

Development of HOTS Test Instruments as an Effort to Improve the Reasoning Ability of Elementary School Students by Using Edugames

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Abstract: This research is motivated by the challenge given by the Industry 4.0 era to increase the high order thinking skill of elementary schools' students thus it is necessary to develop math question used as a reference for further learning development. This study aims to develop test questions based on high order thinking skills (HOTS) to optimize the level of geometric thinking of elementary school students by using Edugames regarding the subject of area and circumference of a plane figure. This is development research using the Design-Based Research method. The results of this study are test questions based on high order thinking skills optimizing the level of geometric thinking of elementary school students with the use of Edugames on the subject regarding area and circumference of a plane figure. The implication of this study is as a basis for knowing students' high order thinking skills in optimizing the geometric thinking abilities of elementary school students.

Keywords: hots questions, geometrical thinking, area and circumference of plane figure

I. INTRODUCTION

Industry 4.0 has changed the entire system of life in the world community [1] [2]. Including changes in educational aspects [3] [4]. Industry 4.0 demands changes and challenges in the education system. These changes focus on the learning process. Learning in the Industry 4.0 must change from conventional learning systems to technology-based learning systems [5] [6]. Learning in the industrial era must make technology as a tool in conveying messages and information to elementary school students.

Also, the industrial era has other challenges, namely schools must produce graduates who have high order thinking skills [7] [8]. It aims to make students can compete globally with other individuals. This thinking ability makes students compete in rational with other individuals while skills aim at making it easier for students to interact into additional values in the globalization process. This change in the education system applies to all levels of education and all subjects. No exception to learning mathematics in elementary school.

Elementary school is the first formal level of education in Indonesia [9]. Elementary schools aim to develop the knowledge, attitudes, and skills of elementary school students to make it easier for them to run their daily lives. These three dimensions are supported by the development of thinking skills that affect the skills of elementary school students. This is realized in the learning process, including in learning mathematics.

Mathematics has a close relationship with technology [10]. Mathematics is the foundation for developing all existing technologies [11]. This is because there is applied knowledge aims to facilitate individuals in understanding life. Besides, mathematics is a science related to abstract concepts, therefore the presentation of mathematics material in learning is often associated with everyday life thus students can find concepts and develop their mathematical abilities based on experience or knowledge they have. [12]. Students can solve a problem if they can examine a problem and use their knowledge in new situations. This ability is usually known as High Order Thinking Skills.

High Order Thinking Skills is a process of thinking students at a higher cognitive level developed from various concepts and methods of cognitive and learning taxonomies such as the method of problem-solving, bloom taxonomy, and learning taxonomy, teaching, and assessment. These high order thinking skills include problem-solving abilities, creative thinking skills, critical thinking, argumentative abilities, and decision-making abilities [13] [14]. High order thinking skills include critical, logical, reflective, metacognitive, and creative thinking [15]. High order thinking skills will occur when someone associates new information with old information stored in his memory and rearranges and develops it to find a solution to a difficult situation [16]. The main purpose of high order thinking skills is how to improve students' thinking skills at a higher level, especially those relating to the ability to think critically in receiving

various types of information, think creatively in solving a problem using the knowledge owned and make decisions in situations complex [17] [18]. It can be concluded that high order thinking skill is a thinking process using unusual thinking skills in solving a problem.

In the teaching and learning process, to know the achievement of indicators taught by a teacher can be seen through the results of tests given to students. Tests can be given in the form of written and unwritten tests included in mathematics learning. The test aims to determine student understanding of learning objectives [19]. In mathematics, three aspects must be mastered by students, namely conceptual understanding, reasoning and communication, and problem-solving [20] [21] [22].

Students only master aspects of conceptual understanding. This is because teachers generally give more questions that are related to conceptual understanding, even though assessment requires 3 aspects. Many teachers are random in filling student grades. This is due to the teacher's lack of understanding of the indicators of each assessment aspect; thus, they do not understand in making questions from reasoning and communication and problem-solving. In the teaching and learning process, only a few teachers use questions to foster student reasoning.

