The Development Of Higher Order Thinking Skills Test Of Geometry Based On Realistic Mathematics Education For Fifth Grade Elementary School At Tanjung Pura

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Abstract. This study aims to: produce a HOTS test of geometry that is valid, effective and practical to use in fifth grade elementary school. This research is a development research of Tessmer's formative evaluation type which has been adapted which consists of two stages, namely; (1) preliminary stage, and (2) formative evaluation stage which includes self-evaluation and prototyping. The results showed that the HOTS test of geometry based on realistic mathematics education that had quality from the aspects of validity, effectiveness and practicality had 15 questions consisting of 11 multiple choice questions and 4 essay questions. The test validity coefficient is 0.69 (high validity) and the test reliability coefficient is 0.81 (very high reliability). Effective based on the achievement of learning objectives reaches 80%, 88% classical completeness, 85% positive response from students and efficient learning time. Practically based on the assessment of experts who stated that the questions were feasible and could be used and, the teacher's response obtained an average score of 88.89% (practical).

Keywords: HOTS Test, Formative Evaluation, Test Quality

1. Introduction

The achievement of primary and secondary education in Indonesia is still below average. Based on the PISA publication released by the OECD on December 3, 2019, in the field of mathematics, Indonesia won a score of 379 with an average PISA score of 489. Indonesia shares rank 70 with Argentina out of 79 countries that participate in the program. Indonesia is only better than the Philippines in Southeast Asia but is far below neighboring Malaysia which scored 440 and was ranked 46th. Even Indonesia's other neighboring country, Singapore, managed to rank second with a score of 569 under China, which won PISA 2018 with a score of 591[1].

The low achievement of Indonesian students in PISA is because in general learning in Indonesia is still not based on HOTS [2]. This can be seen from a study which states "at the elementary school level it can be concluded that the learning media, teaching materials, learning materials, student worksheets, and learning evaluations used are not all HOTS-based"[3]. Even though the

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PISA questions are HOTS questions, it makes it difficult for students to answer PISA questions.[2].
In addition to PISA, other studies also show the low ability of students to answer HOTS questions. A study conducted in the city of Semarang concluded that the Pilot Project Elementary School students' HOTS skills were still at a low level with an average score of 40. Students' abilities in decision making, experience, problem solving and discovery were still at a low level [4].
Similar results were also obtained from a study of elementary school students in Jakarta which showed that HOTS skills were not evenly distributed, an increase was needed by increasing the number of HOTS questions at levels C5 and C6 [5]. One of the causes is the inability of teachers to implement HOTS-based assessments properly. This can be seen from the research conducted on elementary school teachers in East Java which showed the results that teachers had difficulty developing HOTS-based math problems at the level of analysis (C4), evaluation (C5) and creation (C6) [6].
Another study showed that 50% of the research sample on elementary school teachers in the city of Medan had not been able to implement HOTS-based authentic assessments properly [7].This result is corroborated by another study which states that the formulation of an authentic HOTS-based assessment in Medan City Elementary School has an average success rate that has not reached the 75% threshold because it is only 74.65% in the Enough category [8].
In a study, it was stated that most of the HOTS questions made by the teacher were only limited to the level of analysis (C4) in the form of multiple choice. Teachers still have difficulty making HOTS questions at the evaluation (C5) and creation (C6) levels as well as HOTS questions in the form of entries and descriptions. The teachers think that the HOTS questions are difficult questions. So if you want to make HOTS questions, then make very difficult questions with language that is difficult to understand which makes it difficult for students to answer them [9]. Meanwhile, Brookhart said that difficult questions do not automatically measure HOTS.

The low achievement of Indonesian students in PISA (Program for International Student Assessment) is due to the fact that learning in Indonesia is generally not HOTS-based [2].The reason is the weak mathematical ability of students in answering non-routine or high-level questions. In PISA, the questions tested are contextual questions which are problems in students' daily lives which consist of 6 levels. Meanwhile, students in Indonesia are only used to routine questions at level 1 and 2 [10].

In addition, the causative factor is that students are only accustomed to solving conventional problems with standard settlement procedures, with abstract properties, and not related to students' daily lives. So that questions that require mathematical reasoning such as PISA questions will be difficult for Indonesian students to solve [11]. In addition, the lack of realistic math problems specifically designed according to the potential and character of students and using contexts that are relevant to students' lives is also the cause of the low achievement of Indonesian students in PISA [12].

Based on preliminary observations made by researchers, learning outcomes in the field of mathematics for fifth grade elementary school in cluster III, Tanjung Pura sub-district are still low. The low learning outcomes of mathematics can be seen when the mid-semester assessment (PTS) and end-semester assessment (PAS) are odd. Most students have difficulty in solving these math problems and get poor grades. After being investigated, it turns out that one of the causes is that so far students have only been given routine practice questions with low cognitive levels so that students have difficulty answering math questions in the mid-semester assessment

(PTS) and HOTS-based end-of-semester assessments. Viewed from the teacher's side, in the implementation of learning the teacher always presents mathematical material only focused on formulas with abstract questions so that students feel bored when learning takes place, and this affects learning outcomes.

