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THE DEVELOPMENT OF HOTS-BASED MATHEMATICAL PROBLEM USING LOCAL CONTEXT FOR SENIOR HIGH SCHOOL

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Abstract

One of the problems that often occur in learning mathematics at school is the difficulty of teachers in providing test instruments. This research aims to develop a valid and practically high-level thinking mathematics test instrument for senior high school students in the local context. The higher-order thinking levels that are the focus of this research are analysis, evaluation, and creativity. The type of research conducted is development research using a formative evaluation design. The research instrument consisted of validity sheets and practicality sheets. The validity of the test instrument was analyzed using the Aiken index. The practicality test was carried out in a small group tryout with the subject of the tenth grade of Senior High School in Bengkulu. The study results were high-level thinking math questions in the local context for the tenth grade that were valid and practical, consisting of 5 multiple choice questions with 2 levels of analysis, 2 questions for evaluation, 1 creative question, and 3 essay questions covering all three levels. The study results were high-level thinking math questions in the local context for the tenth grade that were valid and practical, consisting of 5 multiple choice questions with 2 levels of analysis, 2 questions for evaluation, 1 creative question, and 3 essay questions covering all three levels.

Keywords: Development research, higher-order thinking, instruments

Abstrak

Salah satu permasalahan yang sering terjadi dalam pembelajaran matematika di sekolah adalah sulitnya guru dalam menyediakan instrumen tes. Tujuan dari penelitian ini adalah untuk mengembangkan instrumen tes matematika berpikir tingkat tinggi untuk siswa SMA dalam konteks lokal yang valid dan praktis. Level berpikir tingkat tinggi yang menjadi fokus dalam penelitian ini adalah: analisis, evaluasi, dan kreatif. Jenis penelitian yang dilakukan adalah penelitian pengembangan menggunakan desain formatif evaluation. Instrumen penelitian terdiri dari lembar validitas dan lembar kepraktisan. Validitas instrumen tes dianalisis menggunakan indeks Aiken. Uji kepraktisan dilakukan dalam uji coba kelompok kecil dengan subjek kelas X SMA di Bengkulu. Hasil penelitian berupa soal matematika berpikir tingkat tinggi untuk siswa kelas X SMA konteks lokal yang valid dan praktis sebanyak 5 soal pilihan ganda dengan level analisis sebanyak 2 soal, evaluasi sebanyak 2 pertanyaan, dan kreatif sebanyak 1 pertanyaan serta 3 soal uraian yang mencangkup ketiga level. Soal memenuhi kriteria valid berdasarkan penilaian penguji dan praktis ditinjau dari keterbacaan pada uji kelompok kecil. Hasil uji coba terhadap 24 siswa menunjukkan bahwa sebanyak 14 siswa berada pada kategori sedang (58,33%), 7 siswa pada kategori baik (29,17%), dan 3 siswa pada kategori tinggi (12,50%).

***Kata kunci**: Higher order thinking skills, instrumen, penelitian pengembangan*

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INTRODUCTION

Mathematics learning has an important role in improving human quality to compete globally. According to Regulation of the minister of education and culture number 59 Mendikbud (2014), one of the competencies emphasized for graduates in mathematics learning is demonstrating a logical, critical, analytical, creative, careful, and thorough attitude, being responsible, responsive, and not giving up easily in solving problems. Mathematical problem-solving requires several levels of mathematical understanding, mathematical reasoning, and mathematical tools integrated into the problem-solving process (OECD, 2012). In facilitating these abilities, students must master high-order thinking skills.

HOTS is a skill that contains aspects of critical and creative thinking (Yusuf et al., 2020) and logical and metacognitively (Nguyen, 2018). HOTS is a thinking skill that begins with the evaluation stage and ends with decision-making (Prayitno et al., 2018). The definition of HOTS according to Misrom et al. (2020) has several aspects, namely applying, analyzing, evaluating, and creating

According to the Ministry of Education and Culture Kemendikbud (2013), training students' HOTS is a curriculum goal contained in the Basic Framework and Structure of the SMA/MA Curriculum and demands for teachers listed in the Graduate Competency Standards for Elementary and Secondary Education. The main goal of learning in the 21st century is to develop and improve students' HOT (Yen & Halili, 2015), creative and innovative in using technology in learning (Alismail & McGuire, 2015). The importance of HOTS learning in facilitating students' thinking skills needs to be developed in understanding.

