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Development of the X-ROOT Learning Medium on Exponents in Grade VIII

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Abstract

This study aims to develop an X-ROOT mathematics learning medium for VIII-grade students on exponents. The research was motivated by the limited use of media in mathematics learning and students' difficulties in distinguishing multiplication from exponentiation and solving related problems. This study is Research and Development using the ADDIE model. Data were collected through observation, interviews, documentation, and questionnaires. The instruments included interview guidelines, observation sheets, and validation sheets. The subjects consisted of 21 students in class VIII B at Hasyim Asy'ari Islamic Junior High School in Malang City, chosen by the Purposive Sampling technique. The validity test was obtained from validation by a learning media expert and a material expert, while the practicality test was obtained from practitioner validation and student response questionnaires. The validity results showed scores of 86,6% from the media expert and 93,3% from the material expert. Practicality results were 90% from the practitioner and 93,3% from student responses. Based on these findings, the X-ROOT instructional media is categorized as very valid and very practical for mathematics learning.
Keywords: Development, mathematics learning medium, exponents.

1. INTRODUCTION

Mathematics has a fundamental role in developing students' logical, analytical, and systematic thinking skills [3]. In the context of formal education, mathematics not only functions as a subject that teaches numerical concepts, but also develops reasoning skills that are needed to face intellectual challenges in various fields [15]. The ability to understand and apply mathematical concepts is the basis for understanding other sciences such as physics, chemistry, economics, and information technology, so strengthening mathematical competencies from elementary to secondary education levels is very important [8].

Referring to the importance of mathematics, the effectiveness of mathematics learning in every educational unit needs to be optimized [16]. One important support for the success of mathematics learning is the use of appropriate and relevant learning media [20], in line with international studies which state that mathematics learning media and technology play an important role in improving

the quality of learning and assessment in the digital era [22]. The essence of learning media is a means of conveying information from the communicator (teacher) to the communicant (student) as the information's recipient [18]. Learning media function as a bridge between abstract concepts and concrete understanding, thereby helping students know the relationship and meaning of the material being studied. Through visual, manipulative, or digital presentations, media can clarify concepts, increase students' involvement, and facilitate students in exploring [5]. Appropriate media can also encourage a more interesting and interactive learning atmosphere, thereby increasing students' learning motivation [6].

Although the learning media are one aspect that supports the effectiveness of a mathematics learning process, in fact, there are many teachers who still do not use the learning media in their teaching and learning activities. Based on the researchers' observation, the application of learning media at Hasyim Asy'ari Islamic Junior High School in Malang City is still very minimal. The teacher reported using the learning medium only once a month. Furthermore, the learning media used are in digital form, so their implementation is often hampered by available facilities and infrastructure.

Furthermore, based on the analysis of student assignments on exponents, many students still struggle with both direct calculations and story problems. The majority of students are even confused about the distinction between multiplication and exponentiation. Limited learning resources and media make it difficult for students to understand the concept of exponents, and ultimately lower their motivation to learn. Limited learning resources and learning media make it difficult for students to understand the concept of numbers and ultimately reduce their learning motivation. This condition is also found in international research which highlights the importance of the quality and availability of mathematics learning resources, especially learning media that are appropriate to school policies and context [12].

Based on the limited use of learning media and students' difficulties in understanding exponents, particularly in differentiating between multiplication and exponentiation and in completing practice problems, the researchers concluded that innovations in the form of learning media are needed that are not only attractive, help students in understanding material, but also easy to use in the classroom, taking into account available facilities and infrastructure. In this study, the researchers developed a cube-shaped manipulative learning medium called "X-ROOT."

X-ROOT is a manipulative learning medium on the exponents in grade VIII in the Merdeka Curriculum in the form of a cube with six sides. Previously, there were several studies that developed learning media on the exponents; one of them was a digital learning medium based on Desmos activities on the multiplication, division, and exponent material that was developed by Daviana Maurora Widya, Sanjani Veronika Pandiangan, Defri Aulia Nurmalitasari, and Antonius Yudhi Anggoro in 2024. The media obtained very valid results. Different from the previous study, this study examines the development of a cube-shaped manipulative learning medium on the exponents. This media is designed to help students understand the concept of exponents and strengthen students' understanding through direct calculations and story problems. The purpose of this study is to examine the validity and practicality of the X-ROOT media on the exponents for grade VIII students of Hasyim Asy'ari Islamic Junior High School in Malang City.

