Development of Higher Order Thinking Skills (HOTS) Assessment Instruments to Improve Students' Mathematical Creative Thinking Skills

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Abstract

The purpose of learning in the millennial era is the development and improvement of students' high-level thinking skills. High-level abilities or often referred to as higher order thingking skills (HOTS) are the level of thinking of students with stages of analysis, evaluation and creation. The indicators of HOTS can be derived from the ability to think critically and think creatively. In order for students' mathematical HOTS abilities to be known, a HOTS assessment instrument is needed. The purpose of this study is the development of a mathematical HOTS assessment instrument for MTs class VII students. The type of research is a development adapted from the development of Borg and Gall. Analysis of research data using quantitative and quality analysis to determine the quality of the mathematical HOTS assessment instrument conducted a review based on the criteria of validity, reliability, difficulty index and differentiating power of the problem. The result of this development is that the HOTS assessment instrument with the form of a description of 15 questions and is suitable for use. The HOTS assessment instrument is included in a valid category that is based on expert assessment with an average score of 36.5 and an excellent category. The difficulty level of the question is moderate with an average difficulty index of 0.5 in the medium category and the differentiating power of the question is good with an average differentiating power index of 0.33 in the good category. The developed mathematical HOTS instrument also meets the reliable criteria with a reliability coefficient of 0.733.

Keywords: *Assessment; Higher Order Thingking Skills; Instruments; Mathematics.*

Abstrak

Tujuan dari pembelajaran di era milenial yaitu pengembangan dan peningkatan kemampuan berfikir tingkat tinggi siswa. Kemampuan tingkat tinggi atau sering disebut dengan higher order thingking skills (HOTS) merupakan tingkat berpikir siswa dengan tahapan analisi, evaluasi dan mencipta. Indikator dari HOTS tersebut dapat diturunkan dari kemampuan berpikir kritis dan berpikir kreatif. Agar kemampuan HOTS matematika siswa dapat diketahui dibutuhkan instrumen assesmen HOTS. Adapun tujuan dari penelitian ini adalah pengembangan instrument asesmen HOTS matematika bagi siswa MTs kelas VII. Jenis penelitian ini adalah pengembangan yang diadaptasi dari

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kuantitatif dan kualitatis untuk mengetahui kualitas dari instrumen asesmen HOTS matematika yang dilakukan peninjauan berdasarkan kriteria validitas, reliabilitas, indeks kesukaran dan daya pembeda soal. Hasil dari pengembangan tersebut adalah bahwa instrument asesmen HOTS dengan bentuk soal uraian sebanyak 15 butir soal dan layak digunakan. Instrument asesmen HOTS dimasukkan dalam kategori valid yang didasarkan pada penilaian ahli dengan skor nilai rata-rata 36,5 dan kategori sangat baik. Tingkat kesukaran soal sedang dengan rata-rata indeks kesukaran 0,5 pada kategori sedang dan daya pembeda soal baik dengen rata-rata indeks daya beda 0,33 pada kategori baik. Instrumen HOTS matematika yang dikembangkan juga memenuhi kriteria reliabel dengan koefisien reliabilitas 0,733.

Kata Kunci: Asesmen; Higher Order Thingking skills; Mnstrumen; Matematika.

INTRODUCTION

One of Indonesia's current learning and assessment reforms is colored by the implementation of learning and assessment oriented towards Higher Order Thinking Skills (HOTS). HOTS began to be applied in classroom learning and assessment with the hope that mathematics learning could further encourage the development of students' thinking skills and creativity. HOTS questions have also begun to be used in national exams starting in 2017, and were further expanded in the 2018 national exams (Sumaryanta 2018).

The success of the world of education, which has the main objective of improving the quality of human beings or human resources, consists of several factors that influence it. The ability of a teacher is one of the factors that affect the success of the activities and how the assessment is utilized, the evaluation of the process, and the learning outcomes. The ability of a teacher is needed to know how to achieve learning objectives in accordance with the curriculum that is being used in the school.

Developing a Higher Order Thingking Skills (HOTS) assessment instrument is a competence of a subject teacher at either the junior high school / MTs or high school / MA levels. Higher Order Thingking Skills (HOTS) has the ability to make correlations or relationships, change or manipulate and can transform the knowledge and experience that has been possessed to be able to think critically and think creatively in solving problems in new situations and

circumstances (Rofiah, E., Aminah, N., & Ekawati 2013). High-level abilities have a special basic thinking ability, namely the ability to think critically and creatively (Winarso 2014).