Some opinions mention the importance of HOTS Murray (2011) states that when students use HOTS, students decide what to believe and do. Students create new ideas, make predictions and solve non-routine problems. When students have HOTS, students are involved independently to take responsibility and accountability for the actions taken (Farren, 2012).

The importance of HOTS as a learning goal, especially in the 21st century, demands improvement in learning and emphasis on HOTS questions in learning mathematics in the classroom. However, the problem is that students' HOTS abilities are still low. Surveys such as PISA and TIMSS with the level of test questions on non-routine criteria and classified as HOTS show that the mastery of Indonesian students is in a low category. For example, the results of the PISA survey in 2018 showed that the average score of Indonesian students in mathematics only reached 379 out of 600, with a maximum score of 72 out of 78 participating countries (Puspendik, 2019). Meanwhile, the 2015 TIMSS survey results showed that the achievement of Indonesian students in mathematics was ranked 46 out of 51 countries with a score of 397 (Mullis et al., 2012). The results of several studies show that the ability of high school students to master higher-order thinking skills still needs to be improved where the average ability in the low category to good category (Susanto & Retnawati, 2016; Saraswati & Agustika, 2020; (Wahyuddin et al., 2021). Furthermore, Purnomo et al., (2022) stated that the ability of teachers to develop students' numeracy test instruments for Minimum Competency Assessment was very low.

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Teachers need to consider these problems to facilitate students' HOTS abilities. One is getting students to work on questions based on HOTS. In general, learning mathematics is still focused on improving memorizing and using concepts, but it is still rare to develop high-level skills (Susanto & Retnawati, 2016).

Through test items based on HOTS, critical thinking skills (creative thinking and doing creativity, and independent learning) will be built through practices in solving real problems of everyday life problem-solving (Warisdiono, 2017). In its emphasis, HOTS questions can be arranged based on everyday problems that are close to students or based on ethnomathematics. Fajriyah (2018) states that ethnomathematics can facilitate students' ability to construct mathematical concepts as part of mathematical literacy based on their knowledge of their socio-cultural environment. Susanti (2016) states that TIMSS questions using the context of a traditional house that was developed have a positive potential effect on students' mathematical reasoning abilities. The process of learning mathematics will always be surrounded by problems related to culture (Sroyer et al., 2018).

Many studies have been carried out on the development of HOTS-based mathematical instruments. Tanujaya, Prahmana, & Mumu (2020) mapped indicators of critical thinking and creative thinking in the HOTS test instrument. In line with this, (Kurniasi & Arsisari, 2020) analyzed HOTS from three indicators: analytical, evaluation, and creative abilities. Rahmawati et al. (2022) developed a HOTS assessment instrument for prospective elementary school teachers. Development of literacy-based HOTS question instruments (Setyaningsih & Mukodimah, 2022). In contrast to previous research, this research will develop HOTS-type math problems based on the Bengkulu local context. Emphasizing the problem using the local context is expected to make it easier for high school students to solve HOTS questions.

The solution to the problem of students' ability to solve higher-order thinking questions is to develop HOTS questions with local contexts. Previous research has proven that the use of HOTS questions has an impact on improving students' abilities. According to Tobing, Somakim and Susanti (2021), HOTS improves students' ability to create and analyze questions. HOTS questions have a potential impact on developing thinking skills (Sumaryanta, 2018); support students to think creatively, (Utari & Gustiningsi, 2021), and analytical, and critical thinking (Kwangmuang et al., 2021). This study aims to develop a HOTS instrument based on the Bengkulu local context that is valid and practical.

METHOD

1. Research Design

This research is a research development. This research is focused on developing HOTS-based mathematical problems using local context for senior high school. The development design used refers to the development of Tessmer (2013). The development stages consist of two: (1) preliminary and (2) formative evaluation. The formative evaluation stage consists of (1) self-evaluation stage, (2) expert reviews, (3) one-to-one, (4) small group, and (5) field test. The development stage can be seen in Figure 1.

