



Development of Rotational Symmetry Media Using Project-Based Learning to Enhance Mathematical Understanding

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Submitted: 16-06-2025

Revised: 17-06-2025

Accepted : 19-06-2025

Published: 20-06-2025

ABSTRACT

This research is motivated by the low level of mathematical concept understanding among elementary school students. The aim of this study is to investigate the improvement in mathematical concept understanding in third-grade students on the topic of rotational symmetry, taught using a rotational symmetry board media and Project-Based Learning (PBL). The method employed is Research and Development (R&D) to develop a learning media designed to assist students in solving problems related to this material. The study was conducted at Budi Asih Elementary School, where the students exhibit low mathematical concept understanding. The subjects of this study are third-grade students, divided into a limited trial class with 10 students and an extended trial class with 20 students. The instruments used to gather research data include non-test methods such as documentation study, teacher interviews, questionnaires for teachers and students, media validation, content validation, practitioner validation, observation, and a test with 5 questions assessing students' mathematical concept understanding in rotational symmetry. These instruments were then tested for validity, reliability, difficulty index, and discriminating power. The results indicate that there was an improvement in students' mathematical concept understanding in the rotational symmetry topic using the rotational symmetry board media with Project-Based Learning, as shown by the average pretest and posttest results in both the limited and extended trial classes.

Keywords: rotational symmetry board media; project-based learning; mathematical concept understanding

INTRODUCTION

Mathematics is one of the subjects taught at the elementary school level that must be understood by every student, as it significantly influences daily life. The goal of mathematical concept understanding is for students to be able to utilize and apply each concept they have learned (Komarudin et al., 2020). Students are able to provide clear and definite answers to mathematical questions if they have a solid understanding of mathematical concepts.

Learning activities for elementary school students cannot be fully comprehended unless they are practiced directly with the students. This can also lead to students being unable to understand mathematical concepts because their learning experiences are not engaging, making it difficult to remember. Therefore, mathematics instruction for elementary students should be tangible and concrete.

The learning process becomes more tangible when learning media is used as an instructional aid. In addition to making learning more meaningful, learning media can engage students actively in the classroom and make lessons more enjoyable, thus preventing boredom during lessons. Learning media is not only beneficial for students but also for

teachers. When teachers use learning media, the material being taught becomes easier to deliver and more comprehensible for students. The learning media used in instruction must align with the material being taught to ensure that learning objectives are achieved effectively. Furthermore, concrete learning experiences are more memorable and easier for students to retain.

The rotational symmetry board is classified as a type of visual media with a rectangular shape, used to calculate the number of rotational symmetries in a plane figure, equipped with decorative images (Wahdaniyah, 2018). According to (Gunawan, 2013), a rotational symmetry board is a board that contains various flat shapes, each framed in a way that allows them to be rotated a full turn, aiming to help students understand the concept of rotational symmetry. Another perspective, according to (Setyaning, 2013), defines the rotational symmetry board as a tool used to help students understand the abstract concept of rotational symmetry. Based on these perspectives, it can be concluded that a rotational symmetry board is a rectangular learning medium, equipped with flat shapes that students can use to calculate the number of rotational symmetries a plane figure possesses.

According to (Murniarti, 2017), Project-Based Learning (PjBL) is a teaching method that involves real-world problems through project-based activities. (Sari & Angreni, 2018) further define Project-Based Learning as a learning process where students are directly involved in producing a project. Meanwhile, (Surya et al., 2018) describe Project-Based Learning as an innovative student-centered teaching method, where students are given the opportunity to independently organize their learning, while the teacher acts as a motivator and facilitator. Based on these various definitions, it can be concluded that Project-Based Learning (PjBL) is a learning approach based on real-world problems that directly involves students, with the final learning outcome being a product or work created by the students.

According to the Ministry of National Education (Depdiknas), (Kesumawati, 2008), conceptual understanding is a mathematical ability that can be achieved in learning by demonstrating an understanding of the mathematical concepts learned, explaining the interconnections, and applying the concepts flexibly, accurately, efficiently, and appropriately in problem-solving. Another perspective, according to (Kristanti, 2019), defines conceptual understanding as a fundamental skill that students must possess as a foundation to solve problems and help students understand subsequent material, since mathematics learning is hierarchical. Meanwhile, (Rosida, 2019) states that conceptual understanding is an important goal in mathematics education, where students are not only required to memorize or remember concepts but also to explain the concepts they have learned, so that they can better grasp the meaning of the material being studied. Based on these explanations, it can be concluded that mathematical concept understanding is essential for students in mathematics learning to solve problems and to help students comprehend the material, enabling them to understand subsequent topics.

RESEARCH METHODS

The research design used in this study is Research and Development (R&D). According to Borg and Gall (Sugiyono, 2019), Research and Development is a process or method used by researchers to validate and develop products. This development research aims to address the need for tools that can assist teachers in delivering lessons in the

classroom. This study was modified according to the researcher’s needs into 8 stages: data collection and search, planning, developing the initial product prototype, product validation, limited trial, revision of limited trial results, wider trial, and final product. The subjects in this study for the limited trial class were 10 third-grade students, while the extended trial class consisted of 20 third-grade students from an elementary school.

