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PATOGE geometry transformation board: A teaching aid to enhance junior high school students' conceptual understanding

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ABSTRACT

Geometric transformation is a vital mathematics topic that should be learned at the junior high school level. Students often consider This material difficult because it is abstract and lacks concreteness. One effort to overcome this difficulty is by using teaching aids. This study aims to develop a geometric transformation board teaching aid to improve the conceptual understanding of 9th-grade junior high school students. This research employs a research and development method. The research sample consists of 17 9th-grade junior high school students. The results show that using the geometric transformation board teaching aid can enhance the conceptual understanding of 9th-grade students. The average student learning outcomes evidence this increase from 57.65 to 79.41. This study implies that PATOGE can effectively make abstract mathematical concepts more concrete and easier to understand.

Papan transformasi geometri PATOGE: Alat peraga untuk meningkatkan pemahaman konsep siswa SMP

Kata Kunci:

Pemahaman konsep
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Pendidikan matematika
Hasil belajar siswa
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ABSTRAK

Transformasi geometri merupakan salah satu materi matematika yang penting untuk dipelajari di tingkat SMP. Materi ini sering dianggap sulit oleh siswa karena abstrak dan kurang kongkret. Salah satu upaya untuk mengatasi kesulitan ini adalah dengan menggunakan alat peraga. Penelitian ini bertujuan untuk mengembangkan alat peraga papan transformasi geometri untuk meningkatkan pemahaman konsep siswa kelas IX SMP. Penelitian ini menggunakan metode penelitian dan pengembangan. Sampel penelitian adalah 17 siswa kelas IX SMP. Hasil penelitian menunjukkan bahwa penggunaan alat peraga papan transformasi geometri dapat meningkatkan pemahaman konsep siswa kelas IX SMP. Hal ini dibuktikan dengan peningkatan nilai rata-rata hasil belajar siswa dari 57,65 menjadi 79,41. Penelitian ini berimplikasi bahwa PATOGE dapat menjadi alat yang efektif dalam membuat konsep matematika abstrak menjadi lebih konkret dan mudah dipahami.

1. INTRODUCTION

Mathematics is one of the most important subjects, this learning is given from the elementary school level. Mathematics has an important role in the development of science, technological progress and the success of educational programs [1]. A realistic mathematics approach provides hope for education in Indonesia to improve students'

mathematical abilities and mathematics learning achievement [2]. If students have not mastered the basic concepts in understanding mathematics, the expected learning objectives will not be achieved and students will experience difficulties solving mathematical problems [3]. Students with strong conceptual knowledge or strong linking ability can devise a solution for a given mathematical problem [4]. If students have difficulty understanding the material, then students will also have difficulty solving questions related to the material [5]. With technological developments in education, innovations in mathematics education learning will be able to be created [6]. Mathematics education provides students with skills in calculating and forming a basic conceptual understanding of material [7]. Students tend to only memorize the material, do not understand the essence of the meaning of the material, and do not even know the application of learning material in the real world [8]. This understanding can help develop analytical and problem-solving skills.

The importance of learning mathematics requires that the learning process be interactive, inspiring, fun, and challenging, motivate students to participate actively, and provide sufficient space for initiative, creativity and independence by talents, interests and physical and psychological development [1]. Interactive mathematics learning involves students in learning activities, discussions and understanding concepts [9]. Technology-based mathematics learning is expected to display exploratory visualization and be more interactive so that students can easily understand mathematics material that requires visual displays [10]. With technology-based interactive mathematics learning, it is hoped that students will become enthusiastic in studying mathematics [11]. However, in reality, many students are less enthusiastic about learning mathematics and consider mathematics to be a difficult and scary subject [12]. In the research conducted, the results of interviews with class IX Middle School (SMP) students showed that they experienced difficulties in understanding geometric transformation material because the learning method used was a lecture method accompanied by explanations and distribution of tasks and exercises.

Geometric transformation is a discussion in geometry regarding changes in shape, location and presentation based on an image and matrix [13]. Also, geometric transformation materials are essential in various fields, such as architecture, engineering and design. Understanding the concept of geometric transformations is essential to students' success in learning this material. Geometric transformations are also related to various mathematical materials such as trigonometry, linear algebra and analytical geometry [14]. However, geometric transformation concepts can be abstract and complex for students to understand [13]. This difficulty can be seen in solving geometric transformation material problems [14].