Several studies have shown that a realistic mathematical approach can be used in learning mathematics in elementary schools. According to Fauzan, learning mathematics with a realistic mathematics approach is better which makes students active and creative and teachers leave the lecture method and change themselves from learning centers to mentors and resource persons [13]. Meanwhile, Armanto's research shows that elementary school students in the cities of Medan and Yogyakarta with a realistic mathematics approach in learning can build their own understanding of multiplication and division with the concept of repeated addition and subtraction with a rediscovery strategy. Students become more active both individually and in groups and students are encouraged to reformulate their learning process due to learning opportunities in different situations. Students also make significant progress in learning multiplication and division [14].

In another study, it was stated that learning with realistic mathematics makes students more motivated, active and creative because of interesting material equipped with pictures and stories. Students' understanding of mathematical concepts increased, followed by an increase in scores from pretest to posttest even with conventional tests [15]. Meanwhile, research conducted in Bandung showed that students experienced positive changes in attitudes towards mathematics [16]. Several other studies have obtained similar results. Reasoning, achievement and interest in learning mathematics students are better than ordinary learning [17], [18], [19].

In addition to the selection and application of appropriate learning methods, students must also be given appropriate practice questions and assignments that can improve students' mastery of the material and train students to learn independently. The questions must be contextual and realistic and well designed according to the level of students' cognitive development. In addition, a good question must be valid, and reliable.

Realistic mathematics learning uses real math problems that are close to students' lives. Therefore, the development of realistic mathematical problems is needed. The development of realistic math problems that refer to the PISA standard can be used as an alternative to train students to solve PISA questions[11]. This can be seen from several research results that show the PISA model questions are effective in improving students' mathematics learning achievement [20].

Taking into account the background that has been stated above, the researcher feels the need to conduct research that aims to develop HOTS (Higher Order Thinking Skills) questions based on good quality realistic mathematics learning in the construction material for the fifth grade elementary school in cluster III, Tanjung Pura sub-district.

2. Method

This research is a research and development research, with the product of this development research is the HOTS questions on building materials based on realistic mathematics learning. The purpose of this development research is to produce HOTS questions based on realistic mathematics learning materials that are valid, effective and practical. To answer the research questions, data analysis was carried out on the research results following the stages of the

formative evaluation type development model Tesmer ywhich has been adaptedconsisting oftwo stages namely; (1) preliminary stage, and (2) prototyping stage. The preliminary stage includes analysis, design and self-evaluation. The prototyping stage consisted of expert reviews, trial I, trial II, trial III and trial IV. Sequentially these steps can be made as shown below.

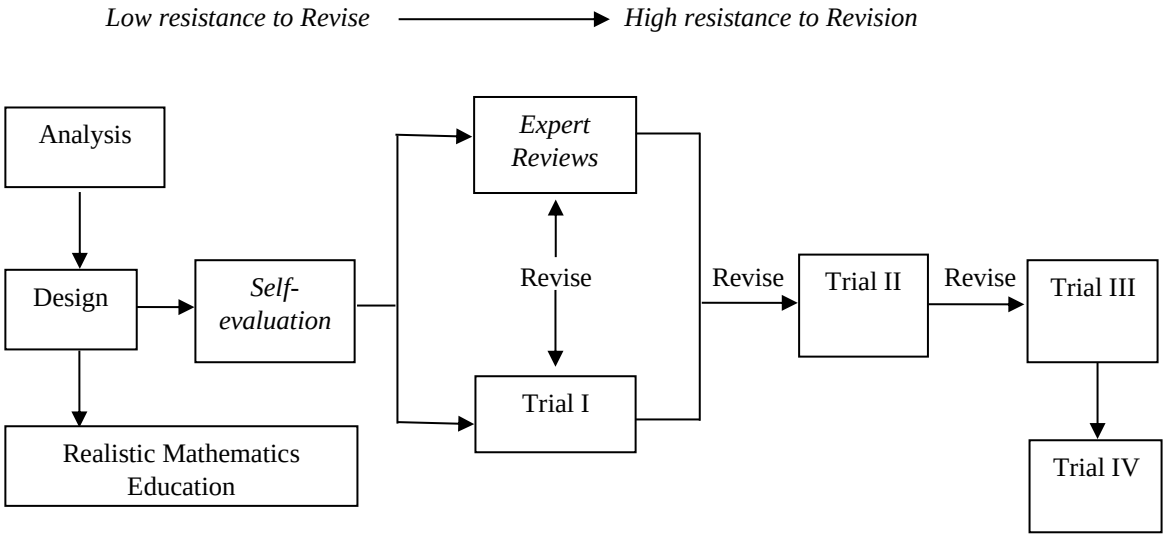

Figure 1. Tessmers formative evaluation design flow adaptation

3. Results and Discussion

3.1. Preliminary Stage

Design Analysis. The design analysis begins by collecting various references related to this research, namely about test development research, HOTS, and realistic mathematics education. From these various references, several theories put forward by experts related to this study were used by researchers to determine indicators of test quality, namely (1) Test Validity, (2) Test Effectiveness and (3) Test Practicality. After determining the indicators used in this study, the researcher then determined the population and research sample. The population in this study were all fifth grade students in cluster III Tanjung Pura, totaling 312 students covering 16 elementary schools. Meanwhile, the number of samples determined was 92 students. The sample in the research trial was divided into high ability students,