2. RESEARCH METHODOLOGY

The type of study used is a development study, or usually known as Research and Development. A development study is a systematic study that focuses on the process of designing and developing a program, process, or learning product along with its evaluation with several specific criteria [13]. Development study functions to produce and check the effectiveness of a product [19]. The development study model used is the ADDIE model, which consists of five stages, namely

Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was chosen because it has a logical, systematic, and organized process that is easy to understand and provides a clear workflow for students in designing and developing a learning medium. [11]. The data collection techniques in this study were interviews, documentation, observation, and questionnaires, which were used as needed at each stage.

The study instruments used consisted of several types, namely interview guidelines, observation sheets, learning medium validation sheets (including validation sheets for material expert, learning medium expert, and practitioner experts), and student response questionnaires. The interview guidelines consist of 9 item questions that are used to explore learning conditions and media needs. The learning medium validation sheets include validation from a material expert with 15 item statements, validation from a learning media expert with 15 item statements, and validation from a practitioner expert with 18 item statements, all of which used a Likert scale of 1–5. Furthermore, there was a student response questionnaire consisting of 15 item statements with a Likert scale of 1–4.

The research subjects were 21 students of class VIII B at Hasyim Asy'ari Islamic Junior High School to determine the response to the use of the learning medium. The sample selection used a Purposive Sampling technique based on the recommendations of the teacher, taking into account ease of access and student coordination. The product developed in this study was a manipulative learning medium called "X-ROOT" for the material of exponents for grade VIII in the Merdeka Curriculum. The product was tested twice: a small class trial and a large class trial. Before being tested, the product was validated by a material expert, a learning medium expert, and a practitioner expert to get feedback for learning medium improvement before being implemented.

3. RESULTS AND DISCUSSION

This section describes the results of a study on the development of X-ROOT learning medium on the exponents for grade VIII in Hasyim Asy'ari Islamic Junior High School in Malang City by presenting findings at each stage of the ADDIE model, starting from needs analysis, design, product development, implementation in class, to learning medium evaluation. The following is a presentation of the results obtained at each stage of the ADDIE development model.

a. Analysis Stage

At the Analysis stage, the researchers analyze the problem, the causes, and the appropriate solution. To find out this, the researchers analyzed several things, including: 1) student characteristics, 2) learning outcomes and learning objectives, 3) learning process in the classroom, 4) student needs, and 5) the appropriate type of learning medium. The Analysis stage was carried out through interviews with the teacher and observation in class VIII B.

After conducting an analysis, researchers found a fact that the implementation of learning media at Hasyim Asy'ari Islamic Junior High School is still very minimal. The teacher reported using the learning medium only once a month. Learning media used are in digital form, so available facilities and infrastructure often hamper their implementation. Furthermore, based on the analysis of student assignments on exponents, many students still struggle with both direct calculations and story problems. The majority of students even still confused about the distinction between multiplication and exponentiation. Limited learning resources and media make it difficult for students to understand the concept of exponents, and ultimately lower their learning motivation. The result of the analysis stage is presented in Figure 3.1 as follows.

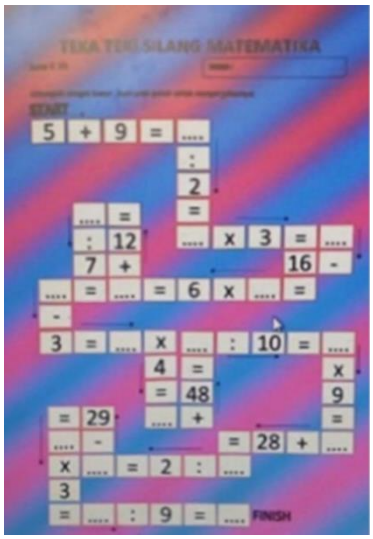

Figure 3.1. Learning medium used at Hasyim Asy'ari Islamic Junior High School in Malang City

b. Design Stage

At the Design stage, researchers determine several things, including: 1) the requirements for designing the learning medium, 2) the learning context used to deliver the material, 3) the appropriate learning medium design, and 4) instruments to measure the validity and practicality of the learning medium. The result of the Design stage is a learning medium prototype that will be validated by a learning medium expert and a material expert. The validated prototype will be developed in the Development stage. The result of the Design stage is presented in Figure 3.2 as follows.