Based on the problems above, appropriate learning media are needed to help students understand these concepts. One way to improve understanding of the concept of geometric transformation is to use teaching aids as a form of effort that can be made to understand the concept of geometric transformation [15]. This teaching aid is used as a visualization to make it more exciting and help students understand the material presented [16]. Mathematical teaching aids can be defined as a set of concrete objects designed, made arr, and deliberately and used to help instil and understand concepts or principles in mathematics [17]. Teaching aids can give students concrete and visual understanding to more easily understand abstract concepts [18].

Based on the description and explanation above, research will be carried out with the development of geometric transformation board teaching aids. This development research aims to increase understanding of geometric transformations, which are difficult for students to understand. This prop is made using materials that are readily available and

affordable. The geometric transformation board teaching aid consists of two main parts, namely the coordinate board and the transformation tools. The coordinate board is square with dimensions 30 x 30 cm. The transformation tools used are yellow squares, black squares, reflection mica, rotation arcs, role ID cards, dilated antennas, and magnets. The geometric transformation board props are used in learning geometric transformations in class IX of junior high school.

In classroom learning, one of the ways students can have high interest is by presenting teaching aids as a tool to generate students' interest in learning [19]. Students can explore how to determine formulas using these teaching aids according to the independent curriculum [20]. Students' difficulty in applying reflection, translation, rotation and dilation formulas in geometric transformation material for class IX junior high school students is a problem for them. From this problem, we have a way to help students learn about formulas for geometric transformation material by using mathematical teaching aids, namely "PATOGE (Geometry Transformation Board)". With this teaching aid, it is hoped that mathematics learning on geometric transformations can be mastered easily, fun and creatively for students.

This research was conducted on class IX junior high school students. Class IX junior high school students experience difficulty understanding the concept of geometric transformations in mathematics learning. Therefore, this development research was carried out with the hope and aim of solving the problems currently being experienced by students in class IX-A junior high school. The results of this research will show the influence of the development of this geometric transformation board teaching aid in increasing students' understanding of concepts in class IX-A junior high school regarding geometric transformation material.

The PATOGE that the researcher made was inspired by the geometric transformation mathematics teaching aids made by Moh. Fernando, Fatkhul Khoiru R., Teguh Sumadi, Annisa Nur Aini, and Nabila Zahida are researchers of the modification of this teaching aid, namely a board made using layers of iron plate and all objects that will be transformed using magnets. The advantage of the props we make is that the geometric transformation board is not easily damaged because it is attached using a magnet. Flexible because the components can be changed according to question requests.

Research on the use and development of teaching aids to enhance students' conceptual understanding has been extensively conducted, including the implementation of the TPS model with the aid of teaching tools to enhance conceptual understanding [1], fraction board media to enhance conceptual understanding [21], the development of audiovisual media and teaching aids to enhance conceptual understanding [22], the development of the fun fraction set teaching aid to enhance conceptual understanding [23], teaching aids as an effort to enhance conceptual understanding [24], and manipulative object teaching aids to enhance conceptual understanding [25]. However, there has been no research on developing transformation board teaching aids to improve students' conceptual understanding.

This study aims to develop a geometric transformation board teaching aid to enhance students' conceptual understanding. In previous research, teaching aids such as fraction boards were used, whereas in this study, the focus is on geometric transformations. Therefore, this research aims to fill the gap in studies on developing teaching aids as learning media.

Contribution to the literature
This research contributes to:
- Providing empirical evidence showing a significant improvement in students' understanding of geometric transformations, with the average scores notably increasing after using the PATOGE tool.
- Demonstrating the effectiveness of using visual aids to make abstract mathematical concepts such as reflection, rotation, translation, and dilation more concrete and easily understood by students.

2. METHOD

This research was conducted to obtain accurate data and information. The development method is called Research and Development (R&D) research. This research uses an approach that refers to the ADDIE development model. Population is the total number of research subjects. Meanwhile, the sample is part of the number and characteristics of the population. Sampling occurs when the population is large, and the researcher cannot possibly study everything in the population [23]. Research can use samples taken from this population. The samples in this research were 17 students in class IX-A of SMP Muhammadiyah 5 Surakarta. This type of research is Research and Development with the ADDIE model. Data collection techniques use observation and tests. The developer chose the ADDIE research model because the product being developed is a learning medium, not software engineering, so the ADDIE method is suitable for the product development process [26]. ADDIE's idea is to receive continuous feedback while developing learning materials. With this model, it is hoped that it can save time and costs by catching problems when they can still be corrected [27]. Study the stages are explained in Figure 1.

