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# Developing of HOTS-Based Pythagorean Theorem Questions in Mathematics Learning

**N. Noerhasmalina[1], N. Nurmitasari[2]**

[1,2]Faculty of Teacher Training and Education, University Muhammadiyah Pringsewu
UMPRI, 112 KH. Ahmad Dahlan St., Pringsewu, Lampung, Indonesia
Email: noerhasmalina@umpri.ac.id, nurmitasari@umpri.ac.id

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**Abstract:**

The impact of question-based HOTS on learning Mathematics during a pandemic encourages students' development of thinking skills and creativity. As a result, the aim of this research is to develop feasible HOTS-based Pythagorean Theorem questions in Mathematics learning. This type of research is development research design. This research development design is a 4-D development model. This 4-D development model is divided into four stages: *define*, *design*, *develop*, and *disseminate*. However, this research has only progressed to the stage *develop*.Based on the results of expert validation, it was found that HOTS-based Pythagorean Theorem questions were in correlated with the indicators of the feasibility's questions to be applied. Then based on the test results using the correlation formula, *Pearson product-moment* found that the fiveitems were valid, for the difficulty level the five items were included in the moderate criterion, for the distinguishing power that the five items had good distinguishing power, then using the formulait was *alpha Cronbach* determined that the five items are reliable. According to the research findings, HOTS-based Pythagorean Theorem questions are feasible to use for Mathematics instruction.

**Keywords:** HOTS, Pythagorean Theorem, 4-D Development, Mathematics

## INTRODUCTION

Education in Indonesia is constantly improving, resulting in a high-quality educational productor outcome. Various attempts have been made in order to increase the quality and quality of existing education in order to provide the next generation that is reliable and capable of facing life's challenges.

In order to improve the quality of education in schools, pursued through various upgrading activities, seminars, education and training or workshops. Through these various activities, learning innovations are introduced, because innovation is a necessity. Development of teaching materials, development of learning strategies and methods, development of learning media, assessment system, evaluation, and assessment has become the main menu of the world of education, but from

empirical experience it seems that these efforts have not significantly brought about changes in the meaning of improving the quality of education in schools (Saifulloh, Muhibbin, & Hermanto, 2012)

A material that is available at any level of education as a foundation for dealing with the challenges of life is Mathematics. For there is a need for innovation in learning Mathematics so that theconcepts of Mathematics that students want to achieve are achieved optimally. Mathematics is one of the subjects that is taken very seriously in the school system, irrespective of country or level of education (Olanrewaju & Suleiman, 2019)

Likewise, SMP N 1 Gadingrejo can often innovate to promote Mathematics learning both in terms of learning methods, learning media, and the questions used to determine the extent of students' abilities about Mathematics. This is very important, because the development of skills and creativity ofstudents of SMP N 1 Gadingrejo needs to be grown in order to face life's problems later. The use of HOTS-based questions in mathematics learning can be the right solution to develop students' skills andcreativity. For this reason, HOTS (Higher Order Thinking Skill) based math problems must be developed at SMP N 1 Gadingrejo. Higher Order Thinking Skills (HOTS) among students is crucial tobe developed in the education system as to prepare students to face the 21st century situations as well as to develop students to reach their full potential (Wilson & Narasuman, 2020)

According to the revised Bloom's Taxonomy, cognitive processes are classified into two types,high-order thinking skills or often called *Higher Order Thinking Skills* (HOTS), and low-level thinkingskills also known as *Lower Order Thinking Skills* (LOTS). Low-level thinking skills involve the abilityto recall, interpret, and apply information, while in higher-order thinking skills include analysis and synthesis, evaluate, and create or creativity. HOTS requires students to imagine themselves solving mathematical problems based on principles and concepts which are then developed to obtain the desiredresults. HOTS began to be applied in classroom learning with the goal that learning Mathematics wouldhelp students encourage their development of thinking skills and creativity.

