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Development of Media for A Rotating Wheel Protocol for Volume and Surface Area of Flat-Sided Spacious Figures for Grade IX MTs Tarbiyatul Islamiyah

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ABSTRACT

Mathematics learning, particularly on the topic of volume and surface area of polyhedrons, remains challenging due to students' limited conceptual understanding and the lack of concrete instructional media. This study aimed to develop a rotating wheel teaching aid that meets the criteria of validity, practicality, Universitas Nurul Jadid, Indonesia and effectiveness for Grade IX students at MTs Tarbiyatul Islamiyah. The study employed a Research and Development (R&D) approach using the Four-D (4D) model, consisting of the Define, Design, Develop, and Disseminate stages. The product was tested on 10 ninth-grade students. Data were collected through validation sheets, student response questionnaires, and learning achievement tests, and were analyzed using descriptive quantitative and qualitative methods. The results showed that the developed teaching aid achieved a validation score of 4.02 (very valid), while the student response questionnaire and achievement test obtained validation scores of 3.05 and 3.02, respectively (valid). The practicality of the media was indicated by an average student response score of 3.56 (high), whereas its effectiveness was demonstrated by an average learning achievement score of 9 4 with a classical learning mastery of 80% (8 out of 10 students). Therefore, the rotating wheel teaching aid is considered valid, practical, and effective for teaching the volume and surface area of polyhedrons.

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1. INTRODUCTION

Mathematics is a subject that plays a crucial role in developing logical and analytical thinking skills, as well as problem-solving abilities. However, learning mathematics is still often considered difficult because it involves many abstract concepts, particularly in the topics of volume and surface area of three-dimensional shapes with flat sides. This material requires strong visualization skills so that students can understand the relationships between the shapes, their elements, and the formulas used. Observations in the 9th-grade class at MTs Tarbiyatul Islamiyah indicate that most students still struggle to distinguish and recall the formulas for the volume and surface area of cubes, rectangular prisms, prisms, and pyramids. This situation has led to low academic achievement, as evidenced by the students' average score of 65, which remains below the Minimum Proficiency Criteria (KKM) of ≥75.

One of the factors contributing to students' low understanding is that instruction is still dominated by the lecture method with limited use of instructional media. In fact, the concepts of three-dimensional shapes require concrete media so that students can connect visual representations with mathematical concepts in a more meaningful way. The use of manipulatives allows students to interact directly with the learning objects, thereby increasing their attention and engagement and helping to reduce the abstract nature of the material. Several previous studies have reported that spinning wheel media can increase motivation and active participation in mathematics learning. However, the

Based on these conditions, this study developed a spinning wheel teaching aid designed to present the names of three-dimensional shapes, volume formulas, and surface area formulas in a single, easy-to-use interactive medium. The novelty of this study lies in the development of a 4D-model-based teaching aid that not only displays information visually but also actively engages students through activities such as rotating, observing, and matching information, thereby supporting more interactive and meaningful learning. Therefore, this study aims to develop a rotating wheel teaching aid for the topics of volume and surface area of flat-sided three-dimensional shapes that meets the criteria of being valid, practical, and effective for use in mathematics instruction for ninth-grade students at MTs Tarbiyatul Islamiyah.

2. METHODS

This study is a research and development (R&D) project using the 4D model, which includes the Define, Design, Develop, and Disseminate stages. The study aims to develop a rotating wheel teaching aid for the topic of volume and surface area of flat-sided three-dimensional shapes that meets the criteria of validity, practicality, and effectiveness. Product testing was conducted on 10 ninth-grade students at MTs Tarbiyatul Islamiyah. Data collection was conducted using validation sheets, student response questionnaires, and learning outcome tests. The validation sheets were used by experts to assess the suitability of the instructional media and research instruments. The student response questionnaires were used to measure the practicality of the instructional media after it was implemented in the classroom, while the learning outcome tests were used to determine the effectiveness of the instructional media based on students' learning outcomes.

The data were analyzed using quantitative and qualitative descriptive analysis. Quantitative analysis was conducted on the validation scores, student response questionnaire scores, and test scores by calculating the mean, percentage, and determining assessment categories. Qualitative analysis was used to process the validators' input and suggestions as a basis for product refinement. The media were deemed valid if they met the "valid" category based on expert assessment results, practical if they received positive responses from students, and effective if the overall learning achievement rate reached at least 80% with individual achievement scores of ≥75.