Figure 1. Explanatory Design

At the analysis stage, researchers reviewed literature on teaching aids, geometric transformations, and mathematics learning. Researchers also interviewed mathematics teachers and observed mathematics learning in class IX of junior high school. There is a lack of use of mathematics learning media that can make the learning process student-centred, and the teacher's role is only as a facilitator [28]. At the design stage, the researcher created a design for a geometric transformation board prop. The geometric transformation board props have two parts: the coordinate board and the transformation props. Meanwhile, transformation props consist of four types: reflection, rotation, translation and dilation.

At the development stage, the researcher made a prototype of a geometric transformation board prop according to the design that had been made. The prototype was then tested on class IX junior high school students for feedback. Student feedback improves the prototype to better suit students' needs. At the implementation stage, the researcher implemented a geometric transformation board teaching aid in mathematics learning in class IX of junior high school. Mathematics learning using geometric transformation board props is carried out for 1 meeting.

Awareness of evaluation is one step towards improvement because evaluation can provide a more comprehensive approach to providing information to education to help improve and develop the education system [29]. At the evaluation stage, the researcher evaluated the effectiveness of the geometric transformation board teaching aid in improving the concept understanding of class IX SMP students. The results of the learning outcomes test show an increase in students' understanding of concepts after using the geometric transformation board teaching aid [30]. Researchers with students in class IX-A carried out the trial stage. The trial was carried out once during the research and development process. The trial was carried out using the experimental method at the implementation stage.

3. RESULTS AND DISCUSSION

This research uses the ADDIE model. Based on the trial data that has been presented, the following are the results of the analysis and test results according to the ADDIE method.

3.1 Analysis

The results of the analysis of interview activities conducted by researchers with class IX teachers can be concluded that in the mathematics learning process, teachers have never used mathematics teaching aids, and there are no mathematics teaching aids available that facilitate students' concept understanding skills. Understanding concepts is memorizing and studying concrete examples so students can define themselves or information [21]. The teacher explained that it was necessary to develop mathematics teaching aids because students' interest in learning mathematics was very low, and student's understanding of concepts was still challenging to achieve using lecture and group discussion methods. Apart from conventional methods, mathematical concepts can be conveyed using tools or media that are culturally easy for students to understand. This cultural learning of mathematics can be linked to ethnomathematics [31].

3.2 Design

The design of the geometric transformation board teaching aid aims to make it easier for students to understand the concept of geometric transformation and the process behind the existence of a formula. Thus, the design of the tool has the following design.

