

# Development of Higher Order Thinking Skills Problem on Statistics Senior High School

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**Abstract.** This study aims the development of valid and practical HOTS questions for senior high school and investigating the potential effects. The method is to design research type development studies. This research was conducted on eleventh-grade students of SMA Negeri 1 OKU, which include walkthrough, documentation, interview, and test for data collection. The validation was applied on the basis of the validator's assessment of the questions in terms of content, constructs, and language as well as student comments/suggestions at the one-to-one stage on clarity and readability. From the results of the students' work in the field test, it can be concluded that the questions developed can lead to HOTS. The result of this study produce HOTS Statistics questions, each consisting of three questions that are analyzing (C4), Five questions are evaluated (C5), and one question is create (C6) that is valid, practical, and has a potential effect based on the HOTS framework.

**Keywords:** *Higher Order Thinking Skill, mathematics*

## I. INTRODUCTION

In the present century, science has developed in accordance with the demands of life, which have also evolved based on technology and the progress of the times. One effort in dealing with the demands of the 21st century is by developing skills and literacy skills that can be used in facing challenges in today's life. Mathematical literacy can be said as an individual's skill in using, explaining, and formulating mathematics into various real contexts. It is what guides individuals to be able to recognize the role of mathematics in everyday life and make correct judgments and can make constructive and reflective decisions [1]

Mathematics learning, according to the 2013 curriculum [2], aims to emphasize the modern pedagogical dimension of learning using a scientific approach. In mathematics, learning activities used during the learning process so that meaningful learning by observing, asking, trying, reasoning, presenting, and creating as contained in the 2013 curriculum.

2013 curriculum requires the active learning of student-centered, as more teachers as inspirators, generators in guiding students to be able to find concepts in the learning. In evaluating learning activities, an evaluation of the learning must be conducted. In addition to competence, teaching and learning activities and assessments also need to be observed. Teaching and learning activities in the 2013 curriculum

emphasize active learning, student-centered, and scientific approaches. The assessment used in the 2013 curriculum emphasizes authentic assessment. These three components, namely, competence, learning activities, and assessment, are a series of interrelated. One of them refers to the questions used in the 2013 curriculum that must make students think critically so that the teacher is required to present high-level thinking questions.

High-level thinking should already exist in students in Indonesia as their provision in facing the global era, advances in information technology, technological convergence, and technology as an impact of techno-science, and the rise of creative industries in the future [2]. According to [3], students who have good high-level thinking will have a commitment to continue learning, grow, and develop and evolve to become more advanced. In addition, these students will be better able to interpret and be able to review existing information and be able to use that information to solve the problem at hand.

According to [4] HOTS is defined therein, including critical thinking, logical, reflective, metacognitive, and creative. In the integrated thematic learning technical guide, the ministry of education and culture explains that teachers must train students in the form of higher-order thinking skills (HOTS), with the aim of increasing students' ability to think reasoning to answer more complicated questions and solve a more complicated problem case. This ability to think at a higher level requires someone to apply new information or prior knowledge and manipulate information to reach possible answers and new situations [5].

The US-based Apollo Education Group identifies ten (10) skills needed by students to work in the 21st century, namely critical thinking skills, communication, leadership, collaboration, adaptability, productivity and accountability, innovation, global citizenship, ability and spirit entrepreneurship, and the ability to access, analyze, and synthesize information [6]. Based on the results of the research conducted by OECD, three (3) descriptions of learning dimensions in the 21st century were obtained, namely information, communication, and ethics, and social influences [7].

According to [8], HOTS is defined in it, including critical thinking, logical, reflective, metacognitive, and creative. In

the technical guide to integrated thematic learning, the Ministry of Education and Culture explains that teachers must train students in the form of high-level thinking skills with the aim of increasing students' ability to think using reasoning in answering more complicated questions or solving a case of a more complicated problem.

In the technical guide to integrated thematic learning, the Ministry of Education and Culture explains that teachers must train students in the form of high-level thinking skills or Higher Order Thinking Skill (HOTS), with the aim of increasing students' ability to think reasoning to answer questions that are more complicated and or solve a case of a more complicated problem. According to [8] Higher Order Thinking Skills are defined therein, including critical thinking, logical, reflective, metacognitive, and creative.

Some relevant studies include [9], who developed the Higher Order Thinking Skills (HOTS) questions on the volume and cube volume application type based on problem-based learning for eighth-grade students. The results of the analysis produce high-level thinking skills with a percentage value of 41%, where this value includes having a high level of thinking ability in a good category. [10] with the title "Development of student worksheets in linear inequality one PMRI-based variable level Higher Order Thinking Skill (HOTS) in class VII." The results of the analysis can make the students easier to remember and study material in one variable linear inequality and make learning more comfortable and easily understood so that students have no problem in understanding the meaning of the sentences.

