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Research Article

The development of inquiry-based mathematics teaching materials for space figures for elementary schools

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ABSTRACT

This study aims to develop inquiry-based worksheets on the material area and volume of cylinder shapes that are valid, feasible, effective, and improve learning outcomes. This research is a research and development (R&D) using the ADDIE model, which consists of 5 stages: the Analysis, Design, Develop, Implement, and Evaluate stages. Subjects in the study were grade VI students of SD Negeri 2 Bengkulu City. The research instrument used a validation sheet, a teacher and student response questionnaire, and a question test sheet. The research data were then analyzed using descriptive analysis. The results showed that the inquiry-based LKPD products that had been developed and assessed by expert validators were in the very valid category with an average percentage of 94.79%; the teacher's response to the guided inquiry-based LKPD obtained a percentage of 80.0% with appropriate categories or criteria, and student responses to guided inquiry-based LKPD received a percentage of 74.62% in the appropriate category and an effective level of 80.95% in the effective category. Thus, it can be concluded that the inquiry-based students' worksheets on the cylinder shapes developed are very valid, feasible, effective, and can improve student learning outcomes to be used as supporting teaching materials in the learning process. Finally, these inquiry-based student worksheets are expected to be used as a basic framework for developing students' worksheets for other materials.

Keywords: LKPD; research & development; (R&D); inquiry; space figures;

1. INTRODUCTION

Mathematics education in Indonesia is developing in line with the development of world mathematics education. Changes in classroom learning, besides to being influenced by demands of technological and scientific developments, are often preceded by changes in views about the nature of mathematics and its learning. To create a quality learning process, teachers often find it difficult to provide learning materials. Especially for mathematics teachers, implementing learning in schools still shows shortcomings and limitations. This causes the learning process of mathematics to be unpleasant, and students are not interested in learning mathematics as well as having a negative impact on Student's academic achievement. This condition will continue to occur as long as mathematics teachers ignore the role of learning media. According to Susanta et al. (2020), student mathematics teachers should be able to develop problem-solving skills and critical thinking skills so that they can link the means of all mathematical concepts in solving problems in each lesson.

Based on the observation that mathematics learning at SD Negeri 2 Bengkulu City is still guided by the teacher's handbook that has not been developed, it is necessary to have a learning media that is by the needs, such as the cylinder material that can be obtained on local cultural, knowledge and mathematics, so it is hoped that mathematics learning will be more effective, meaningful, and dynamic. Learning media that contribute significantly to the effectiveness of learning outcomes for a subject are media developed based on real life. These media are around or close to the lives and cultures of students. The media will make students feel close to the material they received.

According to Rochmad (2012), the use of culture in mathematics learning is very important because it can add insight to students about the culture they are learning. Students will be more interested in learning if they are invited to study objects they often encounter or habits they usually see. The approach to learning mathematics by linking cultural elements with mathematics learning, especially the tube, will make students feel interested and have challenges. Several studies have shown that the role of culture or local context in teaching materials affects student learning outcomes. Research conducted by Susanta et al. (2022) shows that teaching materials in the form of Bengkulu context e-modules effectively improve students' abilities, especially literacy skills. Teaching materials developed by linking culture can improve student learning outcomes (Rohmah, 2019; Dediliawan, 2016).

Bengkulu City is located in Bengkulu Province, with many historical relics, one of which is the Tabot culture. In the Padang Harapan Museum, various historical relics are placed, such as musical instruments in the form of Dol, drums, chrysanthemums, and drums, then consists of various items from other dynasties in the form of ceramics as a place for food and drink, and even a replica of the tomb is available. Bangalore kings. The city of Bengkulu also has one type of art that has begun to be rarely known, namely the art of Dol, beduk, and serunai, known as musical instruments originating in the city of Bengkulu. This cultural content is integrated into a very important cultural-art content so that it is not forgotten and can be integrated into learning all subjects, including mathematics.

The success of learning, in addition to depending on the learning approach used and teaching materials, is an important factor in determining the success of implementing the 2013 curriculum. One approach that can support students' thinking skills is inquiry. Inquiry learning can develop students' natural skills in learning (Kitota, 2010). The inquiry method is a series of learning activities that maximally involve all components of students to search and investigate systematically, critically, and logically to find their knowledge, attitudes, and skills as a form of change (Hanafiah & Suhana, 2009).