3. FINDINGS AND DISCUSSION

This study produced a learning medium in the form of a spinning wheel teaching aid for the topic of volume and surface area of three-dimensional shapes with flat faces, developed using the 4D model. The development of this medium was based on the results of a needs analysis, which indicated that students still struggle to distinguish between the volume and surface area formulas for cubes, rectangular prisms, prisms, and pyramids, and that the use of concrete learning media remains limited. Therefore, a spinning wheel teaching aid was developed that includes the names of three-dimensional shapes, their forms, volume formulas, and surface area formulas in a single interactive medium; it was also evaluated based on three criteria: validity, practicality, and effectiveness. Validity was determined based on the results of validators' assessments of the teaching aid, student response questionnaires, and test questions. Practicality was assessed based on student feedback after using the medium in the classroom, while effectiveness was determined based on students' test performance. The assessment results for each criterion are described as follows.

a. Product Validity Criteria

The suitability of the materials was assessed through expert validation of the teaching aids and research instruments. The results of the expert validation are

presented in Table 1, “Summary of Validation Results for Teaching Aids, Student Response Questionnaires, and Test Items,” below.

Table 1. Validation Results of the Rotating Wheel Teaching Aid

No.	Assessment Aspect	Statement	Ii	Ai	Va
Content Suitability					
1	Content Suitability	The rotating wheel teaching aid is consistent with the learning objectives.	4	3.75	
2	Content Suitability	The concepts of polyhedrons are presented accurately without misconceptions.		3.50	**4.02**
Media Appearance					
3	Media Appearance	The appearance of the rotating wheel teaching aid is attractive.	4	4.30	
4	Media Appearance	The presentation of the teaching aid is appropriate and well organized.		3.50	
5	Media Appearance	The visualization of the polyhedrons is clear.		3.50	
6	Media Appearance	The teaching aid is easy to use.		3.50	
7	Media Appearance	The text and mathematical symbols are easy to read.		3.50	

Table 2. Validation Results of the Student Response Questionnaire

No.	Assessment Aspect	Statement	Ii	Ai	Va
Content					
1	Content	The questionnaire items are appropriate for measuring the practicality of the teaching aid.	3	3.00	
2	Content	The questionnaire reflects students' experiences in using the rotating wheel teaching aid.		3.00	**3.05**
Construction					
3	Construction	The statements are clear and easy to understand.	3	3.16	
4	Construction	The statements do not create multiple interpretations.		3.00	
5	Construction	The questionnaire is systematically organized.		3.00	
Language					

No.	Assessment Aspect	Statement	Ii	Ai	Va
6	Language	The language is easy for students to understand.	3	3.00	
7	Language	The wording follows proper Indonesian language conventions.		3.00	

Table 3. Validation Results of the Learning Achievement Test

No.	Assessment Aspect	Statement	Ii	Ai	Va
Content Suitability					
1	Content Suitability	The test items are aligned with the topic of volume and surface area of polyhedrons.	3.5	3.30	
2	Content Suitability	The test items are aligned with the learning indicators.	3		
3	Content Suitability	The test measures students' conceptual understanding of volume and surface area.	3.5		**3.02**
Language					
4	Language	The language used in the test is easy for students to understand.	2.5	2.75	
5	Language	The test is free from writing errors.	3		
Suitability					
6	Suitability	The test appropriately measures students' learning achievement.	3	3.00	
7	Suitability	The level of difficulty is appropriate for Grade IX students.	3		

Based on the table presented above, the validation results show that the teaching material received an average score of 4.02, falling into the “highly valid” category, while the validation of the student response questionnaire received a score of 3.05 and the validation of the test items received a score of 3.02—both of which fall into the “valid” category. These results indicate that the teaching materials and research instruments are suitable for use in the learning process after refinements are made in accordance with the validators’ suggestions. The overall validity results of the data above are summarized in the table below.

Table 4. Summary of Product and Instrument Validation Results

No.	Validated Component	Mean Score	Category
1	Rotating Wheel Teaching Aid	4.02	Very Valid
2	Student Response Questionnaire	3.05	Valid

No.	Validated Component	Mean Score	Category
3	Learning Achievement Test	3.02	Valid
	Overall Mean	**3.36**	**Valid**

b. Criteria for Assessing the Practicality of the Product

The practicality of the teaching aid was measured through a response questionnaire administered to 10 students after they participated in a lesson using the spinning wheel teaching aid. The results of the analysis of the student response questionnaire are presented in the following table.