According to another opinion, the ability to think highly is an ability that requires the ability to think creatively and critically, not just the ability to remember (Al'Azzy, U, L., & Budiono 2013). Critical thinking skills and creative thinking skills are characteristics of Higher Order Thingking Skills (HOTS). In addition to critical and creative thinking skills, HOTS is also formed from metacognitive, reflective, and logical abilities (Suwartini, Samsi Haryanto, & Prihatni 2017). This high-level thinking ability has indicators obtained from the criteria for critical thinking ability and creative thinking ability. The use or benefit of using HOTS in the learning process is that the knowledge or information transferred by the teacher to students is not quickly forgotten and stored longer when compared to the use of lower order thinking skills (LOTS).

Indicators of HOTS are derived from critical thinking and creative thinking ability. The definition of creative thinking is the ability to think higher, smarter, innovative ideas, flexibility which can be interpreted as being able to think about ideas or modern ways and have the ability to be able to master the situation, smoothness arises through a large number of ideas or ideas, a few words to express according to elaboration, namely being able to multiply the student's experience in detail. The creative thinking aspect of mathematics consists of 4 aspects of fluency, flexibility, novelty and detail (Mahmudi 2010).

Higher Order Thingking Skills (HOTS) is one of students' thinking abilities in the cognitive realm of students. In the 2013 or K-13 curriculum, there are standard content teachers design assessment instruments with the aim that students have the ability to think critically, creatively, analytically and logically. Currently, Higher Older Thingking Skills are things that need to be considered in the 2013 curriculum. Assessment standards are also emphasized on learning outcomes that focus more on higher-order thinking skills (Kemendikbud 2017).

Students' thinking skills are divided into two thinking skills, namely: Higher Order Thinking Skills (HOTS) and Lower Order Thinking Skills (LOTS).

This corresponds to a cognitive process according to BLOOM that has gone through revisions. The ability to remember (C1), the ability to understand (C2) and the ability to apply (C3) are classified into low-level thinking abilities, while synthesis analysis ability (C4), evaluation ability (C5), and ability to create or creativity (C6) are classified into higher-order thinking abilities (Anderson, L.W., dan Krathwohl 2001).

In the current millennial era 4.0, it is necessary to develop students' mathematical creative thinking skills because at this time in the world of work and education, creative thinking skills are needed. The ability to think critically, cretaively, logically reflectively, and metacognitively will form higher thinking skills or Higher Older Thingking Skills. The ability to think critically and creatively is characteristic of high-level thinking or HOTS (Suwartini, Samsi Haryanto, & Prihatni 2017). The result of critical and creative thinking ability becomes an indicator of higher-order thinking ability. The information or knowledge taught to students will be stored or longer remembered than just using lower order thinking skills.

Another word of creative thinking is divergent thinking, that is, it provides a wide variety of possible solutions or solutions based on the information obtained by focusing on different types of quantities and also matches (Munandar 1999). Colleman and Hammen (in Rohaeti 2008) put forward a way of thinking that can produce something that has not existed before in concepts, understandings, inventions and works of art, is the notion of the ability to think creatively.

According to Puccio and Mudock in the ability to think creatively, there are aspects of metacognitive and cognitive skills in which they can recognize problems, make questions systematically, recognise or recognize data that has a relationship and that is not bound and that is not, productive, generated ideas that are not small and are not the same as products or ideas that latest contain dispositions, such as being unclosed, Not afraid to take a position, it is not slow that an object is part of a complicated thing or a complex part, using other people's ways of thinking that are critical and also sensitive to what others feel.

Meanwhile, according to (Sabandar 2008), the real understanding of mathematical creative thinking ability is the ability to think which is initially from a sense of sensitivity to the situation being passed, that the situation is visible or can be identified as a problem that must be completely solved. Next, there is an element of authenticity or originality arising from the thought of a person connected to what is identified. In general, the ability to think creatively is defined as creativity. It is not uncommon for an individual who is considered creative to be someone who is a really not bad synthesis thinker who builds connections or something that others are unaware of or spontaneity. At least that creative attitude is just as important as creative thinking.

