Development of high order thinking skills (HOTS) test instrument on exponent for junior high school students

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Abstract. This study aims to produce the HOTS test instrument on valid, practical and effective exponent material for Class IX students of SMPN 5 Langsa, Aceh. This research is development research (R & D) using the Tessmer development model which consists of 2 stages, namely preliminary and formative evaluation stage. The test run was held in class IX of SMPN 5 Langsa. Data collection instruments include question lattice, HOTS test instruments, validation sheets, and practical questionnaire sheets. HOTS test instrument that has been produced in the form of a set of questions consisting of a grid and 10 HOTS questions in the form of a description that meets the criteria of valid, practical, and effective. The HOTS test instrument was declared valid with an average score criterion of 85% in a very valid category and was declared practical with a score criterion of 80% in the very practical category. The HOTS test instrument developed was also very effective, meaning that it had a good effect or effect on students 'higher-order thinking skills with an average score of 64.2 which showed students' high-level thinking skills in good categories.

1. Introduction
Implementation of the 2013 Curriculum is one alternative to answer the demands of an increasingly competitive era. The previous curriculum has a lot of material content given to students, so there is no chance to deepen the material by means of a high level. So the more information is given to students, the lower the way of thinking [1]. For this reason, one of the improvements in the 2013 curriculum is to adopt relevant material to students and to add the need for students to think critically and analytically according to international standards.

Based on the results of a study of the Program for International Student Assessment (PISA) which was held since 2000 and every 3 years. PISA Indonesia's ranking, especially in mathematics, continues to increase but its position is still in the top ten from below [2]. In 2015, especially in the field of mathematics, only 0.8 percent of Indonesian students succeeded in solving problems in level 5 or level 6, then for under level 2 almost half, which was 42.5 percent. This shows that the thinking ability of Indonesian students in solving problems is still low [3].

The phenomenon of the low thinking ability of students is certainly not in accordance with the needs of this 21st century [4,5]. Therefore, the government through the ministries of education and culture continues to highlight and overcome this problem. The implementation of the 2013 curriculum continues and has undergone several revisions to be adaptive to the needs of the 21st century [6]. One of the results of the 2013 curriculum revision was the addition of aspects of the Higher Order Thinking Skills (HOTS).

In the taxonomy of Bloom's revised Anderson, HOTS includes levels C4 (analysis), C5 (evaluation) and
C6 (creation)[7,8]. HOTS is the ability to think critically, logically, reflective, metacognitive, and creative thinking which is a high-level thinking ability. The teacher is required to carry out the HOTS-based learning process so the students are able to solve the HOTS problem. The HOTS problem must be able to measure the transfer of knowledge, problem-solving and critical thinking. The HOTS problem is a measurement instrument used to measure high-level thinking skills, namely thinking skills that are not just remembered, understand, or apply.

Based on the experience of the author when implementing the lecturer-to-school program from the Ministry of Research and Technology Higher Education in 2018, teachers and junior high school students have not been accustomed to discussing HOTS in learning, still only limited to routine questions. Even though starting in 2017, the government has begun to include HOTS questions on the National exam question. One obstacle, besides the lack of evenly distributed training for teachers, is the lack of development of HOTS questions in mathematics. One of them is on exponent. Exponent is still very abstract and rarely associated with everyday problems.

Based on the explanation above, the researcher developed the question of hots in the field of study of material mathematics exponents of class IX junior high school. The purpose of this study is the existence of Higher Order Thinking Skills (HOTS) based test instruments on exponent material that are valid, practical and have good potential effects for students' high-level thinking abilities.

2. Methods
The type of research used in this study is research and development. The development model used is a formative research type development model Tessmer [9]. The subjects of this study were 9th graders of SMP Negeri 5 Langsa. The data analysis technique used is the analysis of the validity of the contents of the questions, the reliability test, analysis of student questionnaire responses related to the practicality of the HOTS test instrument and data analysis of the results of the ability of HOTS students on exponent material related to the effectiveness of the HOTS test instrument.

![Figure 1. Flow chart for development of the Tessmer model test instrument](image)

In Figure 1 shows that the flow of the development of test instruments using the Tessmer development model. According to Tessmer, development research is focused on two stages, namely the preliminary stage and the formative evaluation phase which includes self-evaluation, prototyping (expert reviews, one-to-one, and small group), and the test field [10]. The following is the procedure for developing the Tessmer model test.