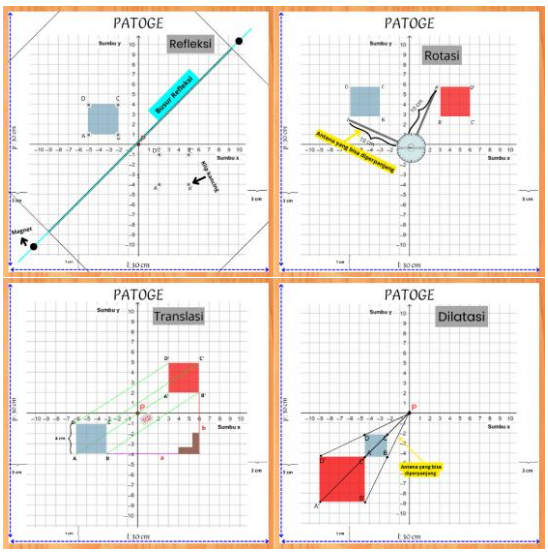
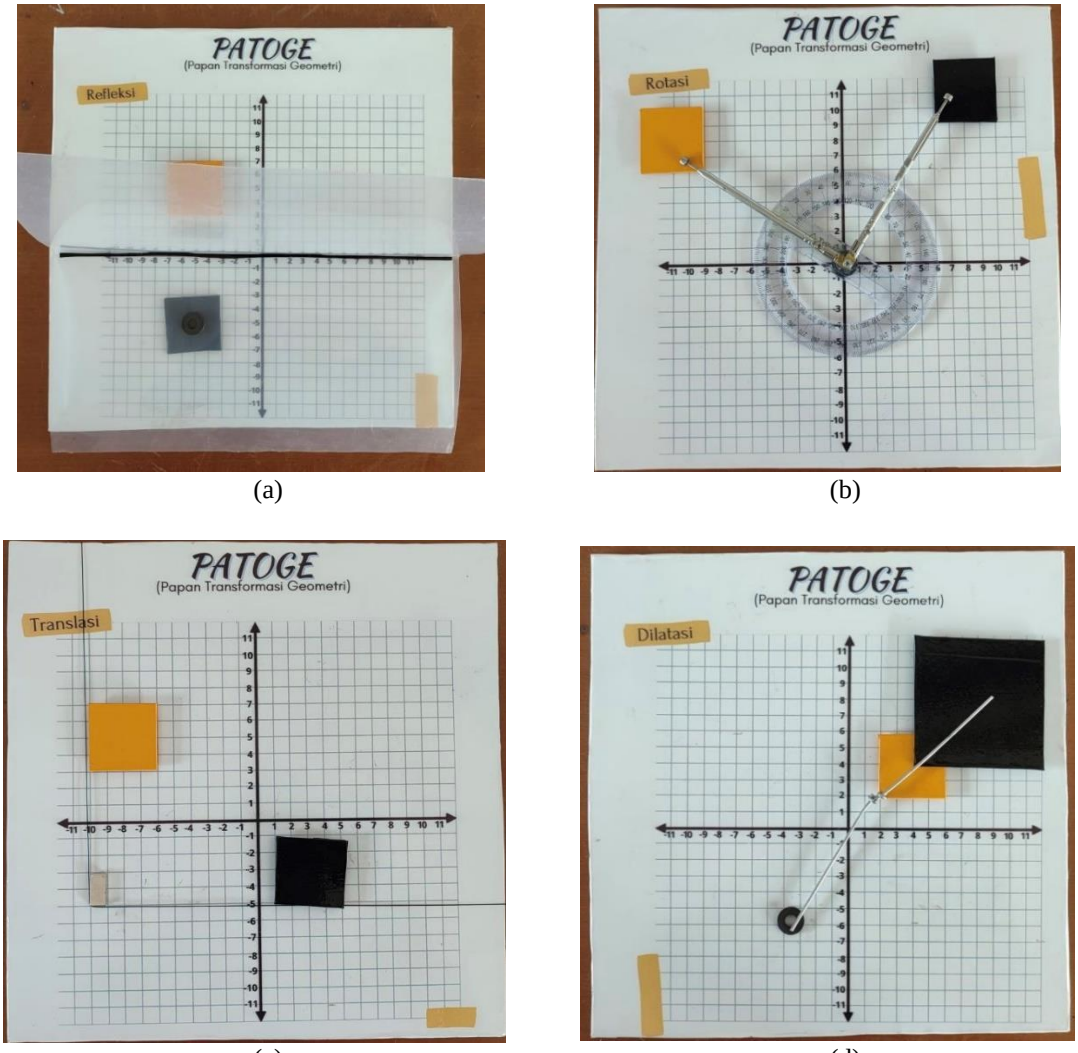


Figure 2. Geometric Transformation Board Design

Based on the design of the geometric transformation board that has been created, it can make it easier for students to use. In this way, one class is divided into four groups, each using one tool and taking turns continuously so that the entire group uses all the tools.

3.3 Development

At this stage, the researcher makes a prototype of the geometric transformation props according to the design created. Based on the design results, the geometric transformation board display is as follows.



(a) (b)

(c) (d)

Figure 3. (a) Reflection Board Display, (b) Rotation Board View, (c) Translation Board View, and (d) Dilation Board View

At this stage of developing geometric transformation teaching aids, two important goals need to be achieved: producing or revising teaching aids to achieve formulated learning objectives and choosing the best teaching materials to achieve learning objectives.

The point that needs to be obtained in making these teaching aids is the form of props that must be made and modified to meet the learning objectives. The tool validation from the validator has no revisions, and the tool is suitable for use.

3.4 Implementation

The PATOGE props were then tested through a four-stage process. The first stage was a pre-test, presenting five questions covering cognitive levels C1-C3. This test was administered at SMP Muhammadiyah 5 Surakarta on November 23, 2023. The treatment phase occurred on Thursday during class IX A's 5th and 6th hours. Students were divided into four groups during this phase, each receiving four props boards for testing. The post-test stage followed, where students answered ten questions with cognitive levels C1-C3 using the teaching aids. Finally, students filled out a questionnaire to assess the effectiveness of the teaching aids in helping them understand the concept of geometric transformations.