Next, it is known that in the ability to think creatively, there are two approaches. The first approach is to pay attention to students' answers in solving problems with cognitive question criteria as a process of creative thinking (Haylock 1997). The second approach is to determine the characteristics and standards for a product. Then, Haylock states that efforts with the aim of describing the mathematical creative. The first view "includes the ability to see new relationships between techniques and areas of application and to make associations between those unrelated to ideas".

That the ability to think creatively mathematically is as an ability to be able to identify and solve mathematical problems consisting of components: fluency, flexibility, elaboration and authenticity. Assessment of creative thinking skills is necessary. Problem submission makes students often used in student creativity assessments to solve problems. Students get tasks that are faced with problems and their solving and solving is used by researchers to identify students who have creativity.

The development of the HOTS assessment instrument needs to be developed to improve students' mathematical creative thinking skills which are used as enrichment questions in the application of Basic Competencies (KD) and can be used as indicators to measure high-level thinking skills and also have good test instrument characteristics and are suitable for use as assessments. Based on the description above, a HOTS assessment instrument was developed to measure

students' mathematical creative thinking ability (Julianingsih, Rosidin, and Wahyudi 2017).

In accordance with government regulations in the Minister of National Education Number 16 of 2007 concerning academic qualification standards and competence of subject teachers. Knowing / evaluating the objectives of complete or incomplete learning is the purpose of an assessment / assessment. Of the various ways of assessment is one way to find out the success that has been obtained after carrying out a learning activity (Lestari 2019). The results of the assessment of learning outcomes can be the basis or basis for being able to continue the next material. Assessment and test measurements are part of classroom assessments.

Supporting this research was seen by previous research that discussed the development of the HOTS assessment instrument. Santi Arum Puspita Lestari's research entitled Development of Higher Order Thinking Skills (HOTS) Assessment Instruments in the Class VII SMP Association Material (Lestari 2019). The result of the study is that the instrument developed has been proven with accurate reliable results and the requirements of a good instrument have been met. Judging from the difficulty level of the instruments developed, they can be classified into moderate test questions and for the differentiating power of the test are classified as good criteria. Junior high school class VII as a trial of a developed HOTS instrument that can measure high-level thinking ability. The results of the study were produced by a valid and reliable test instrument on class VII material, namely plane figure.

From these studies that have produced the HOTS assessment instrument, there is relevance to this research. In this study, a HOTS assessment instrument was developed to improve students' mathematical creative thinking skills. It is different from previous research because the material used is different and also the abilities of the students measured are also different.

Furthermore, La Moma's research entitled Development of Mathematical Creative Thinking Ability Instruments for Junior High School Students. The result of this study is a test that has been compiled and has been validated from

the content and display facets has a moderate level of validity. Then the reliability results of the mathematical creative thinking ability test (KBKM) also have moderate reliability. The development of students' creative thinking skills is carried out by development research and measurement. The test also produces differentiating power (DP) with good criteria and a moderate level of difficulty (TK).

From this research, it is known how important the ability to think at a high level and the ability to think mathematically creatively students are in facing the millennial era. Its relevance to this research is the development of HOTS assessment instruments and students' mathematical creative thinking. Whereas in the previous research was the development of mathematical creative thinking of students.

The next research is the Development of Higher Order Thinking Skills Measuring Instruments for Mathematics of Class X High School Students by Zaenal Arifin and Heri Retnawati. The result was treated with the Aiken formula, known as the value of V in all question items worth 0.3. In addition, in question packages A and B, reliable question package results were obtained with a value of A with Crobach Alpha of 0.378 and Package B worth 0.658. As for the C package with a value of 0.488, unreliable results were obtained. The results of this study show that the HOTS mathematics instrument of class X students is not good. It is known from the value generated from the trial of 26.38 on a scale of 100.

Based on the background described above, researchers developed the Higher Order Thingking Skills assessment instrument to improve students' mathematical creative thinking skills. The development of the HOTS assessment instrument in the form of HOTS test questions aims to obtain a reliable and reliable assessment instrument to measure higher-order thinking ability and improve students' creative thinking ability. A valid and reliable HOTS instrument can be used as a basis for measuring high-level ability or HOTS in other Basic Competencies (KD). This HOTS assessment instrument can also be used as material for training questions in training students' high-level abilities and students' mathematical creative thinking skills.

RESEARCH METHODS

This type of research is developmental research. The product to be developed is a HOTS assessment instrument to improve students' mathematical creative thinking skills at the Madrasah tsanawiyah level. Furthermore, the prototype obtained from the development of this research was adapted from the Borg & Gall development model.