Figure 3.2. The Protoype the X-ROOT learning medium

c. Development Stage

At this stage, the researchers begin to develop a learning medium prototype that becomes a learning medium ready to use. Several steps done by the researchers included: 1) developing the prototype into a real learning medium, 2) validating the product with several experts, and 3) revising the product based on the experts' suggestions/input. The result at this stage was a cube-shaped learning medium with six sides as follows:

1. The base side contains the media identity, which includes the name of the learning medium, material, class, and developer identities. The figure of the base side of the X-ROOT learning medium is presented in Figure 3.1 as follows.

Figure 3.1. The base of the X-ROOT learning medium

2. The first side contains a description of the X-ROOT learning medium, completed with a guidebook. The figure of the first side of the X-ROOT learning medium is presented in Figure 3.2 as follows.

Figure 3.2. The first side of the X-ROOT learning medium

3. The second side contains an explanation of the concept of exponents using several 2 cm x 2 cm wooden cubes. The figure of the second side of the X-ROOT media is presented in Figure 3.3 as follows.

Figure 3.3. The second side of the X-ROOT learning medium

4. The third side contains practice problems on square numbers, completed by direct calculation problems and story problems. The figure of the third side of the X-ROOT learning medium is presented in Figure 3.4 as follows.

Figure 3.4. The third side of the X-ROOT learning medium

5. The fourth side contains practice problems on cube numbers, completed by direct calculation problems and story problems. The figure of the fourth side of the X-ROOT learning medium is presented in Figure 3.5 as follows.

Figure 3.5. The fourth side of the X-ROOT learning medium

6. To facilitate students in doing practice, a whiteboard is provided on the top side. The figure of the top side of the X-ROOT learning medium is presented in Figure 3.6 as follows.

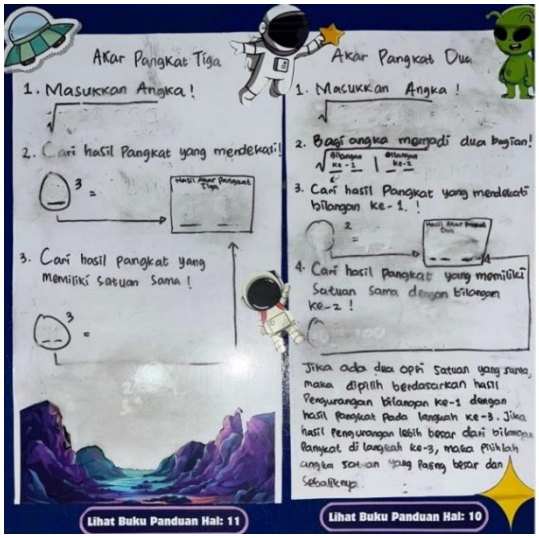

Figure 3.6. Top side of the X-ROOT learning medium

After the learning medium was created, validation was conducted to test its validity before implementation in the classroom. The validation process was carried out in three stages: validation

by a learning medium expert, validation by a material expert, and validation by a practitioner. The validation process was carried out by giving a validation questionnaire to the validators. The validation questionnaires used a Likert scale of 1-5 with the following scoring guidelines [19].

Table 3.1. Validation questionnaire scoring guidelines

Statement	Abbreviation	Score
Sangat Setuju	SS	5
Setuju	S	4
Cukup Setuju	CS	3
Tidak Setuju	TS	2
Sangat Tidak Setuju	STS	1

The scores obtained from the validation questionnaire are then calculated as a percentage using the following formula:

$$Validity\ Level = \frac{Obtained\ Score}{Maximum\ score} \times 100\%$$

The results of the percentage calculation are then interpreted based on the table of qualifications for the level of validity of the learning medium, as follows [1].