Based on the explanations above, it needs to change the habits of students using routine questions by developing questions that promote high-level thinking or HOTS to develop a high-level mindset of students based on the purpose of the train and be familiar with HOTS questions. In this research, the writers investigated how the characteristics of valid and practical high-level thinking questions (HOTS) statistics materials for senior high school are and what the potential effects of high-level thinking questions (HOTS) on high school statistics are.

This study aims to produce HOTS questions that are valid and practical and see potential effects on student work. This research is expected to increase students' knowledge and insight so that they are trained in using HOTS questions.

## II. METHOD

This research was conducted in the form of design research as one type of development research as follows the formative evaluation flow from [11-12]. Which are preliminary step and formative evaluation step (self-evaluation, expert reviews, one-to-one, small group, and field test), at the preliminary step, the researchers determined the place and subject of the study. The researchers also contacted the mathematic teachers and curriculum representatives to inquire about the procedure in conducting research. Then, researchers also analyzed the 2013 curriculum, the HOTS indicators for senior high school. Also, the researchers designed a question instrument consisting of a question grid, a question card, and a scoring

rubric. The results of the preliminary are the initial prototypes, and the self-evaluation is carried out and then followed by expert reviews, one-to-one, small group, and field test. The eleventh-grade students of SMA Negeri 1 OKU in the academic year 2018/2019 were involved as the subject research. The document, walkthrough, test, interview, and observation were used to gather the data.

At the preliminary stage, researchers conducted student analysis, junior high school curriculum analysis, and analysis of HOTS questions. Next, a problem device design is carried out, which includes a grid of questions and questions about HOTS high school mathematics. After producing the question grid and HOTS questions, continue in the formative evaluation stage.

At the stage of formative evaluation, the first stage is a self-evaluation in which the researcher conducts his assessment of the design results of the questions that have been made. The result is referred to as prototype 1. A prototyping phase is carried out consisting of expert review, one-to-one, and small group.

The expert review stage is the stage of testing validity carried out by experienced experts or educators. The experts assessed and tested prototype 1 by examining, evaluating, and evaluating using studies in terms of content, constructs, and language. Expert suggestions are written on the validation sheet and question card. In parallel (together), the one-to-one stage is also performed. At this stage, the prototype 1 was tested to three students as a tester who were asked to work on the questions that had been developed and were also asked to give comments/responses to the questions they had done. The results or findings obtained at the stage of expert review and one-to-one were taken into consideration in revising the prototype 1. After revised, it would produce a prototype 2.

This prototype II is then tested in the small group stage. At this stage, six students were asked to solve the questions on prototype II and also comments on the questions that had been done. Comments and findings in the small group stage were taken into consideration when revising Prototype 2. The results of the prototype revision 2 are called prototype 3. Before proceeding to the field test stage, researchers conducted a trial to see the level of difficulty of the questions, distinguishing power, and also reliability. The results were analyzed and discussed to produce suggestions to improve the prototype III to produce the final prototype. This final prototype was tested on the subjects of the study, namely students of class XII IPA 5, as many as 40 students from SMA N 1 OKU conducted in odd semester 2018/2019. The results of the field test will be calculated on the scores of each student and used as a basis for evaluating students' high-level thinking skills. The instruments of data collection used in this study are validation and test sheets. The validation sheet is used to obtain information from experts as expert judgment to provide input and suggestions about the questions produced. Tests are used to obtain information about the practicality and effectiveness of the questions developed and the students' reasoning abilities. The data

analysis technique used is by assessing the level of feasibility,

The quality and accuracy of the instruments produced. The question set developed into account three criteria are taken from the criteria proposed by [13], which are valid, practical, and effective. Instruments are said to be valid if the results of validation from experts say that the questions developed are valid both in terms of content, constructs, and language. In addition, the instrument is said to be practical if the questions developed can be used by all mathematical education practitioners, and experts who become problem validators state that the questions developed can be applied. While the instrument is said to be effective [14] if experts and practitioners based on their experience state that instruments (questions) have a potential effect on students' abilities in this is reasoning ability.

