The Development of Mathematics HOTS Problems on Trigonometric for Senior High School

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Abstract— **The study aims to describe the development steps of the Higher-order Thinking Skill (HOTS) for the subject of trigonometric and their validation processes. Trigonometric is a subject that is considered difficult for learners due to the use of the mathematical concepts that are not real (abstract). While, the 2013 curriculum demands students to have critical, collaborative, communication, creativity, and innovation ability following 21st-century necessities. In developing the HOTS problem, one should consider the curriculum, select the latest contextual stimulus, then validate and test it. The method used in this research is a qualitative method with a formative evaluation followed with a self-evaluation phase (Tessmer, 1993; Zulkardi, 2006). The results of this study are ten item problems of HOTS based on the C-4 framework (analyze), C-5 (evaluate), and C-6 (create). After being developed, the problem is tested on research subjects to check its validity, practicality, and potential.**

Keywords: component, HOTS, critical, collaborative, communication

I. INTRODUCTION

Trigonometry is one of the subject matter that students must master where students are required to possess the cosine sinus formula in the number and difference of two angles, the method of numbers and difference of sinus and cosine, and use it in problem-solving [1]. Based on the results of research [1], some students have difficulty in understanding trigonometry. Students have not been able to associate the intended description with the concept of trigonometric comparisons on the elbows. Students have not been able to associate problem descriptions with the concept of trigonometric comparisons in each quadrant

21st-century learning is a learning activity that focuses on competencies, among others: communication, collaboration, critical thinking, and problem-solving, and creative and innovative skills [2].

While, HOTS (High Order Thinking Skills) is a thinking skill focused on a higher level of achievement, a thinking ability that is more than just capacity to replicate or recall facts, [3]. [4] categorized high-level thinking skills into three parts that are: as a result of transferring learning material, as a form of critical thinking, and as a problem-solving process.

The curriculum that is currently applied in Indonesia is 2013 curriculum which according to [5] is the result of further analysis of the previously adopted curriculum with the aim to revise the competency standards and basic competencies that are not relevant to the 21st-century learning demands, to improve teacher training quality, and to use technology in the mathematics learning process at schools. One of 21st century required skills is mathematical literacy closely related to the ability of a person/learner in formulating/solving problems of daily life context using mathematical knowledge.

Also, HOTS (High Order Thinking Skills) is a skill in thinking process focused on a higher level, a result of intellectual skill that leads to a higher level of the thinking process. The higher-level thinking is defined as the level of thinking that is more than the ability to replicate concepts, or to recall memory [3]. BSNP Chairman, Mr. Bambang Suryadi, said that Indonesian children would be lacked competitiveness if they are not trained for 21st-century life skills at schools. Thus, HOTS capital assessment is also conducted to improve Indonesia's achievement at the international level.

According to [6], by working on HOTS mathematical problems that require a high level of thinking, students are trained to think at the analysis level, to evaluate and reconstruct. Therefore such problems should be further developed in the 2013 curriculum in order to support the enhancement of student's mathematical literacy skills. For that reason, researchers develop high-level thinking questions (HOTS) so that the resulted questions can be used to develop high-level thinking skills in students.

A. Cognitive Aspect

According to [7], indicators for measuring high-level thinking capabilities are including:

- Analysis C4

The ability to categorize concepts into several components and to relate them one and another in order to gain an understanding of the concept as a whole.

- Evaluate C5

Ability to assign degrees of an object based on specific norms, criteria, or references.

- Create C6

The ability to integrate elements into an integrated and coherent new form, or to create something original.

B. Higher-Order Thinking Skill (HOTS)

Higher-Order of Thinking Skills (HOTS), according to [8], is the ability to think critically, logically, reflective, meta-cognitive, and innovative that is part of high-level thinking skills. [9] defines HOTS as an assessment instrument that is used to measure high-level thinking ability, which is more than an ability to recall, to restate, or to refer without analysis (recite). Operational critical thinking can be seen from the cognitive thinking process of analyzing (C-4) and Evaluating (C-5), while the creative thinking seen from cognitive Asfek creates (C-6). In drafting an indicator of HOTS should be guided in Bloom's taxonomy because it is considered most relevant in the preparation of the indicator of HOTS, the indicators, in general, are seen in the following table

TABLE I. HOTS INDICATOR IN GENERAL

Indicators	Sub Indicators	Explanation	Knowledge Object
Analysis	Distinguish Organizing Attribute	Break the concept into parts. Explaining a thorough idea.	Conceptual Procedural Metacognitive
Evaluation	Checking Criticize	Compare the values of ideas, methods, etc., to a certain standard.	
Construct	Formulating(hypothesis) Plan Producing	Think out of box, produce innovative work.	