The instruments in this study are qualitative and quantitative data, which aims to provide a representation of the quality of product development. The beginning of the HOTS assessment instrument test is obtained from qualitative data from the results of expert trials or mathematics education experts. Then the trial of the HOTS assessment instrument product is obtained from quantitative data. The two instruments meet the criteria of validity and reliability.

This HOTS assessment instrument is validated by an expert or expert in mathematics education. Trials of HOTS assessment instrument products to improve students' mathematical creative thinking skills were carried out by limited and field trials. The implementation of the limited trial was given to 20 students of class VII MTs Al Ahliyah Aek Badak. Furthermore, 50 students from MTs Persiapan N 3 Padangsidimpuan conducted field trials.

The HOTS assessment instrument to improve students' mathematical creative thinking skills is measured by its validity from three aspects, namely material, construction and language. Validation of the HOTS assessment instrument consists of 3 options, namely first it is feasible to be used to improve students' mathematical creative thinking ability (value 3), then if necessary to make improvements (value 2), and if necessary to be replaced (rated 1) for each item of the HOTS assessment instrument. Then for the reliability of the HOTS assessment instrument, test questions are used in the form of essays or descriptions. The HOTS essay assessment instrument or description is tested independently and then analyzed quantitatively.

The data collection techniques of the HOTS assessment instrument are: 1) the preparation of a HOTS assessment instrument to be used in the study, such as the HOTS question, scoring and assessment rubric 2) determining the validity of

the content of the HOTS assessment instrument asking several mathematics education experts as validators, 3) revising the HOTS assessment instrument according to the advice of the validator, 4) testing the research HOTS assessment instrument, 5) determining the reliability of the difficulty level, and the distinguishing power of the HOTS assessment instrument 6) revise the HOTS assessment instrument based on the results of the trial.

The HOTS assessment instrument Data Analysis technique is through qualitative analysis of the HOTS assessment instrument in a qualitative descriptive way. Then the analysis of the HOTS assessment instrument was obtained from the response of students' answers with the help of SPSS 26 software.

RESULTS AND DISCUSSION

The development of the HOTS assessment instrument began with designing test questions with predetermined indicators. The initial product of this HOTS question instrument is then validated in content or content by expert validators. Validators from mathematicians assess whether the HOTS question instrument that has been made is in accordance with the indicators and rules of problem making. Meanwhile, validators from MTs teachers assess whether the HOTS question instrument is in accordance with the material and the language is understood by students. The results of instrument revisions from expert validators are then piloted on a limited basis to students. These limited trials were conducted to obtain estimates of the difficulty level, reliability, and distinguishing power of the HOTS instrument. The revised results from the field trials are used as the main product of the HOTS assessment instrument. Initial HOTS test instruments validated The initial HOTS instruments were validated by expert validators and their grids. The validation results are then analyzed using the SPSS 26 formula to determine the validity of the contents of the instrument.

The result of the development in this study is a HOTS assessment instrument in the form of a description question consisting of 15 mathematical problems for junior high school class VII students. The development product in

the form of a HOTS assessment instrument has passed two stages of assessment, namely from the results of validation and trials. Product validation involved 2 mathematicians from Medan State University, a limited trial involved 10 students of class VII MTsN 3 Padangsidimpuan, and a field trial involved 61 students of class VII MTs S Al- Ahliyah, Aek Badak. The core process carried out in this development research is to compile a draft of the HOTS assessment instrument, expert validation, revision I, limited trials, revision II and field trials, until the final product of the HOTS assessment instrument is ready and suitable for use. The HOTS assessment instrument is structured based on the HOTS indicator synthesized from the creative thinking indicator. The indicators in question are smoothness, flexibility, analysis, and evaluation. Fluency includes the ability to provide multiple answers to problems. Flexibility includes the ability to use a variety of problem-solving strategies. Analysis is the ability to identify relationships between given data and the arguments given. Evaluation is the ability to find and prove errors in a problem and then find a solution to the problem. The initial draft HOTS assessment instrument is a description question consisting of 15 question items on arithmetic material, one-variable linear equations and calculations, plane figures and transformations.