Most of the reforms in the field of schooling is the use of questions geared toward Higher OrderThinking Skill (HOTS). HOTS is a high-level thought capacity that entails a reasoning method to hone critical, analytical, insightful, metacognitive, and imaginative thinking skills (Suryapuspitarini, Wardono, Kartono, 2018). Thinking is a process so that problem solving can be viewed as a process (Mairing, 2018). HOTS allows students to visualize themselves solving mathematical problems basedon principles and ideas that are then created to achieve the desired outcomes. HOTS was first used in the classroom with the goal that learning Mathematics would help students improve their thinking skillsand creativity.

*Higher Order Thinking Skills (HOTS)* are not a new concept in mathematics education, but teachers must be cautious in their interpretation. HOTS vocabulary is described differently by experts. The capacity to think objectively, intellectually, reflectively, metacognitively, and creatively is referredto as HOTS (Mainali, 2012). HOTS is related to three things, namely: transfer, critical thinking, and problem solving (Sumaryanta, 2018) .Meanwhile, according to *The Australian Council for Educational Research* states that higher-order thinking skills are a process: analyzing, reflecting, providing arguments (reasons), applying concepts to different situations, composing, creating. Higher order thinking skills are more than just being able to recall, know, or repeat information. Higher order reasoning capabilities include problem-solving abilities, logical thinking abilities, imaginative thinking abilities, argumentation abilities, and decision-making abilities (Widana, 2017). HOTS can be described as a high-level thought skill that involves the processes of evaluating, contemplating, presenting arguments (reasons), applying principles to various contexts, writing, and making. HOTS allows students to visualize themselves solving mathematical problems based on principles and ideas that are then created to achieve the desired outcomes. Although the problems in HOTS

are not always regular, they are still based on mathematical principles and concepts. HOTS-based problems will covernearly all of the content of Mathematics.

Question that is categorized as a HOTS-based question is actually not always difficult and the type of problem that is difficult is not necessarily HOTS because basically, HOTS only focuses on questions that can stimulate analytical skills and problem-solving, not on complicated types of questionsbeyond the capacity of students. Writing math questions generally has a tendency to write questions that require memory behavior because it is easy to write questions and the material is obtained directlyfrom textbooks. The questions that measure memory give less encouragement to students to study harder. Therefore, students need to be given questions that require higher thinking processes (*Higher Order Thinking Skills or HOTS*). The formulation of the questions based on HOTS was presented witha variety of information, usually with a stimulus. The stimulus can be in the form of text, images, graphics, tables, etc. which contain information from real life. The stimulus used should be interesting,meaning that it encourages students to read (Kemendikbud, 2017). Thus, HOTS-based questions require students to: (1) transfer the information from one context to another; (2) processing and applying information; (3) see the relationship between different information; (4) use information to solve problems; (5) critically studying / analyzing ideas or ideas and information.

The tips for compiling HOTS-based questions are: (1) *Use real-world contexts*, real-world contexts in stimuli that allow measuring application or implementing competencies which are one of the higher-order thinking levels; (2) *Give questions related to visual analysis, the* use of stimuli in theform of newspaper articles, graphics, maps, charts, *flowcharts is* very helpful in preparing HOTS-basedquestions. The presentation of the visual stimulus allows the preparation of questions that measure thecompetence of analyzing and evaluating, making it easier to arrange HOTS-based questions; (3) *Ask the reasons for the answers given,* low-order thinking questions can become high order thinking questions when the questions require an explanation from students. The process of thinking and answering students is not just choosing the answer option, because it also illustrates high-order thinkingquestions because students are asked to explain their calculations which are more than one source of information (Center for Educational Assessment Research and Development Agency of the Ministry ofEducation and Culture, 2017)