Table 5. Student Response Questionnaire Results

No.	Student Initials	P1	P2	P3	P4	P5	P6	P7	P8	Total Score	Mean	Category
1	N.R.F	4	3	2	3	2	2	4	4	60	2,85	Moderate
2	M.D.N.A	4	4	4	4	4	4	4	4	81	3,85	High
3	A.P	4	4	4	4	4	4	3	4	84	4	High
4	A.F.P	4	4	4	4	4	3	4	3	78	3,71	High
5	D.A.P.L	4	4	4	3	4	4	4	3	80	3,38	High
6	I.U	4	3	4	3	3	4	3	3	68	3,23	High
7	F.D	4	4	4	3	4	4	4	4	63	3	High
8	S.M	4	3	3	3	4	4	4	4	78	3,71	High
9	S.F	3	3	3	3	3	3	3	3	84	4	High
10	D.S.P	4	3	3	3	3	3	3	4	67	3,19	High

Based on the table above, the results of the student response questionnaire show an average score of 3.56, which falls into the “high” category, with 9 students giving a “high” response and 1 student giving a “moderate” response. This indicates that the medium is easy to use, engaging, and capable of increasing student engagement during the learning process through the activity of spinning the wheel to match geometric shapes with the corresponding formulas.

c. Criteria for Assessing the Effectiveness of the Product

The effectiveness of the instructional material was assessed based on students’ test scores. The test was used to determine the extent to which learning objectives were achieved regarding the volume and surface area of three-dimensional shapes with flat faces. Students were considered to have met the learning objectives if they scored at least 75. Each student’s test results are presented in the following table.

Table 6. Students' Learning Achievement Results

No.	Student Initials	Score	Remarks
1	N.R.F	100	Complete
2	M.D.N.A	100	Complete
3	A.P	100	Complete
4	A.F.P	100	Complete
5	D.A.P.L	100	Complete
6	I.U	70	Not Complete
7	F.D	100	Complete

8	S.M	70	Not Complete
9	S.F	100	Complete
10	D.S.P	100	Complete

The table above shows that, out of 10 students, 8 achieved the passing score, while 2 did not. Overall, the students' average test score was 94. A summary of the students' learning achievement is presented in the table below.

Table 7. Summary of Students' Learning Mastery

No.	Description	Result
1	Number of students participating in the test	10
2	Number of students achieving mastery	8
3	Number of students not achieving mastery	2
4	Mean score	94
5	Classical mastery percentage	80%
6	Category	Classically Mastered

Based on the table above, 8 out of 10 students scored ≥ 75 and were deemed to have met the learning standards. The class-level learning achievement rate (K_T) is calculated using the following formula (Sudjana, in Arini 2017):

$$K_T = \frac{(Number\ of\ students\ who\ passed)}{n} \times 100\%$$

$$K\_T = 8/10 \times 100\% = 80\%$$

The results of the calculation show that the percentage of student learning achievement reached 80%. This figure meets the established minimum threshold for classical mastery, which is 80%. Thus, student learning outcomes are deemed to have been achieved in a classical sense. Based on these results, the spinning wheel teaching aid for the volume and surface area of flat-sided three-dimensional shapes is deemed effective in helping students understand the concepts of volume and surface area of flat-sided three-dimensional shapes.

Overall, the research results indicate that the developed instructional media meet three main criteria: validity, practicality, and effectiveness. The validity of the media is demonstrated by the alignment of the content, design, and ease of use with the learning objectives. High practicality reflects that the media are easy to operate and receive positive feedback from students, while effectiveness is demonstrated by the achievement of an 80% classical learning mastery rate. These findings are consistent with the research by Angelina et al. (2021), Chamalia et al. (2024), and Wahyuni (2025), which states that the use of concrete media and spinning wheels can increase student engagement and facilitate the understanding of abstract mathematical concepts. However, this study is still limited to a small-scale pilot test and did not employ an experimental design; therefore, the effectiveness of this medium cannot yet be directly compared with that of other learning media.

4. CONCLUSION

This study successfully developed a learning medium in the form of a spinning wheel teaching aid for the topic of volume and surface area of flat-sided three-dimensional shapes using the 4D model. The results showed that the medium received a validation score of 4.02 (highly valid), while the validation of the student response questionnaire and test items received scores of 3.05 and 3.02, respectively

(valid). The practicality of the medium was demonstrated by the average score of the student response questionnaire of 3.56, which falls into the "high" category, while the effectiveness of the medium was demonstrated by 8 out of 10 students achieving mastery with an average score of 94 and a classical mastery rate of 80%. Thus, the spinning wheel teaching aid is deemed to meet the criteria of validity, practicality, and effectiveness as a mathematics learning medium for the topic of volume and surface area of flat-sided three-dimensional shapes. This educational tool can be used as an alternative learning method to help students understand the concepts of flat-sided three-dimensional shapes. Further research is recommended to expand the tool to cover a broader range of topics, incorporate more interactive learning features, and test the tool's effectiveness through experimental designs with a larger sample size to obtain stronger evidence.

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