**III. RESULTS AND DISCUSSION**

*A. Preliminary Step*

Students Analysis, the Curriculum Review, and HOTS Questions Analysis

TABLE I. STUDENTS ANALYSIS RESULT

Proses	Student
One to One	Three students of XII IPA 8 with high ability, moderate ability, and low ability
Small-Group	Six students of XII IPA 8 two students with high ability two students with moderate ability two students with low ability
Field Test	One class: all of the students of XII IPA 5

Table 1 indicated that the students have different abilities in mathematics class. Furthermore, OKU Public High School 1 tries to understand and present in the concrete domain (parsing, stringing, modifying, and creating) and abstract domains (writing, reading, calculating, drawing, and compiling) the 2013 curriculum. And the HOTS questions analysis was on C4, C5, and C6 levels.

*B. Formative Evaluation Step*

*1) Self Evaluation*

In terms of content (content), researchers evaluated the question that had been designed, whether it included the HOTS questions. In addition, it also evaluated the context, and what level prediction is in accordance with the HOTS indicator then evaluating the question whether the question was in accordance with the basic competencies in the curriculum. In terms of constructs, researchers evaluate whether the questions were designed like tables, graphs, images on the question of whether it had been presented clearly, legibly, and functioned. In terms of language, researchers evaluated whether the question language was in accordance with EBI (Indonesian Spelling), the question did not contain multiple interpretations, the questions were not

complicated, the boundaries of the questions, and the answers were clear.

*2) Expert Reviews dan One-to-One*

The validation process with Dr. Destiniar M.Pd is done face to face at PGRI University Palembang. Validation with the Dr. Bambang Suprihatin M.Si was done by giving the device that was developed to his home after a while later, the new researcher received the validation result.

After a test to three students of class XII IPA 1 SMA Negeri 1 OKU with different abilities. The three students are AZ, RS, and YL. The three students were asked to work on the questions amounting to twelve questions, then each student was asked for their opinions, comments, and advice on the questions.

The comments and suggestions obtained from the validator to the problem HOTS math prototype 1 can be seen in Table 2 as follows:

TABLE II. SUGGESTION AND COMMENTS FROM EXPERT REVIEWS AND STUDENT ON NUMBER 1 PROBLEM

Validator	Suggestion and Comments	Revision
Dr. Destiniar, M.Pd	Problems and drawings are obvious where the question of the redeemed weight difference is known to the average, so demanding the students' reasoning to finish.	Capitalization in the world cup word was improved to the "World Cup." Editorial sentences on "average weight of each" in the added player and country words to the "average weight of each player of the country."
Dr. Bambang Suprihatin, M.Si	Improve capitalization in the word world cup should be the "World Cup." Editorial sentences on "average weight of each" in the added player and country words to the "average weight of each player of the country." On the average number of bodyweight, players have a weight unit (Kg). In the sentence of the question, plus the word player becomes "if one of the World Cup players of each country is redeemed out to get the average weight of the player becomes the same."	On the average number of bodyweight, players have a weight unit (Kg). In the sentence of the question, plus the word player becomes "if one of the World Cup players of each country is redeemed out to get the average weight of the player becomes the same."
Student	Problem number 1 is difficult because it does not understand the intent of his problem.	

Based on comments and suggestions from expert reviews (six experts) and one-to-one, the questions on prototype 1 with twice revisions so that they became valid prototype 2 and were tested in the small group stage. Decision revision questions developed based on expert reviews and one to one suggestions and comments can be seen in table 3 :

**TABLE III. THE REVISED DECISION OF THE PROBLEM DEVELOPED BASED ON SUGGESTIONS/COMMENTS EXPERT REVIEWS AND ONE TO ONE ON NUMBER 1 PROBLEM**

Before Revision	
World Cup players from Spanish and Germany.	
Spanish	German
	
The average weight of each body	
76.47	78.39
If one of each country is redeemed, it turns out to get the average weight to be the same. What do you think the difference in weight is exchanged?	

After Revision	
World Cup Player	
Spanish	German
	
The average weight of each country's players	
76,47 kg	78,39 kg
If one of the World Cup players of each country is exchanged, apparently it gets the average weight to be the same. What do you think the difference in weight is exchanged?	

**3) Small-Group**

Questions that have been revised based on expert reviews, one-to-one, are called prototypes 2. The prototype 2 is tested on small group students consisting of 6 students of OKU 1 Public High School with different abilities, namely 2 students with high abilities, 2 students with moderate abilities, and 2 students with low abilities.

Based on the results of the small group, question 2 was revised. The instruction of the question should be changed so that the students understand it better. The sentence that is replaced is, "Do you think the results of the first and fourth points are bigger than the average? Give the reasons that support your answer!" It was changed into "Elda believes that the first point multiplied by the fourth point is greater than the average? In your opinion, is Elda's answer correct? Provide the reasons that support your answer!". The revision can be shown in table 4.