The indicator above is an indicator in general that can be used as a reference in drafting HOTS problems depending on the characteristics of basic competence (KD), which will be used as evaluation material. The problem of HOTS that will be designed not only focuses on material content but must be able to measure all the main objectives of basic competence (KD) contained in the material. In drafting the outline about HOTS, problems should be conducted an analysis of basic competencies (KD) in the curriculum syllabus 2013. KD should contain factual, conceptual, procedural, or metacognition knowledge. If a basic competence (KD) contains only factual knowledge, such as only the application and understanding of the formula, of course, the basic competence (KD) can not be created about HOTS. The problem of HOTS made from basic competence (KD) and indicators that have been made must meet the characteristics of the following HOTS:

Characteristics of HOTS item:

- Change the form from one context to another

- Process and apply information

- Search for the correlation of various information

- Use the information to resolve issues

- Analyze ideas and information critically

- Solve unfamiliar issues

- Find new forms of solutions that is different from the previous one.

C. Development Step of HOTS item

1. Analyzing the 2013 curriculum in terms of syllabus, Study Implementation Plan (RPP), and analyze textbooks used in learning, especially on trigonometric materials.

2. Choosing the basic competencies that can be developed using HOTS, because not all basic competencies can be improved using HOTS, but only KD that contains factual, conceptual, procedural, or metacognition knowledge.

3. Compiling an outline of HOTS item.

4. Designing HOTS problems based on the outline through the following steps:

   - Creating a stimulus in the form of images, tables, graphs, illustrations, diagrams, etc. The stimulus should use real-world context under the most recent conditions.

   - Designing a question sentence that will stimulate students to think reasonably, critically, creatively, logically, and meta-cognitive associated with the cognitive realm in the revised Bloom taxonomy while observing the rules of drafting math problems.

   - The sentence on the matter must conform to good and correct Indonesian language rules.

5. Validation by experts and trial on students.

II. METHODS

A. Research Methodology

The research methods used in this study are qualitative methods. Qualitative method is one of the methods to describe the phenomenon or occurrence occurring in the field naturally. The research consists of two stages, i.e., preliminary or preparation, and formative evaluation stage that are consisting of self-evaluation, expert reviews, one-to-one, small group., and field test [10-11].

Fig. 1. Formative evaluation design [10-11]

B. *Research period*

Research conducted in the odd semester of the 2018/2019 academic year. The subject of study is all eleventh-grade students in the Science Program of Al-Kautsar IT Senior High School, Lahat. They are 15 students, consisting of 5 boys and 10 girls.

III. PREPARE YOUR PAPER BEFORE STYLING

In the early stages of the researcher developing the problem of HOTS is guided in the realm of the revised Bloom taxonomy, then determine what indicators to measure using the operational verb (KKO) in table 1 [12]. The formulated indicators include the C-6 category of creating a new solution that is different from the previous one by leveraging its initial knowledge on the research of basic trigonometric materials. In formulating the indicator is also adjusted to the 2013 curriculum. The following are the formula indicators:

TABLE II.   HOTS QUESTIONS INDICATOR FOR LEVEL C-6 CREATE C-6

Category	Problem Unit	Indicator
C-6	1	Formulate/formulate mathematical models related to trigonometric comparisons, the concept of angles, and other variables of a problem.

After formulating the next indicator, the researcher determines the stimulus in the form of images made interesting and able to make students think and reason. The problem designed by students is required to find a solution from the height of an object by analyzing the information contained in the picture and sentence on the question while still paying attention to the rules of writing questions. The first researcher designed the image as below:
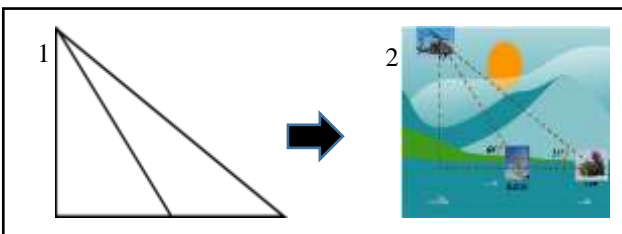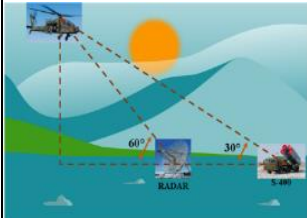

