constructing the goal of the representation target, and (4) determining the suitability of the representation of the results (Bossé et al. 2014).

Table 1. Indicators of the translation process of representation

Translation Process Representation	Translational Process Indicators Representation
Exploring sources	Reading the visual and verbal representations presented in the problem
Coordinating initial understanding	Writing down mathematical ideas in determining problem solving
Constructing the goal of the representation target	Using mathematical ideas that have been written down to find solutions to the problems presented
Determine the appropriateness of the result representation	Evaluate problem resolution

Saol Description

1. A tree with a diameter of 30 cm will be cut down and split into a wooden block with a square cross-section. Explain how to cut the trunk of the tree so that it produces the thickest block of wood. How long is the square side?
2. Dimas bought an aquarium with the size $(50 \times 60 \times 70)\ cm$. Dimas wants to decorate the aquarium by installing an ormanen rope on the diagonal of his space. Of course, the length of the ornamental rope.

Results and Discussion

Result

The results of the answers from 85 students in completing 2 descriptive questions related to the Pythagorean theorem material, the researcher classified them based on true and false answers. Students who answered incorrectly in each question given were not taken

further action, but students who answered correctly were classified based on the many types of mistakes made by students. Many students answered right and wrong shown in Table 2.

Table 2. Many students answered right and wrong

Question Number 1		Question Number 2	
True	**Wrong**	**True**	**Wrong**
35	50	52	33

In question number 1, a tree with a diameter will be cut down and split into a wooden block with a square cross-section. Students were asked to explain how to cut down trees and split them so that the thickest wooden blocks could be produced. What is the length of the square side? In the results of this test, there were 35 student answers that answered correctly and 50 answered incorrectly. Then 2 answers were selected from students representing the group who answered correctly as the research subject in question number 1.

In question number 2, an aquarium with a size that wants to be decorated by installing ornaments on the diagonal of its space. Students are asked to determine the length of the ornamental rope. In the results of this test, there were 52 student answers that answered correctly and 33 answered incorrectly. Then 1 answer was selected from the student who represented the group to answer correctly as the subject of research in question number 2. After selecting representatives from each question that are in accordance with the correct answers and learning styles, it is continued to describe the translation process of student representation in understanding the Pythagorean theorem reviewed from the student's learning style based on the indicators of the stages of the representation translation process.

Analysis of the results of solving students' mathematical problems on the Pythagorean theorem material based on the student's learning style and interviews is as follows.

Table 3. Student Learning Style Score

Name of Learning Style	Score
Visual Bejalar Style	23
Auditory Learning Style	28
Kinesthetic Learning Style	18
Have Two Learning Styles	16

1. **Student in the Visual Learning Style Category (S1)**

   S1 is a student who has a visual learning style. This can be seen from the answers given.

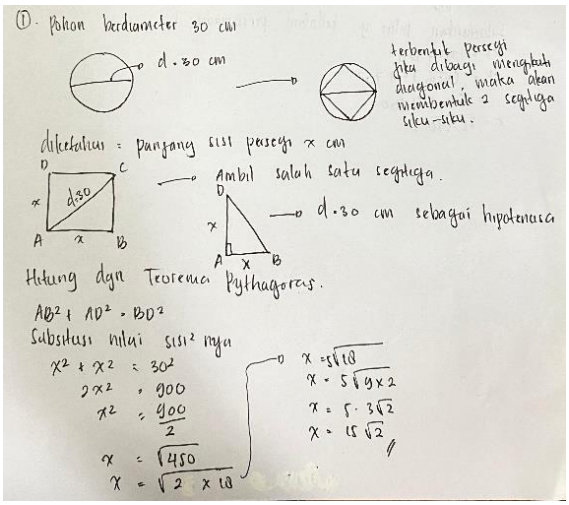

Figure 1

Based on figure 1, the data is described that S1 is able to write what is known based on the questions that have been presented. However, S1 has not been able to apply from verbal to visual and visul to symbolic. The following are the results of the interview with S1.