To write HOTS-based items, the question writer must be able to identify the behavior to be evaluated and devise material that will be used as the basis for questions (stimulus) in specific situationsdepending on the predicted behavior. As a result, mastery of the instructional content, expertise in writing questions (question construction), and instructor ingenuity in selecting question prompts basedon the circumstance and circumstances of the environment surrounding the educational unit are required when writing these questions. The following are the steps for preparing HOTS-based questions: (1) *Analyzing Basic Competence on HOTS-based questions*, first the teachers choose Basic Competenciesthat can be made HOTS-based questions. Not all basic competencies can be made into HOTS-based question models. Teachers independently or through the Subject Teacher Conference (MGMP) forum can analyze Basic Competencies which can be made HOTS-based questions; (2) *Developing a questiongrid.* The writing grid for HOTS-based questions aims to assist teachers in writing HOTS items. In general, this grid is needed to guide teachers in: (a) choosing Basic Competencies that HOTS-based questions can make, (b) selecting subject matter related to Basic Competencies to be tested, (c) formulating question indicators, and (d) determine the cognitive level; (3) *Choosing an interesting and contextual* stimulus, the stimulus used should be interesting, meaning that it encourages students to readthe stimulus. Interesting stimuli are generally new, never read by students. Meanwhile, contextual stimulus means a stimulus that is in accordance with reality in everyday life, is interesting, encourages students to read; (4) *Write question items in accordance with the question grid*. Question items are written in accordance with the HOTS-based rules of writing questions. The rules

for writing items basedon HOTS are somewhat different from the rules for writing items in general. The difference lies in thematerial aspect, while the construction and language aspects are relatively the same. Each item is writtenon a question card, according to the attached format; (5) *Creating scoring guidelines (rubrics) or answerkeys*. Each HOTS-based item written should be equipped with scoring guidelines or answer keys. Scoring guidelines are made for the form of description questions. Meanwhile, the answer key is madefor multiple choice questions, complex multiple choice (true / false, yes / no), and short entries. The following table shows the questions categorized as HOTS-based and not HOTS-based.

**Table 1**. Difference between HOTS-based and non-HOTS-based questions

| | **HOTS Based Questions** | **Non-HOTS Based Questions** |
|---|---|---|
| **The Example** | Ninety-five percent of world trade commodities are through sea transportation, using around 25,000 tankers, shipping vessels and giant cargo carriers. Most of these ships use diesel fuel. The engineers plan to build support power using wind for the ships.Their proposal is to install a sail in the form of a kite onto the ship and use wind power to reduce the use of diesel in the environment.<br><br>rope<br>From this, what is the approximate length of the sailing rope from the kiteso that the sail is pulling the ship at an<br>angle of 45 ° and at a vertical height of150 m, as shown in the picture? | rope<br>If it is known as in the picture, howlong is the sailing rope on the ship? |
| **Indicator** | | |
| Questions Form | Expressed implicitly through the narrative at the beginning of the questionbefore entering the core of the question<br>at the end of the question (analyze) | It is explicitly stated through the direct picture and the information that is known in the picture (apply). |
| The value of theequilateral triangles sides | written implicitly by providing a large explanation The angle of the triangle formed from the sailing rope (evaluate). | It is written explicitly, namely 150 mand 150 m, so that the length of the sailing rope can be immediately found (understand) |
| Material | Combining the concept of the Pythagorean theorem with the congruence on the triangle (create) | Only focus on the material of the Pythagorean theorem (remember). |

HOTS-based questions can be applied to every subject. Likewise in learning mathematics. In mathematics learning, material on arithmetic, Pythagorean theorem, a system of linear equations with two variables, congruence, flat shapes and spatial shapes, and so on, namely material related to everyday life can be developed into HOTS-based questions. In this study, the questions that will be developed in mathematics learning are the Pythagorean theorem. This is considered very important, because the concept of the Pythagorean theorem is closely related to life, so that the development of questions on the HOTS-based Pythagorean Theorem material is needed by students to train critical, logical, reflective, metacognitive, and creative thinking.

The implementation of HOTS in the teaching and learning of mathematics is essential to change the stigma of the society on the difficulty of mathematics. HOTS can also attract students to foster their interest in mathematics (Abdullah, at all, 2017). Therefore, the purpose of this study is to produce HOTS-based Pythagorean Theorem questions in mathematics learning that are suitable for use at SMP N 1 Gadingrejo.