Several previous studies related to effectiveness in improving student learning outcomes. The application of inquiry learning can improve student learning outcomes and creativity (Alsan, 2021; Roida, 2016). Research by Opticia et al. (2022) states that inquiry learning tools are effective because students' responses to learning tools and learning activities meet the positive category and can improve students' critical thinking skills. Based on this description, teaching materials in the form of inquiry-based worksheets are developed, which are a type of printed teaching materials that are systematically designed based on a certain curriculum that contains one unit of learning material using language that is easily understood by students according to their level of knowledge so that they can learn actively and think. Critically to find answers to existing problems with or without teacher guidance.

2. RESEARCH METHOD

2.1 Research Design

The type of study used is Research & Development (R&D). Development research is a method used to produce certain products and test their effectiveness of these products (Sugiyono, 2018). The product of this research is a student worksheet (LKPD) for building materials using inquiry-based dol media to improve learning outcomes for grade 6 elementary school students. The stages of development are shown in **Figure 1**.

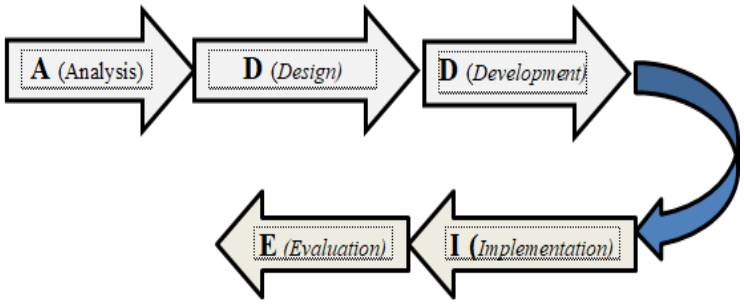

Figure 1. Stages of development

2.2 Research Subjects

The subjects in this study were 6th-grade students of SD Negeri 2 Bengkulu City with an experimental class of 26 students and 27 students as a control class.

2.3 Research Instrument

Based on the research objectives, the following instruments were designed and arranged:

a) Needs Analysis Instrument

The needs analysis instrument was conducted through interviews with teachers and students. The instrument, in the form of an interview guide, was prepared to find out what kind of LKPD was by the needs of students. The data obtained is used as input for researchers in developing LKPD materials for tube space construction using inquiry-based dol media.i.

b) *Validation Instrumenti*

The instrument is a questionnaire concerning the suitability of language, material, and presentation of teaching material products..

c) Product Trial Instrument

This instrument is in the form of a questionnaire that is used to determine the response of teachers and students to the students' worksheet product on building materials using inquiry-based dol media to improve the learning outcomes of grade 6 students that have been developed. The instrument in the questionnaire is in the form of questions using yes and no answers. For positive questionnaire items, the answer is yes (1), and for no answers (0). While for negative questionnaire items, the answer is 0, and the answer is not worth 1.

d) Product effectiveness test instrument
The instrument for testing the effectiveness of the product uses the shape-figure material essay test.

2.4 Data collection technique

The data collection techniques in this students worksheet development research are as follows:

a) Document Analysis
Document analysis is used to analyze the initial stage of identifying problems. This teaching document analysis consists of curriculum analysis, student book analysis, basic competencies, and indicators. Based on the initial analysis and concept analysis, it is determined that the material taken is the shape of the space.

b) Interview
Interviews are used as a data collection technique if the researcher wants to conduct a preliminary study to find problems that must be investigated and also if the researcher wants to know things from respondents who are more in-depth and the number of respondents is small. Used as an input for developing inquiry-based students worksheet..

c) Test
The test instrument given is in the form of a posttest, which is given at the end of each lesson. The test measures the extent to which students can understand learning after applying to learn using an inquiry-based Mathematics student's worksheet. The test instrument is available in the Student's worksheet, which is used as a guide for teachers in measuring the level of knowledge of students.

d) Questionnaire
Student response questionnaires were given to students at the end of the study. This instrument aims to determine the quality of practicality based on students' responses and responses to aspects of the usefulness and convenience of the Student's worksheet that has been developed. At the same time, the teacher response questionnaire was given to the teacher at the end of the study. This instrument aims to determine the quality of practicality based on the teacher's response to the usefulness and ease of learning using learning tools that have been developed.