Thus, if students are given open-ended questions, practice, explore the resources needed to make conclusions, plan work on assignments, choose methods and apply their mathematical abilities, hopefully, students will get several benefits from it. Besides the benefits in the cognitive field, they will also get benefits in the affective field, among others, they feel appreciated because they are given the same opportunity to construct concepts individually. One of the materials related to life is geometry about the area and the circumference of a plane figure. Although it seems easy and simple, if it is presented in the form of HOTS questions, it requires a higher level of thinking. Requires reasoning balanced with implanting concepts. If the concept is good but the reasoning and problem solving are less then it will be complicated to solve the problem with the HOTS level. If students have been taught to use HOTS thinking then it will be easy for students to solve HOTS-based problems.

HOTS-based questions will affect the level of thinking of students, not only limited to knowledge of a concept. But with the questions provided students can also use the ability of reasoning and problem solving to the maximum [23] [24] [25] [26]. This will have an impact on improving the quality of students' thinking. The ability to think at a high level receives special attention from one of the international study institutes that studies the cognitive abilities of students in the fields of mathematics and science.

The institution is called TIMMS (The Trends for International Mathematics and Science Study). The results of the study stated that Indonesia ranked 46 out of 51 countries in 2015 [27]. From this study, it can be seen that students' HOTS thinking ability is still very low. For that improvement in the learning process is needed. One of them is by making HOTS questions to improve students' high-level thinking. The level of thinking will also affect the level of geometric thinking of students on

material about the area and circumference of a plane figure.

The higher the questions, the higher the level of student thinking and will affect the higher level of students' geometric thinking. If the problem is low, then the level of thinking of students is also low which has an impact on the level of geometric thinking becomes too low. Consequently, we need an increase in the provision of questions to improve students' thinking processes. On this occasion, the researchers want to apply HOTS-based test questions as a reference for teachers to find out their success in developing their students' high order thinking skills using Edu-game learning that had previously designed. Edu games learning is one of learning following industry 4.0 that has developed before.

Therefore, the purpose of this study is to develop test questions based on high order thinking skills to optimize the level of geometric thinking of elementary school students using Edugames on the Material of Area and circumference of a plane figure.

II. METHOD

The research method used in this study is the design-based research (DBR) method. Design-Based Research is defined as a series of approaches, to produce new theories, artifacts, and practices that explain and potentially impact on naturalistic learning [28]. The basic research design stages, namely:

- Identify and analyze problems. At this stage, researchers together with practitioners collaboratively to identify problems that occur in the field and linked with theoretical studies to find the real problems.
- Develop a Solution. At this stage the researcher and the practitioner work together to find solutions to the problem based on the predetermined problem formulation.
- The process is repeated. At this stage repeated testing of the product is developed.
- Reflect. At this stage aims to produce principles in product development [29].

Data collection techniques are using interviews, observation and tests.

III. III.RESULTS AND DISCUSSION

A. Collaboratively Identify and Analyze Problems by Researchers and Practitioners

From the researcher's observations and analysis of the questions, it can be seen that the test questions have indeed been developed quite well in schools. The test questions that were developed also varied from multiple-choice questions, essays, and short entries. However, high-level questions or HOTS are less developed in elementary schools. Problem development is still at a low level of thinking or LOTS. High-level questions must be developed at the elementary school to help students develop thinking skills even though only 1: 5 with ordinary questions or LOTS. This is also supported by the results of researchers' interviews with several teachers that they rarely use the HOTS question in learning mathematics in elementary school. Besides, it found that teachers rarely develop other abilities besides understanding concepts. Based on the analysis results it

can be concluded that teachers rarely develop HOTS abilities in geometric thinking. This is evidenced by the lack of development of HOTS questions in elementary school mathematics learning.

Mathematics has many dimensions of ability such as communication, connection, logical thinking, critical thinking, etc. [30] [31]. This ability must be developed since elementary school age. Therefore, the teacher as a subject in learning must develop these abilities thus students can achieve the maximum level of learning mathematics.