## METHODS

The type of research is development research. This design research and development is according to Thiagarajan which is commonly known as the 4-D development model (Trianto, 2010). This 4-D development model consists of four stages, namely define, design, develop, and disseminate. However, this research only reached the stage of development. Activities carried out at the stage define include student characteristics and concepts to be taught, namely preliminary analysis, student analysis, and concept analysis. (1) Preliminary analysis is used to determine the fundamental problems faced by SMP N 1 Gadingrejo so that it is necessary to develop math problems; (2) Student analysis was used to determine the characteristics of class VIII students at SMP N 1 Gadingrejo; (3) Concept analysis, namely task analysis is used to identify, detail and systematically arrange relevant material concepts to be taught based on preliminary-to-end analysis.

At this stage, it design aims to design questions for learning mathematics that can train students to think critically and creatively in order to prepare themselves for the Olympics. The activities in the design are: composing tests, selecting the types of questions, and choosing the format. (a) In the preparation of tests, the basis for the preparation of the tests is the analysis of the concepts outlined in the specification of learning objectives. Tests are prepared based on the indicators or specifications of learning objectives which are summarized in the test specifications. (b) Selection of the types of learning questions, the activity of selecting the types of questions in this study is carried out to determine the types of learning questions that are appropriate for the presentation of learning material. (c) Format selection, the preparation of questions in this development includes choosing the format for making question instruments.

Then the stage, develop which aims to produce a question instrument that is suitable for use after going through several revision processes. Activities at the stage develop are an expert assessment and field trials. (1) Expert judgment, expert judgment includes content validation, which includes all instruments developed at the design stage. Content validity, namely measuring conformity with certain specific objectives aimed at expert validators. Experts are competent validators to assess the question instruments developed and provide input or suggestions, in order to improve the question instruments that have been compiled. (2) Field trials, field trials are carried out to determine the validity of each instrument item, the level of difficulty, the distinguishing power of each instrument item, and the reliability of the instrument.

Validation is an important process to ensure that the developed instrument is able to measure what it intends to measure (Ramli, at All, 2020). The validity of each instrument item was calculated using the formula correlation Pearson product-moment (Riduwan,2009). To determine the difficulty level of the question, it can be done by dividing the total score for each

item by the maximum score times the number of test-takers. As for the questions that are feasible to use, they are at a moderate levelof difficulty, namely a difficulty level that is more than 0.3 and less than 0.7. Then the distinguishing power of each item of the instrument is searched by the formula for the mean score of each item dividedby the maximum score in the upper group minus the average score for each item divided by the maximum score in the lower group. Good distinguishing power that is valued more than 0.3 (Supranata, 2009). Finally, the reliability of the instrument was searched using the formula Cronbachalpha (Riduwan,2009).

## RESULT AND DISSCUSSION

The results of this study are a HOTS-based question instrument that is suitable for use both in content and in the construct using the 4-D development model. The steps in developing the question instrument are (1) define; (2) design; and (3) develop. Activities carried out at the stage defines includestudent characteristics and concepts to be taught, namely preliminary analysis, student analysis, and concept analysis. (1) Preliminary analysis, the questions used in learning mathematics at SMP N 1 Gadingrejo have not referred to the analyzing, evaluating and creating stages which are stages C4, C5,and C6 in Bloom's taxonomy of thinking which is the characteristic of HOTS; (2) Student analysis, the majority of students at SMP N 1 Gadingrejo are skilled, creative and like challenges; (3) Concept Analysis, a concept that often relates to everyday life in the eighth grade of semester 2 by chance is theinitial material in that semester is the Pythagorean Theorem, so it is in this Pythagorean theorem that the researcher decided to develop a HOTS-based question instrument. The KD that can be made basedon HOTS questions are solving problems in everyday life using the Pythagorean theorem and observingeveryday problems related to the Pythagorean theorem, for example the shape of the roof truss, stairs, towers, trees and their shadows, flying a kite