2.5 Data analysis technique

a) *Analysis of Validation Results*
In calculating the validity of experts in this study, it will be analyzed using Aiken's. The validity criteria are as in shown **Table 1.**

Table 1. Aiken's V Coefficient Criteria

Correlation coefficients	Interpretations
> 0,80	High
0,60 ≤ V < 0,80	High enough
0,40 ≤ V < 0,60	Enough
0 ≤ V < 0,40	Bad

(Retnawati, 2016).

b) *Reliability*
After analyzing the results of the material expert validation sheet, linguistic expert validation, and media expert validation, the consistency between validators was also determined to see the validity of the validator in providing an assessment of the product design developed using interrater reliability. The interpretation using McHugh's (2012) theory can be seen in **Table 2.**

Table 2. Interpretation of Cohen's Kappa

Kappa Values	Level of agreement	% Reliability
0 – 0,2	Nothing	0 – 4%
0,21 – 0,39	Less	4 – 15%
0,40 – 0,59	Weak	15 – 35%
0,60 – 0,79	Moderate	35 – 63%
0,80 – 0,90	Strong	64 – 81 %
More than 0,90	Very strong	82 – 100%

c) *Standardization of Question Instruments*
Some of the tests carried out for standardizing the question instruments are test validity and reliability.
Validity Test Results by Experts
Experts must first validate the questions used for the pretest and posttest. The researcher asked two 6th-grade teachers as validators who validated the questions that had been made with the validation instrument. The test used in this study is content validity testing.
Question Reliability Test
Test the reliability of the questions using the Cronbach Alpha formula. Criteria if $r_{11} > r_{table}$ at a significant level of 5%, it means reliable, and if $r_{11} < r_{table}$ at a significant level of 5%, it means not reliable (Winarni, 2011).

d) Effectiveness *test*

The product effectiveness test was carried out using an experimental test with Pretest–Posttest Control Design. The design of the LKPD effectiveness test is shown in **Table 3.**

Table 3. Research Design

Class	Pre-test	Treatment	Pos-test
Experiment	O1	X1	O2
Control	O1		O2

(Sugiyono, 2013).

Hypothesis testing using the t-test formula for two independent samples with the criteria if the value of t count > t t table at a significant level of 5% and degrees of freedom (df) = n1 + n2 – 2, then there is a significant difference. Furthermore, the N Gain Test is also carried out to determine the increase in student learning outcomes with the following criteria.

Table 4. N Gain Criteria

Category	Interpretation
G ≥ 0,7	High
0,3 ≤ G< 0,7	Moderate
G< 0,3	Low

(Hake in Sundayana, 2016).

3. RESULTS AND DISCUSSION

3.1 Results

The results of this study are in the form of research and product development processes in the form of student worksheets and materials for space figures using Inquiry-based dol media to Improve learning outcomes for grade 6 Elementary Schools. The development results are described based on the stages of development activities.

Product validity results

The results of the analysis of product validity tests by experts on aspects of material, design, and language are as follows.

Table 5. Product Validation Results

Aspects	Stage 1	Criteria	Stage 2	Criteria
Material	0,71	Enough	0,89	High
Desain	0,68	Enough	0,85	High
Language	0,68	Enough	0,90	High

Based on **Table 5**, it is known that each aspect meets the validity criteria with high criteria. There was an increase after improvements and revisions were made based on the appraiser's suggestions. Suggestions and revisions from the material aspect validator as shown in **Table 6.**

Table 6. Revision of Material aspects

Validators	Comment/Suggestion	Revision Results
Validator 1	The picture of Dol's nets is not quite right	The picture of Dol's nets has been confirmed
Validator 2	The learning objectives contain elements of audience, behavior, condition, and degree	The learning objectives in the student worksheet already contain elements of audience, behavior, condition and degree.
	Core competencies must be by Permendikbud number 37 of 2018	Core competencies have been adjusted to Permendikbud number 37 of 2018.
	Listing the source under the picture	Sources are listed below the picture

Based on the suggestions given, the product was revised so that the product material was appropriate and the material validation was fulfilled. At the same time, suggestions and revisions from the design aspect are shown in **Table 7**.