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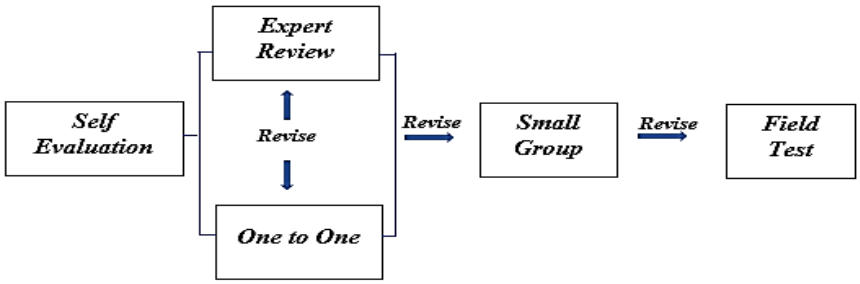

Figure 1. Formative Evaluation Design (Tessmer, 2013)

a. Preliminary Stage

1) Preparation phase

At this stage, an analysis of the curriculum, materials, and student assignments is carried out. At this stage, an analysis of problems related to the Bengkulu context is carried out, focusing on culture, history, tourism, and Bengkulu special food.

2) HOTS Question Preparation Stage

The stages in writing HOTS questions, namely: (1) compiling indicators of basic competencies according to HOTS demands, (2) choosing Bengkulu context problems, (3) choosing HOTS cognitive levels, (4) writing questions, and (5) compiling scoring guidelines.

b. Formative Evaluation Stage

1) *Self-evaluation*

The initial prototype of the HOTS questions that had been developed was reviewed by researchers related to the suitability of the characteristics of high school students, the suitability of the HOTS level, and the suitability of the Bengkulu context.

2) *Expert review*

At this stage, prototype 1, the type HOTS questions written and evaluated by researchers, are then validated by experts. In this case, the expert test was carried out by two mathematics lecturers and a secondary teacher at Bengkulu City High School.

3) *Small-Group*

This stage aims to see the practicality of HOTS questions based on the Bengkulu context by testing them in small groups consisting of 10 students in the tenth grade of State Senior high school 3 Bengkulu city. The results of the analysis of the questionnaire given are used as a reference in revising the questions in terms of practicality.

4) *Field Test*

After being revised, the HOTS questions were tested on research subjects at this stage. The field test results describe students' higher-order thinking skills in solving HOTS-type math problems in the Bengkulu context.

2. Research Subject

The expert review was carried out by two mathematics lecturers and one secondary teacher of State Senior High School Bengkulu City. The subjects who were the target of the trial in this study were students of State Senior high school 3 Bengkulu city. The limited trial was conducted on 10 students in tenth grade, while the large-scale trial was conducted in eleventh grade with 24 students. Research carried out in 2020.

3. Data Collection and Research Instruments

Data collection was carried out by: (1) documentation carried out at the

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self-evaluation stage, (2) questionnaire aimed at practical analysis, (3) walkthrough which aims to collect valid data, and (4) interviews. The data collection instruments in this study consisted of (1) question validity sheets, (2) practicality questionnaires, and (3) HOTS test sheets.

4. Data analysis technique

Data analysis was carried out as follows.

a. Document Analysis

The analysis was carried out on curriculum, materials, and problems using the Bengkulu context, which was carried out descriptively.

b. Validity data analysis

The data analysis technique was carried out to analyze the validity aspects of the problems using the Aiken validity index, with the problem criteria being said to be valid if the Aiken index was more than 0.5. The formula for calculating validity based on the Aiken (Retnawati, n.d.), formula is as follows.

$$V = \frac{\sum s}{n(c-1)}, \text{ s = r – lo (1)}$$

r = the number given by the raters
lo = lowest validity score
n = number of raters
c = highest validity rating score

c. Practical Analysis

Practical analysis based on small group trials was analyzed descriptively where the items were said to be practical if the average student score was at least good criteria. the practicality test criteria based on the student's readability test cn be seen Table 1.