RESULTS AND DISCUSSION

The validity was conducted by three experts: an expert in media, an expert in content, and a practitioner expert.

Table 1. Content Expert Validity Results

Question Number	Score	Scale of Agreement Gradation
1.	3	Good
2.	3	Good
3.	3	Good
4.	4	Very Good
5.	2	Fairly Good
6.	4	Very Good
7.	3	Good
8.	2	Fairly Good
9.	4	Very Good
10.	3	Good
11.	3	Good
12.	3	Good
Total Score	37	

Based on the data above, it can be concluded that the results obtained from the content expert validation, based on 12 statements provided with a maximum score of 4 for each statement, yielded a total score of 37. The percentage result was 80%, which is categorized as "very good." The content expert concluded that the material is deemed appropriate to be used in elementary school teaching without revisions.

Table 2. Media Expert Validity Results

Question Number	Score	Scale of Agreement Gradation
1.	4	Very Good
2.	2	Fairly Good
3.	4	Very Good
4.	3	Good
5.	4	Very Good
6.	2	Fairly Good
7.	2	Fairly Good
8.	3	Good
9.	3	Good
10.	4	Very Good
11.	4	Very Good
12.	4	Very Good
13.	3	Good
14.	3	Good
15.	2	Fairly Good
16.	3	Good

17.	3	Good
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Based on the data above, it can be concluded that the media validity, based on 17 statements provided with a maximum score of 4 for each statement, resulted in a total score of 53. The percentage result was 77%, categorized as "good." The media expert concluded that the media is suitable to be used in elementary school teaching without revisions. The revision suggested was the addition of materials that would strengthen the media to prevent it from being easily damaged.

Table 3. Practitioner Validity Results

Question Number	Score	Scale of Agreement Gradation
1.	3	Good
2.	3	Good
3.	3	Good
4.	4	Very Good
5.	4	Very Good
6.	4	Very Good
7.	4	Very Good
8.	3	Good
9.	4	Very Good
10.	3	Good

Based on the data above, it can be concluded that there were 10 statements provided, each with a maximum score of 4, resulting in a total score of 35, with a percentage of 87%, categorized as "very good."

Student Response Questionnaire Results

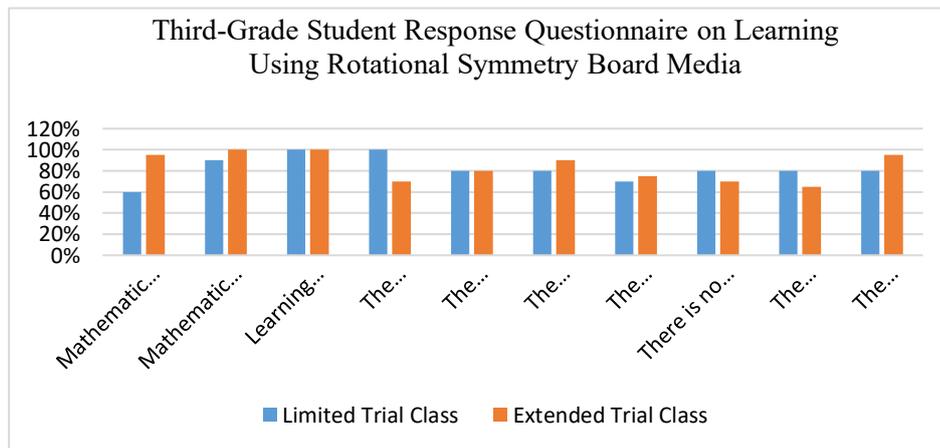


Figure 1. Student Response Questionnaire Results

Based on Figure 1, it can be concluded that in the limited trial class, where the student response questionnaire was completed by 10 students, the results indicate that 60% of students prefer mathematics over other subjects, 90% of students believe that mathematics is not boring, 100% of students think that learning mathematics is very useful in daily life, 100% of students believe that the topic of rotational symmetry in mathematics is easier to understand when using the rotational symmetry board media, 80% of students find the

rotational symmetry board media interesting, 80% of students agree that the appearance of the rotational symmetry board media is very attractive and easy to use, 70% of students think that learning mathematics with this media is beneficial, 80% of students believe that learning mathematics this way is different from traditional teaching methods, 80% of students find the rotational symmetry board media easy to use and understand, and finally, 80% of students agree that the material presented aligns well with the learning media.

Meanwhile, for the extended trial class, where the questionnaire was completed by 20 students, the results show that 95% of students prefer mathematics over other subjects, 100% of students believe that mathematics is not boring, 100% of students think that learning mathematics is very useful in daily life, 70% of students find the topic of rotational symmetry easier to understand when using the rotational symmetry board media, 80% of students find the rotational symmetry board media interesting, 90% of students believe that the appearance of the rotational symmetry board media is very attractive and easy to use, 75% of students think that learning mathematics with this media is beneficial, 70% of students believe that learning mathematics this way is different from traditional teaching methods, 65% of students find the rotational symmetry board media easy to use and understand, and finally, 95% of students agree that the material presented aligns well with the learning media.