Researchers : *Try to explain in your own language about the questions that have been presented!*

S1 : *In this problem, a tree trunk with a diameter of 30 cm will be cut into a wooden block with a square-shaped stick, the question is to explain how to cut the tree trunk so that the thickest wooden beam can be produced, and what is the length of the square side.*

Researchers : *How do you solve the problem?*

S1 : *On the trunk of the tree which is 30cm in diameter, we make it square, we divide it according to its diagonal, then it will be in the form of 2 right triangles. In this circle trunk the length of the square side we assume to be* x *cm , then we take one of the triangles on the trunk of the tree. After that we calculate the oblique side of the right triangle using the Pythagoras theorem formula. Where the Pythagorean formula used is* $AB^2 + AD^2 = BD^2$*, After that substitute the values of the sides, e.g. , and , so that the final result is* $.AB^2 = X^2, AD^2 = X^2 BD^2 = 30^2 X = 15\sqrt{2}$

Researchers : *In the results of your answer above there is a picture, do you have to use a picture, what is the reason?*

S1 : *Yes, because it is necessary to illustrate how the tree trunk shapes and how to form a beam inside the tree trunk. So that it can make it easier for me to understand the problem and make it easier to solve the problem.*

Researchers : *Do you find it difficult to solve these problems? What kind of difficulties do you feel?*
S1 : *No, because I am confident in my answer.*

2. Students in the Kinesthetic Learning Style Category (S2)

S2 is a student who has a Kinesthetic learning style. This can be seen from the answers given

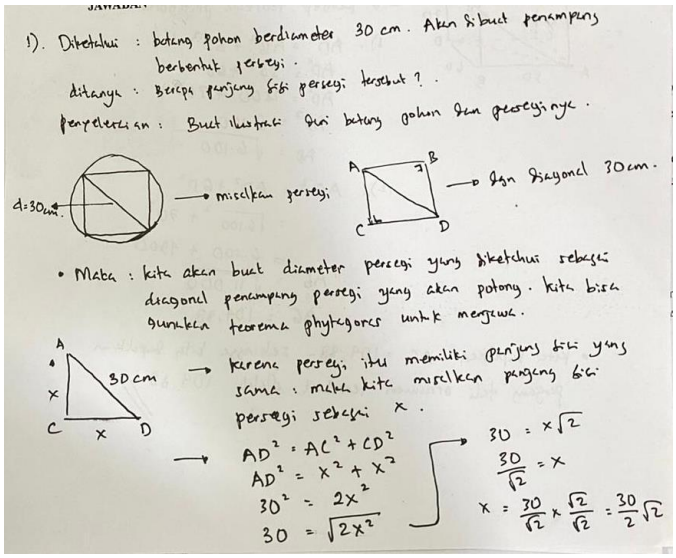

Figure 2

Based on figure 2, the data is described that S2 is able to write what is based on the questions that have been presented. However, S2 has not been able to apply from verbal to visual and visual to symbolic. The following are the results of the interview with S2.

Researchers : *Try to explain in your own language about the questions that have been presented!*
S2 : *What is known in this question is that it talks about a tree trunk that has a diameter of 30cm, this tree trunk will be cut into a wooden block with a square cross-section. After that, he was asked to explain how to cut the tree trunk to produce the thickest wooden block and was also asked how long the square side was.*
Researchers : *How do you solve the problem?*
S2 : *On a tree trunk with a diameter of 30cm, we make a square shape, we divide it along the diagonal, then it will form 2 right triangles. Since the square has the same side length, then we suppose the length of the square side is* x *cm, then we take one of the triangles on the tree trunk. After that we calculate the oblique side of the right triangle using the Pythagoras theorem formula. Where the Pythagorean formula is used i.e* $AD^2 = AC^2 + CD^2$, *. After that substitute the values of the sides, e.g. ,*

and , so that the final result is $.AD^2 = 30^2, AC^2 = X^2CD^2 = X^2X = \frac{30}{2}\sqrt{2}$

Researchers : In the results of your answer above there is a picture, do you have to use a picture, what is the reason?

S2 : Yes, the reason is to make it easier for me to calculate or solve the problem. On the other hand, from the abstract problem, we visualize the shape of the picture to make it easier for us to conceptualize it.

Researchers : Do you find it difficult to solve these problems? What kind of difficulties do you feel?

S2 : I don't think so, because by visualizing the problem into the form of a picture, it makes it easier for me to mix it up.

3. Students in the Auditory Learning Style Category (S3)

S3 is a student who has an audi learning style. This can be seen from the answers given.