Results of Validation

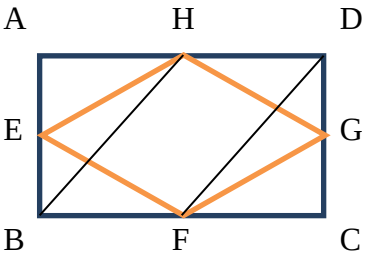
The validation stage is carried out to determine the valid criteria of the HOTS assessment instrument developed. The validation process will result in input, suggestions for improvement and at the same time an assessment of the initial product before use in limited trials. Validation is carried out by two mathematician lecturers. The validation criteria by adapting the four scale criteria from (D. Mardapi 2004) can be seen in the following Table.

Table 1. Validation Result Criteria

Rrange of Score	Category
$x \geq 33$	Excellent
$33 > x \geq 27{,}5$	Good
$27{,}5 > x \geq 22$	Not Good Enough
$x < 22$	Not Good/ Bad

The validation results show that the HOTS assessment instrument developed meets the valid criteria with excellent categories. The HOTS assessment instrument developed obtained a score of 34 (excellent) from the first expert and a score of 39 (excellent) from the second expert. Thus the HOTS assessment instrument developed obtained an average score of 36.5 with an excellent category. An example of an item about the results of this validation process can be seen as follows.

Description

1. 

   In the picture above, specify the size of the BFDH area, if known AB = 8cm, and BC = 10cm. Work in 3 ways.

2. Firda was accepted to work in an enterprise engaged in economics. Every month he will get a salary of 2,200,000., but this value has not been deducted from the income tax of 5%. In order to increase his income, he plans to work while selling honey. His capital he earned from the first salary he received and his savings money in the bank. Previously, he had saved money of Rp. 1,500,000.00 at a bank that gave 2.5% interest per year for 18 months. With the first salary and all the savings money you have. Firda bought pure honey in bee captivity and obtained 40 bottles of honey. If firda can sell all bottles of honey at a price of 125,000,000.00 per bottle. Does firda gain or lose? Explain!

The HOTS assessment instrument developed meets valid criteria because it is prepared with relevant theoretical support. Once declared valid by obtaining a record of improvement, the HOTS assessment instrument is ready to be used in the trial. Product Trial Results Limited trials were conducted to determine the

readability of HOTS assessment instrument products. Readability in this case is whether students can understand the questions in the instrument and measure the time that may be used in field trials. The limited trial involved as many as 10 students of class VII MTs N 3 Padangsidimpuan. Based on the results of limited trials, it is known that to do the HOTS questions developed takes 120 minutes. Some of the editorial questions were also revised so that students did not have misinterpretations in doing the questions.

Table 2. Limited Trial Result Revisions

Before Revision	After Revision
Create a problem that can describe a mathematical model $5x - 6 < 3x + 14$	Create a story problem that can be described in a mathematical model $5x - 6 < 3x + 14$
Draw a plane figure that has an area of 88cm2. You can combine several flat rectangles or triangles that you know	Draw a plane figure that has an area of 88cm2 with combining several plane figures that you know.

After revisions based on the results of limited trials, the HOTS assessment instrument is ready to be used in field trials. The field trial involved 61 students of class VII MTs S al- Ahiyah Aek Badak. The results of field trials were analyzed to obtain the quality of the HOTS assessment instruments developed. The quality in question is seen from the results of estimating its reliability, differentiating power and difficulty index. The level of difficulty that can maximize the information required from the test is that the difference in student abilities ranges from 0.3 to 0.7 (Allen, M.J. & Yen 1979)(N. Hanifah 2014). If p (difficulty level) is 0.5 then the question item provides maximum variability information. So the criteria of 0.3 to 0.7 is the best. Therefore, it can be concluded that items with a difficulty level below 0.3 are considered difficult questions, while if the index is above 0.7, the question items are considered easy. If p is worth 0 (too difficult) or 1 (too easy) then the soa grain is not used, because it does not provide clear information on the difference in students' abilities (Allen, M.J. & Yen 1979).