B. Develop Solutions Based on Benchmark Theories, Existing Design Principles and Technology Innovations

After the researcher has identified the problem, it can be concluded that the problem is the lack of development of HOTS questions in elementary schools, so the researchers conducted a theoretical study of high order thinking and a curriculum to develop HOTS-based test question designs. In this stage, there are several stages conducted by researchers, including

- Student Analysis

Based on observations and documentation, it appears that elementary school students are still in the age range of 6-13 years. This proves that elementary school students are in a concrete operational period. Piaget revealed that children at the concrete operational stage already have the characteristics of adequate use of logic [32]. During the concrete operational period, students learn from tangible objects and are related to students' direct lives [33] [34]. At this time students are taught by relating events that have been seen or encountered by students. It is intended that students can easily understand the information provided. Therefore, the questions developed must be concrete and contextual.

- Analysis of Learning Material

After analyzing the students, the researchers chose to develop questions in the fourth grade. Fourth grade is the beginning of a high class in elementary school so that it will be easier to carry out research. Researchers began to provide a curriculum to determine which material will be selected. The material chosen is about the area and circumference of the plane figure. This material is chosen because it is often found in everyday life.

In the selection of material must consider several aspects. Learning material must be following the curriculum [35]. This aims to make it easier to achieve learning goals that have been set. Learning material must be specifically described [36] so students can develop the learning to a higher level. Good material is a material suitable for the student's condition [37]. It aims to make students easily understand the information provided because it is under the conditions and circumstances of students

- Analysis of Learning Objectives

After analyzing the learning material, the writer analyzes the learning objectives. This is done to know the conditions used in achieving learning objectives. The general learning objectives in this study are students can answer story questions related to the area and circumference of the plane figure. Learning objectives are

made by considering many aspects. The objective of learning must be achieved to measure the achievement of the learning process [38] [39]. Learning objectives are made as a guide for teachers in implementing learning

- HOTS Question Formulation

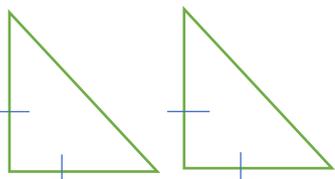
The preparation of questions as follows (Table 1):

Table 1
Table of the Preparation Question

Subjects	Indicator	Question Number	Cognitive Aspects
Mathematics	Explain the meaning of square rectangle and triangle	1 (multiple choice)	C4

The next step is to arrange the rubric for essay questions as follows (Table 2).

Table 2
Table of Rubric for Essay

Question	Answer key
<p>Answer the questions below!</p>  <p>If two triangles are combined with the same side length, then the shape formed is....</p> <p>a. Square b. Rectangle c. Triangle d. Circle</p>	<p>a. square</p> <p>join right on both sides of the slant so this shape will be square. The tilted side that coincides will become a diagonal of the square.</p>

Test questions based on HOTS stage 1 (question design): An origami paper in square shape has a side length of 10 cm. Then the circumference of origami paper is

- a. 20 cm b. 40 cm
c. 50 cm d. 100 cm

C. A Repeated Process to Test and Correct Questions

In the next stage, it is an iterative process to test and improve solutions practically. In this stage, the release makes improvements to produce hots-based test questions that appropriate to use.

- Expert Validation

At this stage, validation is performed on the HOTS-based test question design. Validation is done to determine the quality of the validity of the problem based on expert judgment [40] [41] [41]. Good questions are questions that measure what you want to be measured. As explained previously, the researchers validate the expert with the help of a Mathematics Lecturer, Drs. Syafri Ahmad, M.Pd. to find out how the quality of questions before the trial.

• Revision 1

Some questions have been changed and upgraded to higher cognitive level by improving writing, adjusting the questions grid and HOTS question-level with a validation value of 50 and being at a sufficiently valid level with general assessment C can be used with moderate revision. Examples of improvements made on question no. 5.