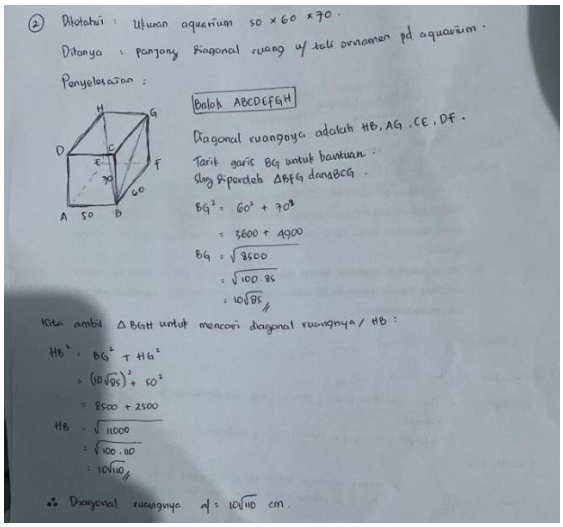

Figure 3

Based on figure 3, the data is described that S3 is able to write down what is based on the questions that have been presented. However, S3 can already apply from verbal to visual and visal to symbolic. The following are the results of the interview with S3.

Researchers : Try to explain in your own language about the questions that have been presented!

S3 : There are 3 different sizes, so I concluded that this is a rectangle with a length $70\text{m}\,cm \times 50cm$ *and height, and Dimas wants to decorate the aquarium with ornamental* $60cm$*ornaments.*

Researchers : How do you solve the above problem?

S3 : I drew an ABCDEFGH block first with an ABCD base. Here there are HB, AG, CE, DF. I want to find the diagonal of the space that

HB is by drawing the help line on BG, so that we get the triangle BGH. After the BG side, GH is known, we find the diagonal of the space using the Pythagorean theorem with the oblique side HB, because BG is already known, it is only necessary to substitute it continuously so that it obtains HB is $10\sqrt{110}$. *So the diagonal of the space is* $10\sqrt{110}\ cm$.

Researchers : *You use BG, can you use another line.?*
S3 : *Yes, in addition to BG we can also use HA, so later the triangle is ABH*
Researchers : *Do you find it difficult to solve these problems? What kind of difficulties do you feel?*
S3 : *It can be said that it is quite difficult, because you have to imagine the right formula to use.*

Discussion

In the process of exploring sources, students with visual learning styles, auditory learning styles, and kinesthetic learning styles have met the indicators of the representation translation process, namely reading verbal and visual representations presented in problems. Of the three learning styles, there is no difference in the results of the answers; the three perform verbal-to-visual representations in the form of images to make it easier to interpret mathematical ideas. This is in line with Rahmawati & Anwar (2020), which states that reading ability can result in being able to understand problems well.

In the process of coordinating initial understanding, students with visual learning styles, auditory learning styles, and kinesthetic learning styles have met the indicators of writing mathematical ideas in determining problem solving. Students are able to interpret mathematical ideas as a form of initial understanding in the form of symbols and mathematical models. Students also write in detail, that is, what is known and asked. In the third answer, the student has a translation of visual repression to symbolic, namely in the form of a known image and solving problems using the Pythagorean theorem formula. This is in line with Mahmud & Pratiwi (2019), which states that the ability to apply symbols and numbers in solving problems will result in the correct conception or result.

The process of constructing the goal of the representation target, students with visual learning styles, auditory learning styles, and kinesthetic learning styles have met the indicators using mathematical ideas that have been written to find solutions to the problems presented. Students can use the mathematical ideas written down to determine solutions and understand concepts and write down the solutions of the given problems. This is in line with Zukhrufurrohmah & Putri (2019), who stated that students were aware of the difference in completion symbols and noticed that the symbols involved had a certain meaning.

In the process of determining the suitability of the representation of the results of constructing the target goal of the representation, students with visual learning styles, auditory learning styles, and kinesthetic learning styles have met the indicators of evaluating problem solving because students can write down the final results and conclusions of the

solutions shown. This is in line with what Syawahid et al. (2017) stated: that the correct result of solving the problem was due to the correctness of decision-making.

Limitations

This study has proven that students have experienced success in solving Pythagorean theorem problems because they have succeeded in translating verbal to visual and visual to symbolic representations. However, the researcher realized that there are limitations that can be recommended for future research, namely that the research sample may be limited to certain populations, such as students from one generation or a certain university. This can limit the generalization of research results to a wider population with different characteristics; causal-comparative research has limitations in establishing strong causal relationships, and the existence of uncontrolled related variables can affect students' learning styles, such as the level of parental education, teaching quality, and learning environment.

Conclusion

This study has proven that students have successfully solved Pythagorean theorem problems because they are able to carry out the translation process from verbal to visual representation and from visual to symbolic. This indicates that understanding concepts and the ability to change information in various forms of representation have a great influence on success in solving mathematical problems. This study also indicates that the success is influenced by the learning style of each student. By understanding and utilizing appropriate learning styles, students can be more effective in processing information and solving mathematical problems. Thus, the development of these translation skills can be a focus in mathematics learning to improve students' understanding and abilities.

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