(a)

(b)

(c)

(d)

Figure 4. (a) Distribution of Pre-Test Questions, (b) Testing of Props with Students, (c) Post-Test Implementation, and (d) Filling out the Student Response Questionnaire

The implementation stage in this research is the stage for implementing the teaching aids developed in real classroom situations. It starts with the pre-test, which is used to determine students' abilities before using the props and testing them, and the post-test, which is used to determine changes in students' understanding before and after using the geometric transformation board props. Then, a student response questionnaire was created as a means for students to provide input on the geometric transformation board teaching aids.

3.5 Evaluation

In this research, the stages in the evaluation include pre-test results, testing the PATOGE props, and post-test results. The PATOGE teaching aid that has been created is then tested. Testing was carried out to ensure that the teaching aids could make it easier for students to understand the concept of geometric transformations. Using the scores

obtained by students who did not use props:

Table 1. Student Pre-Test Scores Before Using Props PATOGE

Score Pre-Test	0	20	40	60	80	100
The number of students	1	1	5	5	2	3

Table 1 shows the value of carrying out a trial (pre-test) before using the geometric transformation board teaching aid. Meanwhile, below is a presentation of student scores from the post-test results using the geometric transformation board props:

Table 2. Student Post-Test Scores After Using Props PATOGE

Score Post-Test	50	60	80	90	100
The number of students	2	3	2	9	1

The research results show that the use of geometric transformation board teaching aids can improve students' understanding of concepts in class IX-A of SMP Muhammadiyah 5 Surakarta in geometric transformation material. This can be seen from the results of student learning outcomes tests, which show that students' scores after using the geometric transformation board teaching aids have a higher average learning outcomes test score than students' scores before using the geometric transformation board teaching aids.

The increase in students' understanding of concepts after using the geometric transformation board teaching aid can be caused by several factors. The geometric transformation board props can provide students with a concrete and visual understanding of the concept of geometric transformation because they can be used to demonstrate various types of geometric transformations, such as reflection, rotation, translation, and dilation. Additionally, these props can increase student activity in learning, as students can be actively involved in the learning process by using them. They also help students understand the relationship between concepts in geometric transformation material, as the teaching tool can be used to apply various geometric transformation concepts in different situations. Furthermore, these teaching aids can improve memory for geometric transformation material; with PATOGE, students will gain a clear visual experience regarding completing geometric transformation material. Finally, the geometric transformation board props can increase students' interest in mathematics and eliminate the perception that learning mathematics is difficult and scary.

This research aligns with previous studies that developed board-based learning media to enhance conceptual understanding. For example, the study conducted by Cardoso et al. on the development of the educational board game UnSaLuDo demonstrated that unconventional learning aids, such as board games, can effectively increase student engagement and their understanding of complex scientific concepts [32]. UnSaLuDo, designed to teach the concepts of unsaturated soil mechanics, provides an interactive and enjoyable learning experience in the classroom environment. Similarly, this study develops the PATOGE to help students understand abstract geometric transformations more concretely and visually. Both studies demonstrate that board-based learning media can enhance conceptual understanding by making abstract material more accessible and understandable to students.

Based on the results of this research, it can be concluded that using geometric transformation board teaching aids is an effective learning strategy for increasing students' understanding of concepts in geometric transformation material. Here are some suggestions to increase the effectiveness of using geometric transformation board teaching

aids in learning. Teachers need to provide a clear and systematic explanation of the concepts in geometric transformation material before using teaching aids to ensure that students have a strong fundamental understanding of these concepts. Additionally, teachers should offer guidance and direction to students in using teaching aids, ensuring that they are used correctly and optimally. Furthermore, teachers should provide opportunities for students to practice using these teaching aids so that they can understand the concept of geometric transformations in depth. By implementing these suggestions, it is hoped that using geometric transformation board teaching aids can be more effective in increasing students' understanding of concepts in geometric transformation material.

4 CONCLUSION

From the explanation above, it can be concluded that using geometric transformation board teaching aids is an effective learning strategy for increasing students' understanding of concepts in geometric transformation material. Based on this research, in the future, it is hoped that mathematics teachers, especially class IX mathematics teachers, can use geometric transformation board teaching aids in the learning process because it has been proven through this research that geometric transformation board teaching aids help students to understand the concept of geometric transformation more efficiently and fun. This is evidenced by the increase in the average value of student learning outcomes from 57.65 to 79.41. This research implies that PATOGE can effectively make abstract mathematical concepts more concrete and easier to understand.

AUTHOR CONTRIBUTION

MW provided direction and guidance in topic development, assisting in writing and editing, and providing input regarding relevant references and literature. ZN contributed to writing articles, analyzing research methods, collecting and processing data, conducting data analysis, and compiling the results and discussion sections.

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