**TABLE IV. THE REVISION OF THE QUESTIONS AFTER SMALL GROUP**

No	Before Revision	After Revision
2	The median and average of points won by the World Cup players in group B preliminary round are sorted starting from the smallest is 4.5. If the range is 5. Do you think the result of the first and fourth points is greater than the average? Give us a reason to support your answer!	The median and average of points won by the World Cup players in group B preliminary round are sorted starting from the smallest is 4.5, and the range is 5. Does Elda argue that the first point of the fourth point is bigger than the average? What do you think is the opinion of Elda true? Give us a reason to support your answer!

The results of the revised questions from the small group stage are called prototypes 3, which are valid and practical and can be seen in the booklet. Prototype 3 was then tested on 40 students of class XII of OKU SMA 1 to find out the potential effects of the questions developed.

**C. Field Test**

On the field test step, prototype 3 was tried out to the 40 students of XII IPA 5. After the students did the questionnaire in order to know their responses to the questions that had been answered, the researchers analyzed the students' worksheets to know the potential effects of the developed questions made by researchers. Picture 1 showed the activity on the field test.



**Fig. 1. Students Activities on Field Test**

To see the Higher order thinking skills of students can be known based on the results of tests on the questions given to students. Then scoring of student answers and scores obtained by students were analyzed descriptively qualitatively and grouped into categories according to the stipulated conditions. After scoring is done based on the higher-order thinking skills of students, the data obtained from the scoring are categorized based on the following table 5:

**TABLE V. SCORING SYSTEM**

Score	Criteria
4	Looks three descriptors
3	Looks two descriptors
2	Looks one descriptor
1	Looks zero descriptors

The high order thinking ability score of each student is the number of scores obtained according to the number of descriptors that appear when completing a high-level thinking ability test. The maximum score is the highest score (score four) multiplied by the number of questions (nine items), the maximum score is  $9 \times 4 = 36$ . While the minimum score is  $9 \times 1 = 9$ , so the average interval score of students' higher-order thinking skills is  $36 - 9 = 27$ , researchers divided the interval into four intervals with a range of seven.

The test results data were then analyzed to determine the average final score then converted into qualitative data to determine the level of high order thinking categories of students. The student-level category is determined as in the following table 6 :

TABLE VI. LEVEL CATEGORY OF HIGHER ORDER THINKING

Interval	Level category of HOTS
30 - 36	Very good
23 - 29	Good
16 - 22	Medium
9 - 15	Low

Based on the results of student tests at the time of the field test obtained the average frequency of student test distribution at the time of fields can be seen in the following table 7:

TABLE VII. AVERAGE STUDENT TEST FREQUENCY DISTRIBUTION AT THE TIME OF THE FIELD TEST

Interval	Categories	Average	
		Frequency	%
30-36	Very Good	3	7,5
23-29	Good	15	37,5
16-22	Medium	17	42,5
9-15	Low	5	12,5

The average frequency distribution of student test results at field test in forty students, it is known that three students (7.5%) have very good higher-order thinking skills, fifteen students (37.5%) have a good category of Higher-order thinking skills, seventeen students (42.5%) have a medium category of Higher-order thinking skills, and five (12.5%) students have a low category Higher order thinking skills.

The following pictures are the explanation of the questions and the student's answers on the field test step in order to know the potential effect from the process of answering the questions and the strategy used by the students.