Fig. 2. Initial draft of the HOTS C-6. Created

In Figure 2, researchers designed the form of mathematics (Figure number 1) of the indicator that has been applied in the previous table 2, then for stimulus on the question of researchers designing images that are guided on the form of mathematics (Figure number 2). Once the image is formed, the researcher designs a supporting sentence to clarify the intent of the image and details the questions that students will answer later. Here's the initial prototype of HOTS level C-6 created:

Kompetensi Dasar : Menerapkan perbandingan trigonometri dalam menyelesaikan masalah.	
Indikator : Merumuskan solusi dari masalah.yang berkaitan dengan (perbandingan trigonometri, perbandingan),dalarn segitiga dan membuat kesimpulan dari solusi yang diperoleh	
Soal	Pembahasan
Perhatikan gambar dibawah ini Sebuah helikopter tempur musuh terdeteksi oleh suatu radar, kemudian informasi tersebut di diteruskan ke sebuah sistem pertahanan udara S-400. Sebelum menembak jatuh helicopter tersebut perlu diketahui ketinggian agar dapat meminimalisir dampak ledakan. Jika jarak antara radar dan S-400 adalah 10 km. Bagaimana cara menentukan ketinggian helikopter itu? Konsep Dasar	**Model I** Misalkan ketinggian = y $\tan 60° = \frac{y}{x}$ $y = \tan 60° . x$ ….(1) Model 1 Misalkan ketinggian = y $\tan 60° = \frac{y}{x}$ $y = \tan 60° . x$ ….(1) **Model II** $\tan 30° = \frac{y}{10 + x}$ $y = \tan 30° .(10 + x)$ $y = 10 \tan 30° + \tan 30° .x$ ….(2) **Model III** $\tan 60° . x = 10 \tan 30° + \tan 30° .x$ $\tan 60° . x \quad \tan 30° .x = 10 \tan 30°$ $(\tan 60° \quad \tan 30°) x = 10 \tan 30°$ $x = \frac{10 \tan 30°}{(\tan 60° \quad \tan 30°)}$ Jadi, model matematika ketinggian helicopter musuh $y = \tan 60° . x$ $y = \tan 60° \left(\frac{10 \tan 30°}{(\tan 60° \quad \tan 30°)} \right)$

To answer the question, students are thinking that students need to do including determining which trigonometric formula to use (sin/cos/tan) then must understand how to create a mathematical model, by specifying what variables searched, submitted the same variable from the first equation to the second equation can then be obtained mathematical models from the height of the plane.

At the preliminary stage, the researcher determined the research site and subject. The research site is the Al-Kautsar IT Senior High School, Lahat. The next step is a literature/reference review, where the researcher analyzed several supporting documents related to the development of HOTS problems. The reviewed documents are consisting of 2013 curriculum instruments, including the syllabus, Learning Plan (RPP), with aims to assess the core competencies (KI), basic competencies (KD), and indicators to support the development process of HOTS items.

The subsequent stage is the prototyping phase. Once the analysis of the documents was done, preliminary prototypes of HOTS items were acquired, which consisting of three

categories based on the revised Bloom taxonomy: C-4 analyze, C-5 evaluate, and C-6 create. The next step is to develop questions of Higher Order of Thinking Skills (HOTS), an outline of questions, and question cards. In this paper, the focus of the discussion is about the Higher Order of Thinking Skills (HOTS) on level C-6 Create unit 1 then, after the initial prototype entered the formative Evaluation, according to the image Flow 1.

Subsequently, a self-evaluation stage is arranged where the researchers conducted a self-/individual assessment on preliminary prototypes that have been designed by examining the consistency and correlation between the instruments and the HOTS indicator with the 2013 curriculum and the learning materials lectured at the school. The result of the self-evaluation stage is a prototype I.

Indicator :
Formulate mathematical models related to the comparison of trigonometric concepts of angles and other variables of a problem.

Perhatikan gambar dibawah ini

Sebuah helicopter tempur musuh terdeteksi oleh suatu radar, kemudian informasi tersebut di diteruskan ke sebuah sistem pertahanan udara S-400. Sebelum menembak jatuh helicopter tersebut perlu diketahui ketinggian agar dapat meminimalisir dampak ledakan. Jika jarak antara radar dan S-400 adalah 10 km. Bagaimana cara menentukan ketinggian helikopter itu?