At this stage, it the design stage, it aims to design questions on the HOTS-based Pythagorean theorem material. Activities in the design are: preparation of tests, selection of types of questions, and selection of formats. (1) Preparation of the test, the instrument compiled at this stage is an expert assessment instrument, namely a material expert as shown in table 2

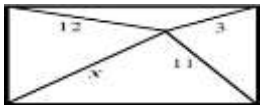
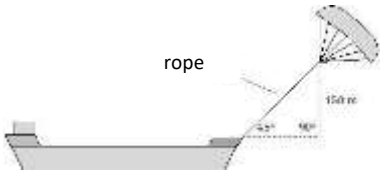
**Table 2**. Assessment of Problem Instruments Aspects of Material

| **Aspects** | **No** | **Indicators** | **Questions number** | | | |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| | | | S | S | S | S |
| **Construction** | | The formulation of the question items has used question words or commands that demand answers to description questions | | | | |
| | | The commands are easy to understand andhave clear meaning | | | | |
| | | The formulation of the items does not create a double meaning. | | | | |
| | | The contents of the questions meet the competencies to be achieved | | | | |
| **Content** | | The contents of the items are the materialthat has been studied by students | | | | |
| | | The formulation of the items uses Indonesian language rules that are goodand correct | | | | |
| **Language** | | The formulation of items using simple, communicative, and easy-to-understandlanguage | | | | |
| **Time** | | The time provided for answering thequestions is sufficient | | | | |

Description **S** = Suitable; **NS** = Not Suitable

*2) Selection of the types of learning questions*, the types of questions used are HOTS-based; (3) *Format selection, the* preparation of questions in this development is in the form of a description. The instrumentfor HOTS-based Pythagorean Theorem is shown in the following table.

**Table 3**. Pythagorean Theorem problem based on HOTS

| |
|---|
| 1. A ship sailing from port A to the west to port B for 210 km. Then proceed again towards the South towards port C as far as 200 km. What is the shortest distance from port A to port C. |
| 2. Look at the following rectangular image!<br>  in cm.<br>The rectangle in the image consists of several arbitrary triangles arranged to form a rectangle. If what is known as in the figure, determine the length x! |
| 3. A child raises a kite with a string that is 25 meters long. The distance of the child on the ground from the point directly under the kite is 7 meters. Calculate the height of the kite from the ground. |
| 4. Ninety-five percent of the world's commodities trade through sea transportation, using about 25,000 tankers, shipping vessels, and giant cargo carriers. Most of these ships use diesel fuel. The engineers plan to build support power using wind for the ships. Their proposal is to install a sail in the form of a kite onto the ship and use wind power to reduce the use of diesel in the environment.<br>  <br>From this, what is the approximate length of the sailing rope from the kite so that the sail is pulling the ship at an angle of 45 ° and at a vertical height of 150 m, as shown in the picture? |

In this study, only 4 questions were developed. In line with Abdullah et al's research, the HOTS- based math problems developed were only 4 items (Abdullah, Abidin, & Ali, 2015). This is adjusted tothe time given to students in working on the questions when the questions are tested. Another reason isthat HOTS-based questions are not used to being applied to students at SMP N 1 Gadingrejo so that if given a lot of questions, it will cause anxiety.

The stage *develop* is aimed at producing a question instrument that is suitable for use after going through several revision processes. Activities at the stage *develop* are an expert assessment and fieldtrials. (1) *Expert assessment,* at this stage, is the assessment of question instruments to experts from thematerial aspect, namely Robia Astuti, M.Pd and Yasimpen, S.Pd. Based on the assessment of the twoexperts, it was concluded that the question instrument was feasible to use. (2) *Field trials, field* trialsare carried out to determine the validity of each instrument item, the level of difficulty of eachinstrument item, the distinguishing power of each instrument item, and the reliability of the instrument.

The results of calculating the validity of each instrument item are shown in Table 4. It statesthat all four instrument items are valid.