Table 1. Practical criteria

No	Interval	Criteria
1	1.00-1.80	very less
2	1.81-2.60	Less
3	2.61-3.40	Moderate
4	3.41-4.20	Good

d. Reliability and Standard error measurement

The instrument reliability test uses alpha coefficients (essay questions) and Kuder and Richardson (multiple choice) (Reynolds et al., 2011).

e. HOTS ability analysis

The test results at the field test stage were analyzed with descriptive statistics. The analysis aims to describe the ability of high school students to solve HOTS questions based on the Bengkulu context. Interpretation of the score of students' HOTS in Table 2.

Table 2. Students' HOTS level category

Student's final score	Interval
100-76	Excellent
75-51	Good
50-26	Moderate
25-1	Poor

(Merta Dhewa et al., 2017)

RESULT AND DISCUSSION

In this study, 10 HOTS math problems were obtained in the Bengkulu context. The questions developed consisted of 7 multiple choice questions and 3 essay questions. The questions were developed based on the HOTS indicator, which refers to Bloom's Taxonomy level, namely analysis (C4), synthesis (C5), and creative (C6). In developing instruments, especially HOTS Questions, it is necessary to choose the right indicators of basic competencies. Indicators are selected from operational verbs from Bloom's Taxonomy and

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refer to the basic competencies of senior high school. The questions developed have a specificity, namely using the Bengkulu context problem. The context of the problem used is focused on aspects: (1) history, (2) tourism, and (3) typical food in Bengkulu. Many can be related to mathematical problems, such as the shape of historical buildings such as Bung Karno's exile house, which can be seen geometrically on the components or furniture of the house. Tourist locations can be used as a problem in compiling instruments, one of which is the position of objects at tourist sites and various other forms. Typical food can be used as a problem in problems, for example, in packing cakes in boxes which can be used in spatial dimensions. The HOTS questions developed using the Bengkulu context can be seen in Figure 2.