Table 3
Table of revision

Initial question	Revision
5. An origami paper in square shape has a side length of 10 cm. Then the circumference of origami paper is.... a. 20 cm b. 40 cm c. 50 cm d. 100 cm	5. A square-shaped carton has an area of 144 cm ² . Then the length of the side is... a. 8 cm b. 10 cm c. 12 cm d. 14 cm

• Revision II

Revision II with a validation value of 88 is at a very valid level with a general assessment in the range A can be used without revision. Questions have been made can be tested on students to see which questions are valid and invalid

• Trials

After revision II, a trial was conducted (Table 4). The trial was conducted in Elementary School 02 with 24 students on May 14, 2019. After that, the test results were analyzed using the SPSS program, Microsoft Excel and manual with the product-moment correlation formula to determine the validity of the questions after the trial.

Table 4

Recapitulation of Multiple-Choice Trial Instrument Analysis

Questions number	Validity		Appropriateness		Level of difficulty		Conclusion
	Value	Interpretation	Value	Interpretation	Value	Interpretation	
1	0,016	I	0,00	B	0,917	Es	NU
2	0,377	I	0,334	E	0,750	Es	NU
3	0,493	V	0,250	E	0,542	M	U
4	0,597	V	0,584	G	0,375	M	U
5	0,487	V	0,334	E	0,500	M	U
6	0,667	V	0,500	G	0,667	M	U
7	0,514	V	0,583	G	0,542	M	U
8	0,208	I	0,333	E	0,583	M	NU
9	0,364	I	0,250	E	0,125	H	NU
10	0,272	I	0,333	E	0,583	M	NU
11	0,254	I	0,250	E	0,375	M	NU
12	0,444	V	0,250	E	0,292	H	U
13	0,506	V	0,333	E	0,417	M	U
14	0,524	V	0,167	B	0,583	M	NU
15	0,609	V	0,417	G	0,458	M	U
16	0,529	V	0,334	G	0,500	M	U
17	0,476	V	0,500	G	0,333	M	U
18	0,535	V	0,333	E	0,667	M	U
19	0,603	V	0,583	G	0,292	H	U
20	0,079	V	0,167	B	0,167	H	NU

Description:

- | | |
|-------------|---------------|
| I = Invalid | G = Good |
| V = Valid | Es = Easy |
| B = Bad | M = Medium |
| E = Enough | NU = Not used |
| H = Hard | U = Used |

From the validation data, the multiple-choice questions show that the questions exceed R-table numbers are 6 (questions no: 1, 2, 8, 9, 10, and 11) invalid questions and 14 valid questions. With a reliability level of 0.783, they are in good criteria and show questions that can be trusted. Whereas in the appropriateness test there are 3 bad questions, 10 enough questions, 7 good questions. For the difficulty index, there are 3 levels: 2 easy questions, 14 medium questions, and 4 difficult questions.

The items that can be used are if the question is valid, Appropriateness is enough to good criteria, the level of difficulty is easy, medium and hard, and reliability is the value $\alpha > r$ -table. It can be concluded from the table above the questions that can be used are 12 questions and 8 questions are not used.

D. Reflecting to Produce Design Principles and Improving the Implementation of Practical Solutions

In the next stage, the HOTS question product was successfully developed with several good revisions from experts following the results of the validity and reliability analysis, along with the grid, HOTS questions and answer keys. After the reflection, questions were developed based on the revision. At the end of the trial, 20 questions were declared statistically valid by experts.

Overall, HOTS questions have been developed to increase the ability to think geometrically in edugames learning. HOTS capability is one of the demands in the industry 4.0 [42]. HOTS ability has many benefits, one of which is that it can improve learning and problem-solving abilities. These two abilities connect to the ability to think geometrically. In this ability, there are elements of geometric problem-solving. Thus, the HOTS ability of students can help them in solving these geometric problems.

IV. CONCLUSION

Based on the results of the research, HOTS-based test questions have been developed in mathematics learning using edugames in elementary schools with the DBR (Design-Based Research) method.

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