At the expert review stage, several validators were involved as the instrument reviewer, that is Dr. Destiniar, M. Pd, as a lecturer at PGRI University Palembang and Dr. Nila Kesumawati, M.Si as a lecturer at PGRI University of Palembang, coupled with peers review. The following table summarizes the suggestions and comments from validators:
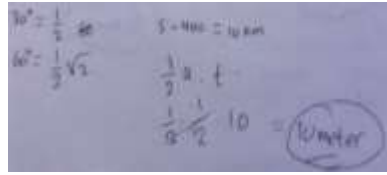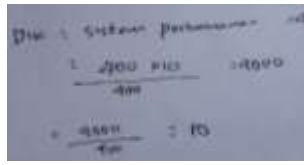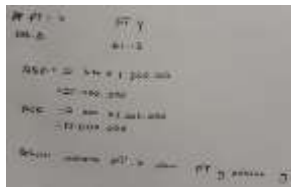
TABLE III.   COMMENTS AND SUGGESTIONS FROM EXPERTS AND COLLEAGUES

Unit	Comments and Suggestions	
	Expert	**Colleagues**
1	**Dr. Destiniar, M.Pd** Avoid using supporting lines on images. We recommend clear colored images	**Dra. Ning Eliati, M.Si** Add the known information to the reference answer sheet Improve the word 'helicopter.'
	Dr. Nila Kesumawati, M.Si Comments No angle information on the question The image is unclear. From where the image is sourced? Suggestions Each image must have the source mentioned and equip with an image number.	**Efti Ayu Setya Pertiwi, S.Pd** Preferably images repaired and questions should be clearly **Rika Puspa Tika, S.Pd** Comments Questions are not well-stated Suggestions The question should be changed to 'at what height, the helicopter could be shot?'

Along with the expert review, a one-to-one test was also conducted by giving HOTS questions sheet of prototype 1 to three students with high, medium, and low levels of ability. The students' initials are IA (high), MM (medium), and MGS (low). The students then worked on ten questions consisting of four categories of C-4 analysis, four questions of category C-5

evaluation, and two questions of category C-6 create. Here are the results of student's answers and comments:

TABLE IV.   THE ANSWERS OF STUDENTS IN THE ONE-TO-ONE PROCESS

Category	Student's Answers	Comments
High		Quite clear
Medium		The picture is unclear, did not understand the elevation angle
Low		The picture is clear. Not understand elevation angles

Revised questions resulted in expert review and one to one stages (Prototype II)

Perhatikan gambar dibawah ini

Sebuah helicopter tempur musuh terdeteksi oleh suatu radar, kemudian informasi tersebut di diteruskan ke sebuah sistem pertahanan udara S-400. Sebelum menembak jatuh helicopter tersebut perlu diketahui ketinggian agar dapat meminimalisir dampak ledakan. Jika jarak antara radar dan S-400 adalah 10 km. Bagaimana cara menentukan ketinggian helikopter itu?

Based on the comments of validators and students in the one-to-one process, prototype 1 was then revised into prototype II. Afterward, a small group test was carried out with six students as the subject, consisting of two high-level, two medium-level, and two low-level students. Here is the summary of students answers:

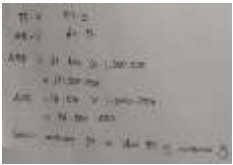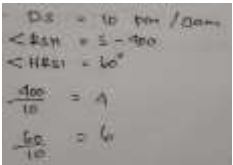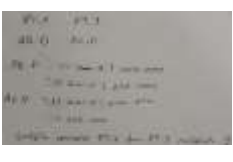TABLE V.   STUDENT'S ANSWERS AT THE SMALL GROUP STAGE

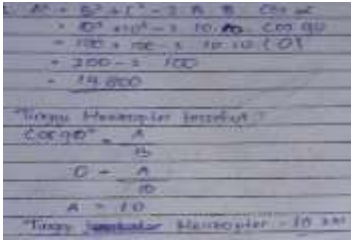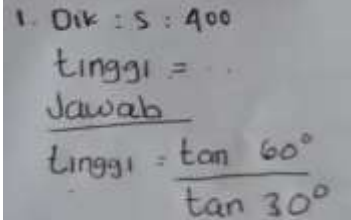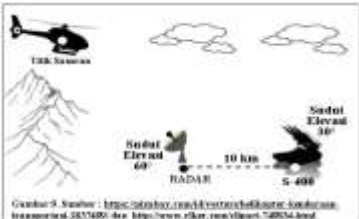| Category	Student's Answers	Comments
Hight		Students are still struggling in the analysis of the problem/image, already understand the intent and purpose of the problem.
Medium		Pictures are still confusing, but the intention of the question is understood.
Low		Not knowing the intent, not understand the concept of trigonometry used.