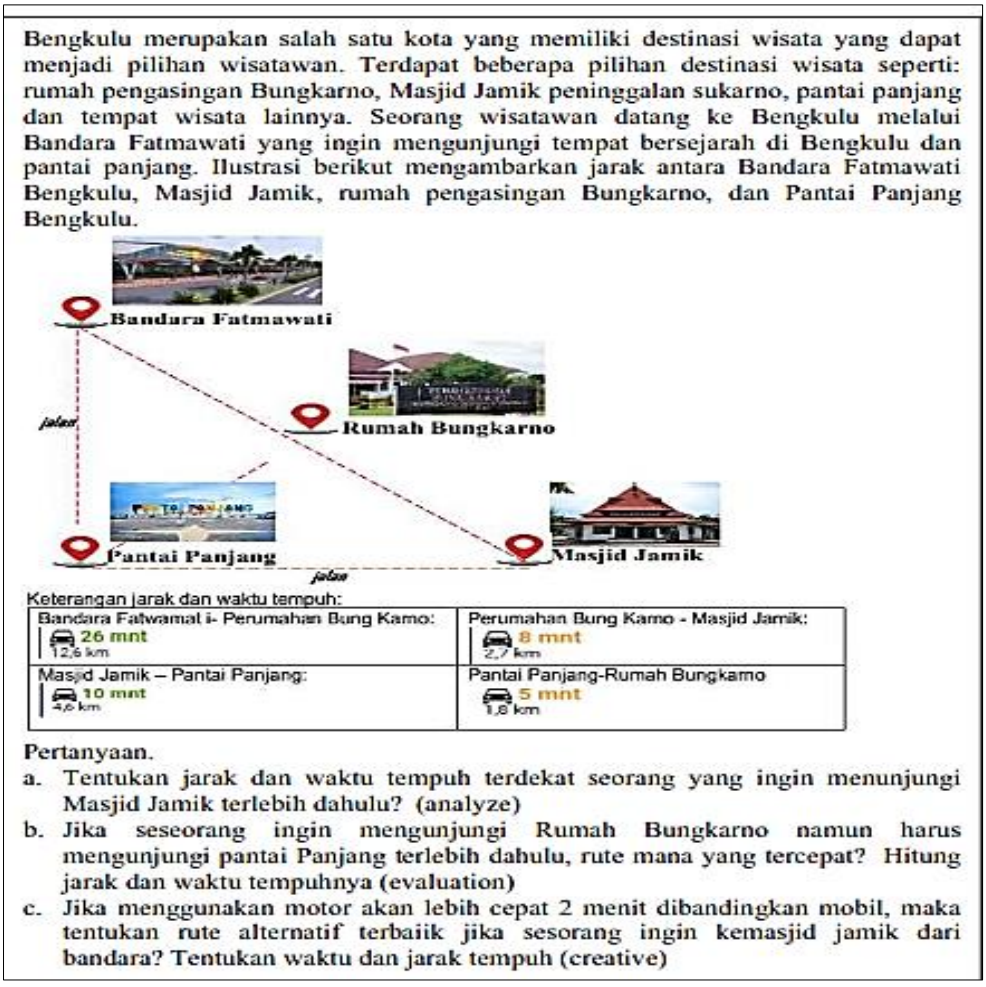

Figure 2. HOTS essay question in Bengkulu context

Translate the problem in Figure 2:

" *Bengkulu is one of the cities that has tourist destinations that can be the choice of tourists. There are several choices of tourist destinations, such as Bungkarno's exile house, the Jamik Mosque, a legacy of Sukarno, long beaches, and other tourist attractions. A tourist came to Bengkulu via Fatmawati Airport who wanted to visit historical places in Bengkulu and the long beach. The following illustration illustrates the distance between Bengkulu Fatmawati Airport, Jamik Mosque, Bungkarno exile house, and Bengkulu Panjang Beach"*

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This question is designed to measure the distance between two points on three-dimensional material for tenth-grade students in senior high school. The problem in Figure 2 uses the Bengkulu context, namely the location of places such as tourism (Panjang beach, airport), and historical buildings (Bungkarno exile house, Jamik mosque). Emphasis on problems familiar to students needs to be done so that students can more easily create mathematical models as problem-solving efforts. The use of the right context according to the student's condition and the location where the student comes from, students can construks (Kadir, 2014).

1. Development results

The results of self-evaluation obtained material focused on development, namely three-dimensional material studied from senior high school. The indicators are compiled based on the HOTS study focused on verbs at the analysis, synthesis, and creative levels. The selection of the Bengkulu context must be under the selected indicators. For example, questions about the distance between points can use the position of a building location or historical place. Another example is the problem of line spacing on the plane can use issues with the use of the Bengkulu context, namely typical foods, such as *Tat* cake. Judging from the characteristics of high school students, the use of language according to the level of students' understanding. This is under Permendikbud Number 65 of 2013 concerning process standards which states that the characteristics of learning in each educational unit are closely related to the conceptual framework of learning objectives that must be achieved, and the conceptual framework of learning and learning activities derived from the level of competence and scope of the material. In general, it is concluded that the competence of high school graduates is suppressed by students who can show a critical, analytical, creative attitude, do not give up easily in solving problems, and can determine problem-solving strategies to evaluate results (Kemendikbud, 2014).

2. Expert reviews results

The assessment of the questions developed in terms of construction, material, language, and use of the Bengkulu context was carried out by two lecturers of the Mathematics Education Study Program at the University of Bengkulu. The results of the content validity of the development product on Table 3.

Table 3. The results of the content validity of the development product

Problem	Contex	Level	Aiken index	Criteria
Multiple choice	Tourism	Analyze	0.63	Valid
	Typical food	Evaluation	0.58	Valid
	Culture	Evaluation	0.68	Valid
	History	Analyze	0.57	Valid
	Food	Creative	0.70	Poor
Essay	Tourism	Evaluation	0.51	Valid
	Typical food	Analyze	0.56	Valid
	Culture	Creative	0.54	Valid

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The results of the validator's assessment provide suggestions that generally emphasize selecting the Bengkulu context under the subject matter. The chosen context must match the indicators of the questions made. For example: to measure the distance between two points, you can use the position or location of historical buildings or tourist attractions. In presenting the Bengkulu context problem, it is necessary to provide an introduction or description of the problem so that students unfamiliar with the context can understand it. For example, Bungkarno's exile house can be made a brief history at the beginning of the question to give students knowledge about the context. Another revision that was emphasized was the display or illustration of the problem so that students easily understood it to determine the solution. An example of the results before and after the revision based on the validator's suggestions on Figure 3 and Figure 4.