**Table 4**. Results of Validity Analysis Item Problem

| Item No. | value $r_{obtained}$ | value $t_{obtained}$ | value $t_{table}$ | Decision | Criteria Index (*r*) |
|---|---|---|---|---|---|
| 1 | 0,917 | 6,515 | 1,860 | Valid | Very High |
| 2 | 0,958 | 9,472 | 1,860 | Valid | Very High |
| 3 | 0,808 | 3,879 | 1,860 | Valid | Very High |
| 4 | 0,960 | 9,731 | 1,860 | Valid | Very High |

The results of the calculation of the difficulty level of each item are shown in table 5 that thefour items have a moderate difficulty level.

**Table 5**.Results of the Analysis of Problem Item Difficulty Levels Question

| Item No. | Total per item | Maximum score × number of students | Difficulty level | Decision |
|---|---|---|---|---|
| 1 | 130 | 200 | 0,65 | Moderate |
| 2 | 120 | 300 | 0,40 | Moderate |
| 3 | 115 | 200 | 0,58 | Moderate |
| 4 | 135 | 300 | 0,45 | Moderate |

The results of the calculation of the distinguishing power of each item are shown in table 6

**Table 6**.The Results of the Analysis of Distinguishing Power of Question Items

| Item No. | Average Score of Each Item Divided by Maximum Score in the Upper Group | Average Score of Each Item Divided by Maximum Score in the Lower Group | Distinguishing Power | Decision |
|---|---|---|---|---|
| 1 | 0,9 | 0,4 | 0,5 | Accepted |
| 2 | 0,63 | 0,17 | 0,46 | Accepted |
| 3 | 0,8 | 0,35 | 0,45 | Accepted |
| 4 | 0,7 | 0,2 | 0,5 | Accepted |

Test instruments that have been declared valid are then tested for reliability to determine the level of consistency of the tests used. The test is said to be reliable, that is, if the test gives relatively the same (consistent) results. The reliability test was carried out using the formula *Alpha Cronbach* and the results showed that the question instrument was reliable with a reliability value of 0.928. Based onthe expert's assessment, namely material experts and field trials including the validity of the question instrument, the level of difficulty, distinguishing power, and reliability, the HOTS-based question instrument is suitable for use in mathematics learning on the Pythagorean Theorem material.

Based on the validation results both in content and item items, the questions developed were declared valid. This is because in the preparation of the items in accordance with the steps in making HOTS-based questions. And according to the characteristics of students, it was found previously that students at SD N 1 Gadingrejo have the characteristics of liking challenges. Bloom's thought taxonomycategory did not go unnoticed when creating questions. Then based on the level of difficulty and discriminatory power, the results of this study indicate that each item of the question can be accepted.

This is because when making questions also pay attention to students' ability to solve problems. As mentioned earlier, HOTS does not mean difficult questions but questions that require students to do analysis. Then from the reliability test of the questionnaire items are said to be reliable. This shows thatthe question can be applied anywhere to anyone with the same educational level record.

Higher order thinking skills (HOTS) is needed by students. Students are not only required to apply what they have learned, but also to analyze, evaluate, and synthesize the knowledge they have gained to solve problems in everyday life. Thus, HOTS needs to be trained and taught to students one of them through textbook on learning mathematics. Therefore, it is necessary to analyze the HOTS contentin mathematics textbook to find out how HOTS opportunities are given by mathematics textbook(Pratama & Retnawati, 2018).Various ways must be done to increase HOTS students so they can increase. Development and use of various learning models, learning methods, learning material, teaching materials, student worksheet, and learning media can improve students HOTS (Ichsan, 2019).

## CONCLUSION

Based on experts, namely material experts and field trials covering the validity of the question instrument, level of difficulty, discriminatory judgment, and reliability, the HOTS-based question instrument is feasible to be used in learning mathematics on the Pythagorean Theorem material. With the results of this study, teachers should start making questions, especially in HOTS-based mathematics learning by paying attention to the characteristics of the mathematics subject matter. Keep in mind that mathematical material that can be developed is more related to the real world, for example social arithmetic, comparisons, flat shapes and spaces shapes, and many others.

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