2.1 Preliminary stage
At this stage, the researcher will determine the place and subject of the study by contacting the principal and mathematics teacher at SMP Negeri 5 Langsa which will be the location of the study. Next, the researcher will conduct other preparations, such as arranging the research schedule and working procedures with the mathematics teacher in class IX as the research subject.
2.2 Formative Evaluation Stage

2.2.1 Analysis and Design (Self Evaluation)
At the analysis stage, the initial step of development research. Researchers will conduct student analysis, curriculum analysis, and analysis of questions related to High Order Thinking Skill (HOTS) on exponent. In the Design stage, researchers will design a grid and questions related to High Order Thinking Skill (HOTS) on exponent. Then the design results that have been obtained can be validated by experts and peers. The results of this design are referred to as the first prototype.

2.2.2 Prototyping
The results of the design of the first prototype were developed on the basis of expert review and student one-to-one in parallel. From the results, both were used as material for revision. The revised results in the first prototype were named the second prototype.

2.2.3 Expert Review
In the expert review stage, products that have been designed are examined, assessed and evaluated by experts. The experts examined the content, constructs, and languages of each prototype. Suggestions from experts were used to revise the devices developed. At this stage, responses and suggestions from experts (validators) about the designs that have been made are written on the validation sheet as material to revise and state that whether this design has been valid or not.

2.2.4 One-to-one
In the one-to-one stage, researchers test designs that have been developed for students/teachers who become testers. The results of this implementation are used to revise the design that has been made.

2.2.5 Small Group
The results of the revision of the expert and the difficulties experienced during the trial on the first prototype were used as the basis for revising the prototype and called the second prototype then the results were tested on the small group. The results of this implementation are used for revisions before being tested in the field test phase. The results of the revision of the question based on the suggestions/comments of students in the small group of non-research subjects to see the practicality and the results of the analysis of these items is called the third prototype.

2.2.6 Field Test
Products that have been tested in the field test are products that have met the quality criteria based on the results of the previous revision at the Formative Evaluation stage. This stage is carried out to get information related to the effectiveness and practicality of the HOTS test instrument. Effectiveness means that the HOTS test instrument that has been developed can have a good effect on students' higher-order thinking skills. Data or information on the effectiveness of HOTS test instruments is obtained by giving HOTS test instruments to students after finishing the Exponent material learning. Whereas practicality is related to the implementation of HOTS test instruments by students, practical or impractical. Data about practicality was extracted by giving questionnaires to students about the practicality of the test instruments developed by researchers. End of this stage produces HOTS quality test instruments, as has been stated by Akkerth that the three quality criteria are: validity (from experts, peers and mathematics teachers), practicality (easy to use and can be used in the learning process), and effectiveness (has a potential effect) [11].

3. Result and Discussion
Based on the stages of question development, the following results are obtained from the preliminary and prototyping stages with formative evaluation flow which includes self-evaluations, expert reviews, one-to-one, small groups, and field tests.
3.1 Preliminary stage
This stage the researchers have prepared everything related to the development of the High Order Thinking Skill (HOTS) test instrument on Exponent material. Researchers have collected and reviewed references related to the development of HOTS test instruments. This stage has also been chosen as a research location in SMPN 5 Langsa, Aceh. The subjects of the trial were class IX students of SMP Negeri 5 Langsa. In addition, the researcher also agreed with the teacher regarding the trial schedule at the next stage, namely: the Formative Evaluation and Field Test stages.

Characteristics of HOTS expressed Resnick which are non-algorithmic, complex, multiple solutions (many solutions), involving a variety of decision making and interpretation, application of multiple criteria (many criteria), and effortful (requires a lot of effort) [11,4]. Conklin states the following characteristics of HOTS: "characteristics of higher-order thinking skills: higher order thinking skills encompass both critical thinking and creative thinking" [12].

3.2 Prototyping stage
3.2.1 Self Evaluation Stage
This stage aims to design a HOTS-based test instrument on exponent material based on the results of the preliminary stage. The test instrument that will be designed consists of a test grid, test questions, test answer sheets, and scoring tables. This stage has 4 activities, namely curriculum analysis, material analysis, student analysis, and design.