Figure 3. Before Revision

Figure 4. After revision

The revision in Figure 4 emphasizes the need to create a more realistic illustration. Before the revision, the airport position was placed in the south so that students who generally visit the location would have difficulty observing the position in the picture. Based on this, in compiling questions using real contexts, it is necessary to emphasize illustrations under real objects, positions, and images. At this stage, a limited-scale test is also carried out to obtain the practicality of the questions based on the readability test by students. The results of the analysis of 12 students on readability were obtained for multiple-choice scores of 4.03 with good criteria and essay questions with a score of 3.86 and good criteria. In general, the assessment on understanding the student context is more dominantly understood by students related to tourism in Bengkulu. At the same time, historical problems are difficult for students to understand.

3. Small-group test results

This test was conducted on 10 students of class X at Bengkulu state senior high school in Bengkulu City by doing and providing an assessment through an assessment sheet. In this case, we asked a small group of students to give an assessment related to the practicality of using the instrument (readability). The average score of assessment by students on each question is summarized on Table 4.

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Table 4. Limited test results

Problem	Contex	Level	index	Criteria
Multiple choice	Tourism	Analyze	3.75	Good
	Typical food	Evaluation	4.01	Good
	Culture	Evaluation	3.42	Good
	History	Analyze	3.40	Moderate
	Food	Creative	4.02	Good
Essay	Tourism	Evaluation	3.38	Moderate
	Typical food	Analyze	3.36	Moderate
	Culture	Creative	3.34	Moderate

Based on the data, table 5 as a whole provides information that the questions compiled based on student observations on the criteria are sufficient to good. This shows that in terms of legibility, namely using symbols, writing, pictures, and command questions. The results of this analysis show that the questions developed to meet the practical criteria. One of the quality criteria in test development is practicality/usability (Nieveen & Folmer, 2013).

4. Field Test Results

The wide-scale testing of the product developed was carried out on 24 students. Descriptively the student test results are on Table 5.

Table 5. Descriptive statistics of wide-scale test data

Statistic	Score
Mean	60,16
Minimum	43,75
Maximum	81,25
Standard Deviation	10,52

The results of the large-scale trial test in Table 5 showed that, on average, the student's mastery got a good category score of 60.16. This means that students' mastery of the developed HOTS questions can be said to have reached 60%.

In strengthening the quality of the HOTS instrument we have compiled, we also use reliability analysis and standard error measurement (SEM). The reliability analysis results with KR-20 showed that the reliability value on multiple choice questions was 0.72, and the Cronbach alpha essay value was 0.64. So that based on the calculated numbers, the questions meet the reliable criteria. Furthermore, the SEM obtained on the multiple-choice questions has a standard deviation of 0.473, so the SEM is obtained at 0.250, and on the essay questions with a standard deviation of 1.198. So, it is concluded that the value of the standard error on multiple choice questions is 0.250, and the description item is higher at 1.198.

The results of the broad-scale test were also analyzed to provide an overview of the student's ability level to solve HOTS questions. The results of student mastery are based on low, sufficient, and high levels, as shown in Figure 5.

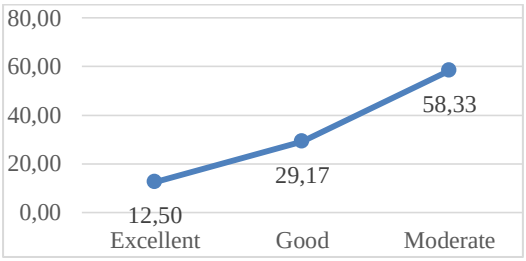

Figure 5. Student HOTS ability results

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Based Figure 5 show that the student's abilities are in the low category with a percentage of 54.16%, the moderate category is 37.75%, and the high criteria are 8.34%. The data in Figure 4 shows that the HOTS ability of students based on trials is still in the low category. The results of the analysis of student answers indicate that, in general, students have been able to know what the question is asking. The following is one of the student's answers who answered the description question with the context of Bengkulu City tourism.