Table 3.2. Validity level qualifications

Validity Level	Category	Information
$85.01 \leq$ Score ≤ 100.00 %	Very Valid	Can be applied without revision
$70.01 \leq$ Score ≤ 85.00 %	Valid	It can be applied, but requires some revision
$50.01 \leq$ Score ≤ 70.00 %	Less Valid	It is better not to apply it because it requires major revision
$01.00 \leq$ Score ≤ 50.00 %	Invalid	Cannot be applied

The following is a table of the results of the validation by the learning medium expert.

Table 3.3. Learning medium expert validation results

No	Aspect	Score
1.	Content Eligibility	17
2.	Appearance and Design	18
3.	Presentation and Use	18
4.	Language and Communication	13

During the validation stage, a learning medium expert was given a questionnaire with 15 item statements, each with a maximum score of 5, for a total maximum score of 75. After calculation, a total score of 66 was obtained, with a validity level of 88%, placing it in the very valid category,

allowing the learning medium to be used without revision. The learning medium was then validated by material experts, and the results as shown in Table 3.4 below.

Table 3.4. Material expert validation results

No	Aspect	Score
1.	Content Eligibility	19
2.	Appearance and Design	20
3.	Presentation and Use	18
4.	Language and Communication	13

In the validation stage by a material expert, the validator was given a questionnaire with 15 item statements with a maximum score is 75. After calculation, a total score of 70 was obtained, with a validity level of 93%, placing it in the very valid category, allowing the learning medium to be used without revision. The learning medium was then validated by the practitioner, and the results as shown in Table 3.5 below.

Table 3.5. Practitioner validation results

No	Aspect	Score
1.	Content Eligibility	29
2.	Appearance and Design	20
3.	Use	18
4.	Attractiveness	10
5.	Quality	4

In the practitioner validation stage, the validator was given a questionnaire with 18 item statements with a maximum score of 90. After calculation, a total score of 81 was obtained with a validity level of 90% and it is included in the very practical category, so that the learning medium can be used without revision. The learning medium was then tested in the Implementation stage.

d. Implementation Stage

At this stage, the student conducted a trial in class with 21 students in class VIII B. The following is a documentation of the trial in class.

Figure 3.7. Trial of the learning medium

At the end of the implementation stage, students were given a response questionnaire regarding the use of the learning medium. The questionnaire consisted of 15 item statements using a Likert scale of 1-4. The scoring guidelines for the student response questionnaire are as follows [19].

Table 3.6. Student response questionnaires scoring guidelines

Statement	Abbreviation	Score
Strongly Agree	SA	4
Agree	A	3
Disagree	D	2
Strongly Disagree	SD	1

The scores obtained from the questionnaire are then calculated as a percentage using the following formula:

$$Practicality\ Level = \frac{Obtained\ Score}{Maximum\ Score} \times 100\%$$

The results of the percentage calculation are then interpreted based on the qualification table for the practicality level of the learning media as follows [1].

Table 3.7. Practicality level qualifications

Practicality Level	Category	Information
$85.01 \leq Score \leq 100.00\ \%$	Very Practical	Can be applied without revision
$70.01 \leq Score \leq 85.00\ \%$	Practical	It can be applied, but requires some revision
$50.01 \leq Score \leq 70.00\ \%$	Less Practical	It is better not to apply it because it requires major revision
$01.00 \leq Score \leq 50.00\ \%$	Impractical	Cannot be applied

After the calculation, with a maximum score of 1.260, the learning medium obtained a total score of 1.176 with a practicality level of 93% so that it is included in the very practical category and can be applied without revision.

e. Evaluation Stage

The evaluation stage is the final stage of the ADDIE model. At this stage, the implemented media is evaluated based on the data analysis. The results of the evaluation stage then serve as a benchmark for the validity and practicality of the learning medium. In the ADDIE model, evaluation is not only carried out at the final stage but also at each stage. After the evaluation, the X-ROOT learning medium is categorized as a very valid and very practical category.