Table 7. Design aspect revision

Validators	Comment/Suggestion	Revision Results
Validator 1	On the cover, the location of the picture and the title (writing) must have a balanced.	Fixed the position of balance on the cover, including the title and image, in harmony
	The margins in the contents of the Student's worksheet must be considered left and right as well as up and down	Margins have been fixed with margins 3 4 3 3
	The picture on the Student's worksheet is not quite right	The drawings on the student's worksheet have been corrected according to the material
	The picture on the Student's worksheet must be corrected because the students misunderstood it	The pictures on the student's worksheet have been corrected to suit the children's understanding.
Validator 2	Colors must be appropriate and consistent.	Fixed colors, consistently using blue from cover page to back.
	The use of letters must be appropriate and can be read clearly	The font has been corrected by using Verdana font size 11

Table 7 shows that several design revisions, such as paper size, image layout, and font size, had to be revised. Furthermore, the results of the revision notes on the language aspect are summarized as follows:.

Table 8. Revision of Language Aspects

Validators	Comment/Suggestion	Revision Results
Re	The language on the instrument sheet is not/less communicative	Language has been improved to be more communicative
	Use language that is more effective, clear, communicative and straightforward	The language used is effective, clear, communicative and straightforward
NY	Pay attention to the use of punctuation marks such as commas and periods	Fixed comma and period punctuation
	Pay attention to the use of capital letters	Using capitalization has been Fixed
	Create glossary and bibliography	Glossary and bibliography have been added

Expert Reliability Test Results

The reliability analysis results of expert agreement on the material aspect after revisions obtained a score of 83%, with a strong agreement level. This means that reliability shows no significant difference in the assessment between raters. Thus, the student worksheet material that has been developed uses inquiry-based DOL media for students. In theory, it is said to be valid and reliable so that it can be carried out in the trial phase as further research by researchers. Furthermore, the design assessment obtained a reliability score of 87%, with a strong agreement level. Reliability shows that there is no significant difference in the ratings between raters. Thus, the students' worksheet material that has been developed uses inquiry-based DOL media for students. In theory, it is said to be valid and reliable so that it can be carried out in the trial phase as further research by researchers. While the results of the agreement test on the language aspect with a reliability score of 80% with a strong agreement level. Thus, the LKPD material that has been developed uses the Inquiry-based DOL media for students.

Effectiveness of Students Worksheet

An independent test was conducted to test the effectiveness of the data meeting the analysis requirements, namely normality and homogeneity. The students' worksheets effectiveness test that has been developed is carried out by t-test. To determine the effectiveness of Student learning between the experimental class and the control class after being given treatment, the t-test was carried out with the t-count result being 3.89. It shows that the t_{count} score is greater than the t table score (3.89 > = 2.010). Based on these calculations, there was a significant difference in the value of the effectiveness of student learning after being given learning treatment with students' worksheets on building materials using inquiry-based dol media. Furthermore, to see the effectiveness of the pretest-posttest, the N-gain test was carried out in the experimental class. Based on the results of the N-gain test in the experimental class, an average score of 0.7 was obtained. Furthermore, judging from the N-gain criteria, a score of 0.7 is included in the high category.

3.2 Discussion

Students' worksheets validity

The product produced in this development research is in the form of a Mathematics student's worksheet for class VI semester 1 with material on building space in KD 3.7 Explaining the shape of a space which is a combination of several shapes, as well as surface area and volume and KD 4.7 Identifying the shape of a space which is a combination of wakes, and area and surface. The Student's worksheet was developed using inquiry-based Dol media to improve learning outcomes. Students' worksheets that researchers develop students are required to be able to solve problems to be able to think critically to find their knowledge. Learners are directed according to the steps in learning according to the inquiry method, starting from the introduction or orientation of spatial structures, formulating problems, formulating hypotheses, collecting data, and testing hypotheses until at the final stage; students can develop conclusions. In addition, the developed Student's worksheets also relate to the environment around students, especially in the cultural realm. Learning that relates to everyday life will make learning more meaningful. Students will be more interested in learning if they are invited to study objects they often encounter or habits they usually see. One of the appropriate learning resources by the material of building space which of course is a requirement for cultural values, is Dol. Dol is a musical instrument originating from the city of Bengkulu which has the opportunity to be explored, promoted, and developed as a medium for learning mathematics. The shape of the Dol, which resembles a tube, can be used as a learning resource for students in the developed Student's worksheets. So, besides learning mathematics, students also learn about the culture in Bengkulu.