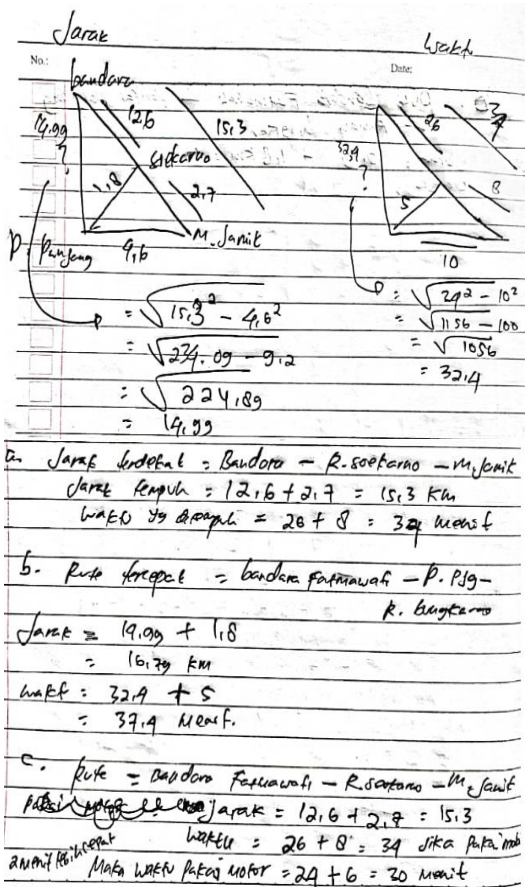

Figure 6. Examples of student answers

Based on the student's answers in Figure 6, it can be concluded that at the level of analysis, students have answered correctly, namely by adding up the closest distance traveled and showing other higher mileage. However, the students did not find a solution by testing each distance at the evaluation stage. While on the creative level, questions have not shown some answers.

The analysis results show that some students in solve problems have HOTS abilities with sufficient criteria. This supports the implementation of the curriculum, especially the 2013 curriculum, which requires students to master HOTS. Susanto and Retnawati (2016) argue that the main focus of mathematics learning objectives and curriculum demands is to develop students' higher-order thinking skills (HOTS). The analysis of student answers also showed that students in answering the HOTS questions, especially in the description questions, could understand the problem by writing down what was known from the problem. Using local contexts, for example, the Bengkulu context can encourage students to understand the problems presented in the questions. These results are supported by several previous studies which show that questions with local contexts can improve students' ability to answer questions. The study's results (Kadir, 2012) show that the mathematical problem-solving ability of coastal students can be enhanced by using coastal potential-based learning. Mathematical problems that use various contexts will be able to present situations that have been experienced for real for children (Zulkardi, & Ilma, 2006).

Other research data implies that traditional games in mathematics learning can foster enthusiasm in developing students' problem-solving abilities (Kamid, Rohati, Hobri, Triani et al., 2022). The results of this study also show that the use of the local

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context, namely the Bengkulu context, can attract students' interest in reading questions. The student's interest supports students in creating mathematical models of problems so that they can be solved. According to research (Susanti, 2016), the context in learning mathematics makes abstract concepts understandable based on thoughts built on certain realistic situations that are well known to students.

This study's findings showed a tendency of the value obtained by students in the context used. Judging from the context of the question, the tendency of students to answer correctly is in the context of tourism and special food. However, in historical contexts, it tends to be lower than in other contexts. This proves that tourism and special food problems are more familiar to students than history. The findings of this study are supported by the results of research conducted by Susanta & Sumardi, & Zulkardi (2022)which states that in using problems, students must use problems that are close or familiar to students. The results of the research analysis in terms of the HOTS level students have higher scores with questions at the analysis level when compared to evaluation and creativity. These findings indicate that it is necessary to pay attention to the percentage distribution of each HOTS level in preparing test instruments for students.

The limitation of this study is the time of data collection. This causes no interviews with students to explore information related to assessment and experience in answering the developed HOTS questions. In addition, the research subject as a trial instrument is limited to one school, so diversity is still lacking.

CONCLUSION

The HOTS math problem for high school Bengkulu in the Bengkulu context that was developed met the valid and good criteria. The Bengkulu context that focuses on development is Bengkulu History, Bengkulu Tourism, Bengkulu Food, and Clothing. The results of the HOTS test showed that there were 14 students in the low category (58.33%), 8 students in the medium category (33.33%), and 2 students in the high category (8.34%). Suggestions based on research findings: in developing regional context-based questions, it is necessary to introduce the selected context in the questions so that students more easily understand the problem.

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