The analysis stage shows the need for an innovative learning medium, highlighting several key findings from the field observations. First, the implementation of learning media is minimal, with teachers reporting usage only once a month. Second, the majority of student face significant difficulties in distinguishing the concept between multiplication and exponentiation. These results underscore than main problem a lack of appropriate tools to bridge abstract concepts. This situation is reinforced by literature, which states that the learning media act as a bridge connecting abstract concepts to concrete understanding, thereby facilitating exploration and increasing students' learning motivation [18, 20]. Learning media functions as a bridge between abstract concepts and

concrete understanding, thereby helping students see the connection and meaning of the material being studied. In the context of exponents, students often perceive symbols such as as procedural rules rather than meaningful mathematical relationships. The X-ROOT manipulative media provides concrete and visual representation that allow students to observe repeated multiplication patterns directly, identify the relationship between base and exponent, and compare exponential expressions through guided activities. By interacting physically with the cube based media, students are encouraged to explore, discuss, and construct their own understanding rather than memorize formulas mechanically. This concrete to abstract learning process helps reduce misconceptions, strengthens conceptual connections, and ultimately improves students' conceptual understanding of exponents. This is in line with previous findings which emphasize that the use of technology and mathematics learning media is able to strengthen students' conceptual understanding through more meaningful representations [4].

Based on the literature review, the researchers concluded that there is a need for the development of a learning medium that is appropriate to existing conditions. The solution designed is the X-ROOT manipulative media in the form of a cube with six sides, each of which contains instructions for use, the concept of exponents, and practice problems.

Validity testing was conducted through validation by a learning media expert, a material expert, and a practitioner. Validity testing was conducted to determine the extent to which the learning medium met the criteria for appropriate substance, construction, and language [19]. The results of the validation test showed that the percentage of the learning medium validity level was 88% from learning media expert validation and 93% from material expert validation, thus obtaining a very valid category (Table 3.2). Based on the validity test that had been conducted, it can be concluded that the X-ROOT media was visually and functionally feasible (appearance, design, navigation, and usability), and materially feasible (accuracy of the concept of exponents, relevance of questions to the curriculum). These results are in line with the findings of a previous study on learning media development on the same material. A study on the development of a digital learning medium based on Desmos activities on the material of multiplication, division, and exponentiation operations obtained a validity percentage of 93.33% with a very valid category [21].

In addition to the validity test, the media was also tested in terms of its practicality. The results of the practitioner test of 90% and the student response of 93% both placed the X-ROOT learning medium in the very practical qualification (Table 3.7). The high positive response from students (93%) indicates that this cube-shaped manipulative media succeeded in overcoming problems at the analysis stage, namely increasing learning motivation and making it easier to understand the concept of numbers with powers. This finding is in line with previous findings which emphasizes that the integration of appropriate learning media, accompanied by the teacher's role in facilitating learning activities, can increase students' engagement and conceptual understanding in mathematics learning [7]. The tangible (cube) and interactive (manipulative) media design make it easier for students to distinguish the concept of exponents. This is in line with the function of the learning media as a support in understanding mathematical concepts [17]. These findings are also in line with a related study that reviews the practicality aspects of learning media. For example, a study on the development of e-modules based on the Flip PDF Professional application on the material of exponents and radicals obtained a practicality test result of 87.48% with a very practical category [14]. The summary of the validity and practicality test results for the X-ROOT learning medium is presented in Table 3.8.

Table 3.8. Validity and practicality Test Results

Evaluator	Precentage	Category
Learning Media Expert	88%	Very Valid
Material Expert	93%	Very Valid

Practitioner	90%	Very Practical
Student Response	93%	Very Practical

The consistency of these results strengthens the conclusion that a well-developed learning medium on the material of exponents such as X-ROOT, can achieve a high level of practicality and is well received by students. After the evaluation, the X-ROOT learning medium received a very valid and very practical category for use as a learning medium on the exponents for grade VIII students in Hasyim Asy'ari Islamic Junior High School in Malang City.

4. CONCLUSION

Based on the calculation, the level of validity of the learning medium obtained was 88% from learning media expert validation and 93% from material expert validation. The level of practicality of the learning medium obtained was 90% from practitioner validation and 93% from student response questionnaire results. The level of validity was obtained through validation by a material expert and a learning media expert. The level of practicality was obtained through validation by a practitioner expert and student response questionnaires. Based on the validity and practicality tests that have been carried out, the X-ROOT media is very valid and very practical for use as a learning medium for exponents.

THANK-YOU NOTE

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