Students' worksheets Eligibility

In stage, I, the material assessment results, input, and expert suggestions are used to revise the Student's worksheet draft 1, which will produce design 2. After the revision of the material, the section is based on the validation results of stage 1. Then draft 2 Students' worksheet is re-validated by a material expert. The assessment in stage 2 results of the average acquisition of validators I and II material experts is 0.89. Furthermore, the results are converted to the level of product achievement as presented in chapter III; then, these results get high criteria. In the design validation assessment in stage I, the average value of the two experts is 0.68, with relatively high criteria. In this stage, the results of the design assessment,

input, and expert suggestions are used to revise the students' worksheets draft 1, which will produce design 2. After the design revision, the section is based on the results of validation stage 1. Then the design 2 students' worksheets are validated again by the design expert. Assessment in stage 2 The results of the average acquisition of validators I and II design experts are equal to 0.85. Furthermore, these results are converted to the level of product achievement; then, these results get high criteria.

User Response to Students Worksheets

In the fourth stage of implementation. At this stage, the Student's Worksheets were applied in the Experimental class and responded to by users, both teachers, and students. The results of the percentage of user responses from teacher 1 aspect were 100% with very, very good criteria. Teacher 2 got a score of 95% with very good criteria. Furthermore, the results of the two responses or teacher responses were averaged to 97.5% with very good criteria. In addition to assessing according to the aspects evaluated in the teacher's response questionnaire, the teacher also provides notes, comments, and suggestions about the Student's Worksheets on building materials using the Inquiry-Based Dol Media. Teacher 1 commented that the Student's Worksheets were exciting, feasible, and good to support the learning process, while teacher 2 commented that the LKPD was good. Based on this, students' worksheets can be used in the learning process. In addition to teacher responses, student responses were also obtained. Student response data were acquired from all students in the experimental class, as many as 26 students. The instrument in the questionnaire was in the form of questions; then, each item used yes and no answers. For positive questionnaire items, the answers were yes (1) and the answer no (0). the results of the percentage of user responses the results of 26 student responses in the experimental class averaged 97.69%, with very good criteria.

Students' Worksheets Effectiveness

The results showed that, on average, the posttest of the experimental class was higher than the control class. The results of the independent t-test showed that there was a difference between the learning outcomes of the class that was given treatment and the class without treatment. While the effectiveness test with N-gain also shows that inquiry learning is more effective in improving student learning outcomes. The results of this study are supported by research conducted by Rajagukguk et al. (2016), which states that inquiry-based teaching materials can improve learning outcomes, namely critical thinking skills. The increase in learning outcomes is due to the teaching materials designed using inquiry learning. According to Tangkas (2012), inquiry learning helps students develop intellectual skills and other skills, such as asking questions and finding (looking for) answers from their curiosity. Meanwhile, Sanjaya (2006) mentions the advantages of learning strategies in emphasizing the development of cognitive, affective, and psychomotor aspects in a balanced way so that learning through this strategy is considered more meaningful. The results also show that the use of context, namely Dol Bengkulu, supports the improvement of student learning outcomes. This is supported by the research of Susanta, Koto, and Susanto (2022), which states that in developing teaching materials, it is necessary to include local contexts such as culture in teaching materials. The results of research conducted by Deliliawan (2016); Rohmah et.al (2019) state that culture-based teaching materials can improve student learning outcomes.

4. CONCLUSION

Based on the results and discussion of this study, the following conclusions can be drawn: (1) Inquiry-based mathematical worksheets using Dol Media with space figure material meet the valid criteria from the material, design, and language aspects. (2) Inquiry-based mathematics worksheets using Dol Media with shape-figure materials increase student response in learning. (3) Inquiry-based math worksheets using Dol media with effective space figure materials in improving learning outcomes.

AUTHOR'S CONTRIBUTIONS

The authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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