. Based on the analysis results on the student's response and student interviews, it was found that students have been able to understand the questions, the sentences on the HOTS items are fairly well-defined, but they have not been able to understand the concept of elevation angles and applied trigonometric concepts. Based on the above analysis, the HOTS question was further revised to produce prototype III. The following figure displays the revision results:

Revised question based on the results of the small group stage (Prototype III)

Perhatian gambar dibawah ini

Sebuah helicopter tempur musuh terdeteksi oleh suatu radar, kemudian informasi tersebut di diteruskan ke sebuah sistem pertahanan udara S-400. Sebelum menembak jatuh helicopter tersebut perlu diketahui ketinggian agar dapat meminimalisir dampak ledakan. Jika jarak antara radar dan S-400 adalah 10 km. Bagaimana cara menentukan ketinggian helikopter itu?

The next stage is the field test involving 15 students of class XI of Science Program of Al-Kautsar IT Senior High School, Lahat, as the subject. Once the process was completed, an interview with some students was done. The following table recapitulates the students' answers:

TABLE VI.   STUDENTS' ANSWERS AT THE FIELD TEST PROCESS

Category	Student's Answers	Description of analysis results
High		Indicators and objectives of the HOTS problem are almost correctly fulfilled. Students have been able to devise problem solution from images and formulate facts into other forms, but still made errors in predicting the final answer.
Medium		The questions and objectives indicators were not met. Students have not been able to design a solution to the problem and formulate facts to create solutions for the problems asked the question — error in predicting math formulas.
Low		The questions and objectives indicators are still not met. Not yet able to design problem-solving and formulate facts in innovating solutions from problems in the problem. Erroneous predicts formulas.

Higher-Order Thinking Skills (HOTS) represents the comprehension of information and reasoning skills, not merely information memorizing. Learners are required to answer questions and demonstrate knowledge of ideas and information or manipulate or use the provided information.

However, this paper only discussed one of the HOTS items that have been developed that is HOTS question of level C-6 (Create). For the questions/items above, students are required to create/formulate a mathematical model by reviewing images as well as by searching/using information contained on the images and information to find the mathematical model solution in accordance with the indicators listed in the HOTS items. The HOTS items above are contextual-based questions using a technological context that is in line with the development of science and technology today, which using the

stimulus in the form of images that have been designed in a certain way.

TABLE VII.   PERCENTAGE OF STUDENTS ABILITY TO WORK ON HOTS CATEGORY C-6 CREATES UNIT 1 OF THE RESULTS FILED TEST

Score Range	Category	Number of students	Percentage
0 - 5	Bad	10	66,67%
6 - 10	Medium	5	33,33%
11 - 15	Good	0	0%
16 - 20	Excelent	0	0%
Total		15	100%

Based on table 7 above in general for problems HOTS C-6 Unit 1, there are 66.67% who answered no one reaches the indicator of the problem set, has not been able to find, develop, formulate a problem of mathematical form, but Able to associate with trigonometric concepts. Various students ' answers are not yet compliant with the indicators. While the 33.33% who answered already meet the indicators and the use of trigonometric concepts is almost correct, a common mistake because it is not used to model a trigonometric form into the form of mathematical models of the results of interviews because it has not to Understand and get used to when making equations use variables if using trigonometric material. The problem belongs to the category very, very difficult. The student's primary difficulty is evident from the interviews on how to sketch a triangle (a trigonometric concept) that will be applied, then model the height that means students are struggling to create/determine which variables to use.

IV. CONCLUSION

To develop the HOTS question, one should be concerned about establishing an indicator of behavior to be measured through the stimulus using the latest real-world context. The resulted questions should lead students to use reasoning skills, mastering the rules of writing questions and subject matter related to the problems being developed, creating indicators of questions that lead students to critical and rational thinking.

This study resulted in ten rounds of the Higher-order Thinking Skill (HOTS) items that have been declared as valid based on validator's comments and one-to-one process, practical as seen in the small group stage, as well as contained potential effects as indicated by the analysis results of the field test.

The problems that become products in this research should be used as a practice to work on HOTS problems to face the national exam, for further studies can use other more diverse stimuli, or can To develop HOTS on other mathematical materials.

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