Recent studies highlight the effectiveness of interactive learning media in mathematics education. Research shows that digital tools like interactive puzzles can stimulate student engagement and understanding, with 80% of students responding positively (Ramlah, 2022). Similarly, specialized media like siputspin for rotational symmetry and autograph for geometric transformations have been found to enhance student comprehension and motivation (Maulani, 2020; Pencawan et al., 2024). These media make abstract concepts more tangible and enjoyable for students. Furthermore, interactive learning media have demonstrated significant improvements in student learning outcomes and motivation in trigonometry, with 83% of students reporting enhanced learning support and motivation (Saepuloh et al., 2022). Across these studies, students consistently reported finding mathematics less boring and more relevant to daily life when using interactive media. These findings suggest that incorporating such media into mathematics instruction can lead to more engaging and effective learning experiences.

Student Pre-Test and Post-Test Results

Table 4. Average Results of Third-Grade Students on Rotational Symmetry of Plane Figures in the Limited Trial Class

		Paired Samples Statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Test Uji Terbatas	36.00	10	15.776	4.989
	Post Test Uji Terbatas	80.00	10	9.428	2.981

Based on Table 4, the average pre-test score obtained was 36.00, while the average post-test score was 80.00. A total of 10 students participated in this study. It can be concluded

that there is a significant difference in the average learning outcomes in the limited trial class, as the average pre-test score (36.00) is lower than the average post-test score (80.00).

Table 5. Average Results of Third-Grade Students on Rotational Symmetry of Plane Figures in the Extended Trial Class

		Paired Samples Statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre Test Uji Luas	30.00	20	16.543	3.699
	Post Test Uji Luas	88.00	20	11.965	2.675

Based on Table 5, the average pre-test score obtained was 30.00, while the average post-test score was 88.00. A total of 20 students participated in this study. It can be concluded that there is a significant difference in the average learning outcomes in the extended trial class, as the average pre-test score (30.00) is lower than the average post-test score (88.00).

Effectiveness of Using Rotational Symmetry Board Media

The effectiveness of using this media was tested using the N-Gain test. Below are the results of the test,

Table 6. Results of the N-Gain Score Calculation

No.	Limited Trial Class N-Gain Score (%)	No.	Extended Trial Class N-Gain Score (%)
1.	33.33	1.	75.00
2.	66.67	2.	100.00
3.	66.67	3.	66.67
4.	66.67	4.	100.00
5.	66.67	5.	50.00
6.	50.00	6.	100.00
7.	66.67	7.	100.00
8.	66.67	8.	50.00
9.	80.00	9.	50.00
10.	100.00	10.	100.00
		11.	100.00
		12.	75.00
		13.	75.00
		14.	100.00
		15.	50.00
		16.	66.67
		17.	100.00
		18.	75.00
		19.	75.00
		20.	100.00
Mean	66.3333	Mean	80.4167
Min.	33.33	Min.	50.00
Max.	00.00	Max.	100.00

Based on Table 6, the N-Gain test results for the limited trial class show that the average N-Gain score is 66.3333 or 66.3%, which falls into the fairly effective category. The

minimum score obtained was 33.33, and the maximum score was 100.00. Furthermore, the N-Gain test results for the extended trial class show that the average N-Gain score is 80.4167 or 80.4%, which falls into the effective category. The minimum score obtained was 50.00, and the maximum score was 100.00.

The N-Gain test is widely used to evaluate the effectiveness of educational interventions. Studies have shown varying results across different contexts. (Triyono et al., 2024) found both think-pair-share and conventional methods "ineffective" for improving geometry learning outcomes, with N-Gain scores below 40%. Conversely, (Fatya Dewi Mayada et al., 2024) reported 100% N-Gain for an expository learning model, indicating high effectiveness. (Sesmiyanti, 2019) observed moderate effectiveness (N-Gain 0.43) for a Basic Reading textbook in improving reading skills. (Kristina Maisaroh et al., 2023) demonstrated high effectiveness of smart card learning media for enhancing reading skills, with N-Gain scores of 0.77 and 0.79 for wider and limited class scales, respectively. These studies highlight that N-Gain scores can vary significantly depending on the intervention, subject matter, and student population, ranging from ineffective to highly effective across different educational settings and methodologies.

CONCLUSION

Based on the results of validation from experts and practitioners, the rotational symmetry board media using Project-Based Learning is deemed suitable for use in teaching the rotational symmetry material for third-grade elementary school students. The validation results obtained from the content expert were 80% with a "very good" rating, the media expert validation was 77% with a "good" rating, and the practitioner validation was 87% with a "very good" rating. The teaching of rotational symmetry material using the rotational symmetry board media with Project-Based Learning received positive responses from students. This is evident from the results of the questionnaire completed by the students.

Students' mathematical concept understanding improved, particularly in the topic of rotational symmetry using the rotational symmetry board with Project-Based Learning. This is reflected in the average pre-test and post-test results, which showed improvement in both the extended and limited trial classes. The average pre-test score was 36.00, and the post-test score was 80.00 in the limited trial class, while in the extended trial class, the average pre-test score was 30.00, and the post-test score was 88.00.

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