3.2.1.1 Curriculum analysis
This stage is done to determine the problems needed in the development of HOTS tests on exponent. The curriculum analyzed is the 2013 junior high school curriculum in grade IX mathematics subjects. The curriculum analysis carried out is oriented towards achieving competencies that include cognitive aspects, attitudes, and skills. At this stage also, an analysis is carried out on the learning process that applies the scientific approach (scientific approach) and problem-based learning carried out by the subject teachers. This activity was carried out with the aim that students were able to improve HOTS's abilities in learning activities.

3.2.1.2 Student Analysis
Student analysis activities focused on class IX students as test subjects. The average number of students in each class is 20 students. Based on observations and the results of interviews from mathematics teachers, it can be seen that the mathematics knowledge of class IX students varies, there are those who are less, moderate and high. This shows the existence of a factor of the interest held by each student differently on mathematics. In general, students' HOTS abilities have never been specifically explored by teachers and other researchers.

3.2.1.3 Material Analysis
Material analysis is an activity to identify the main concepts that will be used in tests on class IX material. The scope of exponent material that must be mastered by students are (1) An integer whose exponents are positive, negative and zero, (2) Fractional number; (3) Appointment of the root of a number; and (4) Operation times, divide, add, subtract, and rank an actual number.

3.2.1.4 Design
Based on the material analysis activity, the researcher has designed the HOTS test instrument, which is the test grid, test questions, answer sheets and assessment guidelines. The researcher designed the test instrument in the form of a description test based on the characteristics of the HOTS. The appearance of the test questions has also been well designed so that students are interested in working on the questions, one of the examples is by displaying contextual images.

The test instrument that has been developed consists of 10 mathematical problems with HOTS cognitive domains that correspond to bloom's taxonomy, namely analyzing, evaluating and creating. The
A researcher produced 4 questions with analyzing domains, 3 questions with evaluating domains and 3 questions with creative domains. The initial product or design of HOTS-based questions in this exponent material is called the initial prototype.

### 3.2.2 Expert Review Stage

Researchers have validated the instrument by providing a validation sheet of test instruments, test questions, and answer sheets to the validator, which consists of two mathematics lecturers from Universitas Samudra and two mathematics teachers at SMP Negeri 5 Langsa. In this stage, the validator has assessed 10 aspects related to the instrument that has been designed (Prototype I). The validator gave an opinion that the instrument that was made still had some shortcomings so it needed to be revised. Some validator suggestions related to the election in using diction that is appropriate for the junior high school level, need for additional contextual questions accompanied by pictures and some questions need to be improved because it is considered very difficult for junior high school level. The results of comments and suggestions from the validator are used as consideration for revising the prototype of the test instrument so that a second prototype is produced.

#### Table 1. Results of HOTS exponent material validation questions

| No | Aspects      | Statement number | Score of validation | Total score | Total score each aspect |
|----|--------------|------------------|---------------------|-------------|-------------------------|
|    |              | number           | 1       | 2       | 3       | 4       |            |             |             |
| 1  | Material     | 1                | 4       | 5       | 5       | 5       | 19        | 101         |
|    |              | 2                | 4       | 5       | 5       | 5       | 18        |
|    |              | 3                | 4       | 4       | 4       | 4       | 16        |
|    |              | 4                | 5       | 4       | 5       | 5       | 19        |
|    |              | 5                | 3       | 4       | 3       | 3       | 13        |
|    |              | 6                | 4       | 4       | 4       | 4       | 16        |
| 2  | Construction | 7                | 4       | 5       | 4       | 5       | 18        | 81          |
|    |              | 8                | 4       | 4       | 4       | 4       | 16        |
|    |              | 9                | 3       | 3       | 3       | 3       | 12        |
|    |              | 10               | 4       | 4       | 3       | 4       | 15        |
|    |              | 11               | 5       | 5       | 5       | 5       | 20        |
| 3  | Language     | 12               | 4       | 4       | 4       | 4       | 16        | 56          |
|    |              | 13               | 5       | 5       | 5       | 5       | 20        |
|    |              | 14               | 5       | 5       | 5       | 5       | 20        |
|    | Total score  |                  | 58      | 60      | 59      | 61      | 238       |
|    | Percentage   |                  | 82.86   | 85.71   | 84.29   | 87.14   |
|    | Average scores |              | 85.00   |         |         |         | Very Valid |

Based on Table 1, it is known that the average percentage score of HOTS 85% with a very valid category.