Table 3. Difficulty Level of HOTS Assessment Instrument

Category	Question Number	Total	Percentage
Difficult	4,6,13,15	4	27%
Medium	1,2,3,5,7,8,9,10,11,12,14	11	73%
Easy	-	0	0%

Based on Table 3 above, it can be seen that the difficulty level in the difficult category is 4 questions or 27% and in the medium category it is 11 questions or 73%. There are no question items with an easy difficulty level. The average difficulty level of the question item is 0.5 with a medium category. Determining the index of differentiating power can be done based on the differences shown between the two groups. There are several ways to determine two groups, one of the commonly used methods is to determine the upper and lower groups of test takers based on the test results obtained. According to Kelley (Reynolds, C., Livingston, R., Willson 2010) the upper and lower group calculations amounted to 27% of the total number of test takers, while for the middle group 46% were not included. Of the number of field trial respondents as many as 61 students, the number of upper and lower groups was 16 students each. The differential power index is obtained by subtracting the difficulty level for the upper group by the lower group. The differentiating power of the question items in the HOTS assessment instrument can be seen in Table 4 below:

Table 4. Differentiating Power of HOTS Assessment Instruments

Category	Question Number	Total	Percentage
Excellent	9	1	6,67%
Good	1,3,5,6,7,8,10,11,12,13,14	11	73,3%
Quite Good	2, 15	2	13,3%
Not Good	4	1	6,67%

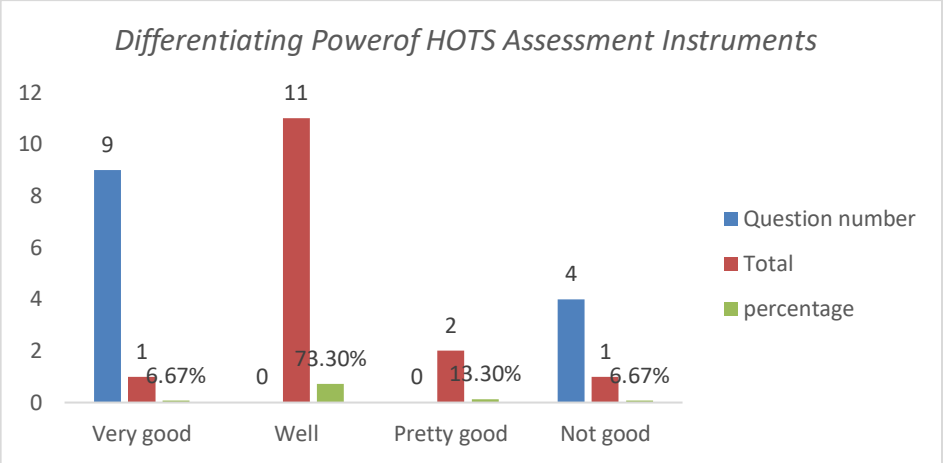


Figure 1. HOTS Assessment Instrument Differential Power Chart

Questions with the category of differentiating power are excellent and good, accepted without revision. This shows that the description items in the HOTS assessment instrument can distinguish students' HOTS abilities. The question with the differentiating power category is quite good, accepted with revisions. Meanwhile, the problem with the differentiating power category is not good, it is not used. The results of the analysis of the characteristics of the HOTS question items above show that the number of question items in the excellent category is 1 question or 6.67%, in the good category a number of 11 questions or 73.3%, in the category is quite good a number of 2 questions or 13.3% and in the category is not good a number of 1 question or 6.67%. This means that there are 2 questions that must be revised and analyzed for shortcomings. Revisions are carried out by improving the instruction of questions and materials to better describe the characteristics of student HOTS. There is one question item with a poor differentiating power category, so the question item is not used. From these results, the average differentiating power of the question item was 0.33 in the good category. The final result is from 15 questions, 14 questions are obtained that can be used to measure student HOTS. The reliability of the assessment instrument is known with the help of the SPSS program. The coefficient of reliability obtained is 0.733. The results show that the HOTS assessment instrument developed meets the reliable criteria.

CONCLUSION

Based on the results of research and discussion, the following conclusions were obtained. First, the development of mathematical HOTS assessment instruments for grade VII students is carried out by going through stages: (1) research and information collection, (2) planning, (3) initial product development, (4) limited trials, (5) product revisions, (6) field trials and (7) final product revisions. The result of the development is a HOTS assessment instrument in the form of a description question consisting of 15 questions. The HOTS assessment instrument is valid based on expert assessments with an average score of 36.5 and excellent categories. The HOTS assessment instrument has a moderate difficulty level with an average difficulty index of 0.5 in the medium category and a good differentiating power with an average differentiating power index of 0.33 in the good category. The HOTS assessment instrument developed also meets the reliable criteria with a reliability coefficient of 0.733. The final results of the development show that the HOTS assessment instrument is feasible to use. With the known quality of the HOTS instrument, teachers can use the development results to improve and also to measure students' mathematical HOTS ability.

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