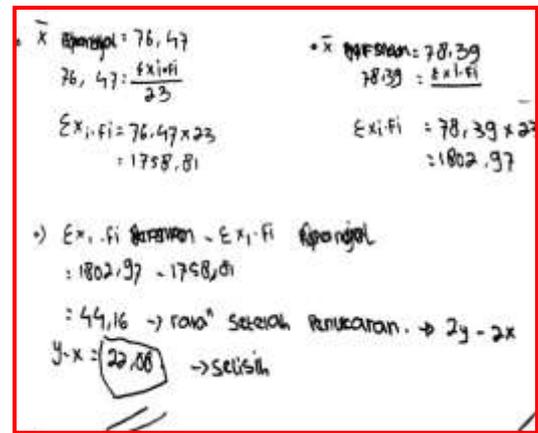


Fig. 2. Answer Question 1

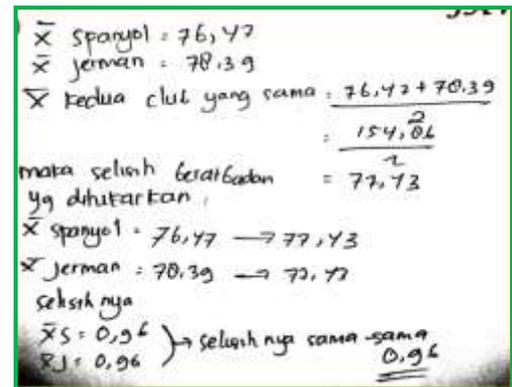


Fig. 3. Answer Question 1

Picture two and three described the students answer on question 1, the red picture showed the students ability in analyzing data of the world athlete weight and explaining the information to the smallest point to find out the difference of world athlete weight and also identifying the question correctly based on analysis ability (C4). Then, the green picture presents about the students are not able to explain the information so that they cannot answer correctly. From the field test analysis result, fifteen of forty students reach the indicator of analysis ability (C4).

The next picture is the strategy of students' answers to question number two can be seen in picture four as follows:

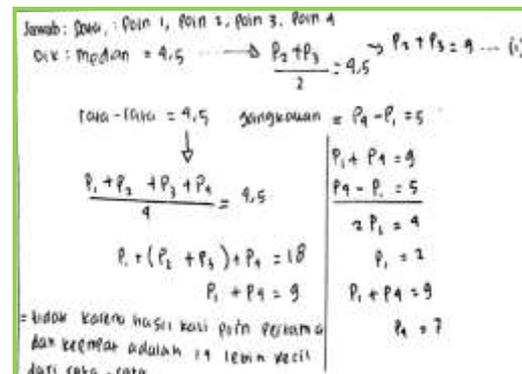


Fig. 4. The Answer of Question 2

Picture 3 presents the student's answer on question 2, and the students can give judgment on the given statement "Elda argues that the first point times the fourth point is bigger than average? "In your opinion, is Elda's statement, right?". From the field test analysis, thirteen of forty students were in the indicator of evaluation ability, and the others were wrong in judging the statement and incorrect in explaining the information. It can be concluded that the developed questions have the potential effect that can allow the ability of analysis (C-4), evaluation (C-5), and Creating (C-6).

From the results of the students' work in the field test, it can be seen that the questions developed can lead to high-level thinking skills. The high-level thinking ability that emerges is analyzing (C4), which is divided into 3 first parts capable of recognizing and distinguishing the causes and consequences of a complex scenario, both being able to analyze the information that enters and divide or structure information into smaller parts to recognize patterns or relationships. The three can identify/formulate questions, evaluate, and create. Evaluating (C5) is divided into 3 abilities, namely being able to strengthen hypotheses, criticize, and test, accept or reject a statement based on predetermined criteria and be able to provide an assessment of solutions, ideas, and methodologies using suitable criteria or existing standards for ensuring the value of effectiveness or benefits. Creating (C6) is being able to design a way to solve a problem, generalize an idea or perspective on something, and organize elements or parts into structures.

From the results of the students' work in the field test, it can be concluded that the questions developed can lead to HOTS. The result of this study produce HOTS Statistics questions, each consisting of three questions that are analyzing (C4), Five questions are evaluated (C5), and one question is create (C6) that is valid, practical, and has a potential effect based on the HOTS framework.

The results of previous studies on HOTS are the research of Marlina, [15] with the title "Development of HOTS questions on the type of application of volume cube and beam-based problem based learning on class VIII students." The results of the analysis of this study produce HOTS students with a percentage value of 41%, which means they have high-level thinking skills in both categories. What distinguishes this study from previous research in terms of content, research subjects, and research results from this study resulted in 9 HOTS mathematics questions that are valid and practical high school statistics mathematics.

#### IV. CONCLUSION

As conclusion, nine HOTS questions on statistical material were valid and practical and had a potential effect and feasible to be used. The validity of the question could be shown from the results of the assessment validation from the expert reviews stage, where the researcher got suggestions and comments in terms of content, constructs, and question languages. Validity was also obtained from comments or suggestions from students at the one-to-one stage as a part of the readability of the questions. Practicality in the small group stage, students could understand the HOTS math

questions well. After being valid and practical, the question was tested in the field test to find out the potential effects of the problem. Finally, the researchers offered some suggestions: the students should be able to train themselves to understand or solve math problems better, especially HOTS questions, the teachers can provide additional material for HOTS questions in learning, and for other researchers, they can provide this result as resources of subsequent research. Advice for researchers can be used as reference material for further research. Problems designed can be images, graphs, diagrams, and tables with little information without having to use long sentences.

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