### 3.2.3 One-to-one stage

This stage, the researchers conducted a One-to-one trial, involving 3 students. The selected students are students who are of the same age as non-subject trials in the next stage. The questions are tested on students to be asked for comments on these questions about the readability of the questions. Based on
the results of this trial, researchers have revised several items about HOTS, so that in the One-to-one activity a prototype of the second test instrument has been produced.

### 3.2.4 Small Group Stage

Besides, the questions are validated by experts and tested on one to one. The problem was also tested by a small group involving several students of SMP Negeri 5 Langsa. The students involved were asked to read the questions that had been made, to find out whether or not there were multiple interpretations of items. Based on the results of this Small Group trial, researchers have also changed some of the word editors on HOTS item items, so that in the Small Group activities prototype third test instruments have been produced.

### 3.2.5 Stage Field Test

The prototype, which has been validated and revised (prototype III), was tested on the subject of a research trial, namely, grade IX students of SMP Negeri 5 Langsa with a total of 20 student respondents. Researchers have conducted Field Tests to obtain information related to the effectiveness and practicality of the HOTS test instrument. The results obtained from the work of grade IX students of SMP Negeri 5 Langsa were analyzed to measure or know the level of students' HOTS ability on exponent material. Besides, based on the results of student work are also analyzed the value of reliability test. Based on the results of data analysis from 20 students who completed HOTS questions on exponent material with a total score of 1208, the average score of students was 60.4 in the good category. The following table 2 distributes the average score of HOTS abilities on exponent material.

| Interval score | Frequency | Percentage | High level thinking ability categories |
|----------------|-----------|------------|----------------------------------------|
| 76 - 100       | 3         | 15         | Very Good                              |
| 51 - 75        | 9         | 45         | Good                                   |
| 26 - 50        | 4         | 20         | Enough                                 |
| 0 - 25         | 4         | 20         | Less                                   |
| Total          | 20        | 100        |                                        |

Table 2. Distribution of average scores of HOTS abilities on exponent material

Thus, the HOTS problem developed by researchers has a good potential effect on students' high-level thinking abilities. Based on the analysis of the questionnaire responses of students regarding the practicality of the HOTS instrument, it is found as presented in Table 3.

| Statement number | Student assessment scores | Total score |
|------------------|---------------------------|-------------|
|                  | 1  | 2  | 3  |         |
| 1                | 4  | 5  | 4  | 13       |
| 2                | 4  | 4  | 3  | 11       |
| 3                | 4  | 5  | 4  | 13       |
| 4                | 4  | 4  | 4  | 12       |
| 5                | 4  | 4  | 4  | 12       |
| 6                | 4  | 4  | 3  | 11       |

Table 3. The results of the questionnaire analysis of student responses to the HOTS on exponent.
| Statement number | Student assessment scores | Total score |
|------------------|---------------------------|-------------|
|                  | 1  | 2  | 3  |         |
| 7                | 4  | 4  | 4  | 12      |
| 8                | 4  | 4  | 4  | 12      |
| 9                | 4  | 4  | 4  | 12      |
| 10               | 4  | 4  | 4  | 12      |
| Total score      | 120|
| Score percentage | 80 |

Table 3. shows that the HOTS test instrument developed on the Exponent material consisting of 10 item items shows there are 9 questions are getting a score exceeding 11, and exactly only one item in item no.5 gets a score of 11. Overall a score of 80 %, meaning that the practicality of the HOTS test instrument that has been developed is very practical or can be done for students.

4. Conclusion

The development of the HOTS test instrument on exponential material uses the Tessmer development model which consists of 2 stages, namely the preliminary stage and the formative evaluation stage. By using this Tessmer development model, HOTS test instruments for exponent material have been produced by meeting the criteria, namely (1) Valid, Based on the results of expert assessments, the question instrument was declared to be very valid with average score criteria of 85%. (2) effectiveness, based on an analysis of students' answers to the Hots test instrument that has been developed shows that the average score of 64.2 means that the Hots test instrument has a good potential effect on the ability to think of high-level students of class IX SMP Negeri 5 Langsa, and (3) Practical The test instrument was also declared to be very practical with a score criterion of 80%, meaning that the Hots test instrument that had been developed could be carried out well by grade IX students of SMP Negeri 5 Langsa.

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