Self Evaluation. The self-evaluation stage aims to design HOTS questions of geometry based on realistic mathematics education. At the Self Evaluation stage, it is divided into four parts, namely:

a). Curriculum Analysis

At this stage the researcher analyzes the curriculum on the material of geometry. In the 2013 curriculum, for the fifth grade of elementary school, materials of geometry are in the even semester. As for the material included in the material of geometry in fifth grade elementary

school in the even semester, namely cubes, blocks, prisms, pyramids, tubes, cones and spheres. However, due to limited time and energy, the researcher only took cubes and blocks with basic competencies.
Besides being used to design HOTS questions, curriculum analysis is also needed by researchers to design lesson plans (RPP). The RPP designed by the researcher is based on realistic mathematics education. Therefore, the HOTS questions of geometry developed are based on realistic mathematics learning. This means that before testing the questions, students must first get realistic mathematics education about cubes and blocks.

b). Student Analysis
Characteristics of students studied include cognitive development, academic ability and socio-economic background. Fifth grade elementary school students are in the age range of 10 – 11 years. According to Piaget students at the age of 7 - 11 years are at the stage of concrete operational development. This means that in general, the cognitive development of fifth grade students in the four schools entered the concrete operational stage. The concrete operational period means that students need concrete things to learn something. Students at that age have not been able to imagine abstract things to be digested into new knowledge for themselves. Therefore, realistic mathematics education is very suitable to be applied in elementary schools because it can make abstract mathematics material realistic so that it is easier for students to understand.

The results of the analysis of the academic ability of Tanjung Pura fifth grade students for the 2021/2022 academic year showed varied results consisting of students with low, medium and high abilities so that students' abilities in mathematics also varied.

The results of the analysis of the socio-economic background of students' parents are various, including farmers, entrepreneurs, traders and others. In addition, the school's relationship with parents/guardians and the community around the school has been well established.

c). Analysis of HOTS Questions for Building Space Based on Realistic Mathematics Learning
At this stage, the researcher reviewed the HOTS questions of geometry based on learning. The learning base chosen in this study is realistic mathematics education of geometry, especially cubes and blocks.

d). Design
In this study, the researchers designed HOTS questions with 20 items consisting of 15 multiple choice questions and 5 essay questions with reference to Bloom's taxonomy revised at level 4 (analysis), level 5 (evaluation) and level 6 (creating). These questions contain contextual material and are related to students' daily lives according to the characteristics of realistic mathematics education. The questions are also designed in simple language to make it easy for students to understand and in standard language according to the Enhanced Spelling (EYD).
Question design *HOT* of geometry based on realistic mathematics learning that are made include:
1. The HOTS question grid of geometry based on realistic mathematics education is based on the researcher's analysis.
2. The HOTS questions of geometry based on realistic mathematics education.

The instrument set produced at the self-evaluation stage is called prototype I, which is a HOTS question of realistic mathematics learning-based space-building material, which consists of 15 multiple choice questions and 5 essay questions.

3.2. Prototyping Stage

Expert Reviews. At this stage, a qualitative test of the validity of the test was conducted by material experts, constructivists and linguists. In addition, the researcher also asked for opinions, suggestions and input from two experienced teachers. As for comments and suggestions from the validator for the development of questions *HOT* of geometry based on realistic mathematics education can be seen in table 1. below:

Table 1. Validator's Comments/Suggestions Towards Questions

Validator	Comments/Suggestions
Validator 1	Adjust all the questions with the indicator
	Use operational verbs that match the HOTS cognitive level.
	Correct the sentence in the description of number 2 by adding "Can all the Rubik's cubes fit in a box?"
Validator 2	Give instructions in doing the questions
	Set time to solve the problem
Validator 3	Pay attention to the use of punctuation and EYD
Teacher 1	It's better not to ask questions too long
	Pay attention to the use of punctuation and EYD
Teacher 2	Adjust the level of difficulty of the questions with the cognitive level of elementary school students.
	Pay attention to the use of punctuation and EYD

Based on the results of the validator's assessment, in general, the HOTS questions of geometry based on realistic mathematics education that were developed were classified as good and could be used with a few revisions.

Realistic Mathematics Learning. This study develops HOTS questions of geometry based on realistic mathematics education in fifth grade elementary school in Tanjung Pura sub-district. Therefore, before carrying out the test phase of the questions that have been developed in prototype I, a realistic mathematics learning is carried out on the material about cubes and blocks. Learning tools used in realistic mathematics learning such as lesson plans (RPP), student activity sheets (LKS) and question instruments have also been validated by experts and teachers at the previous stage.

Realistic mathematics education of cubes and blocks is carried out in class V for three meetings each with a duration of 2 x 35 minutes each. Realistic mathematics education is carried out in four different schools with the exact same steps of learning activities. This is done because the focus of this research is the development of HOTS tests/questions, not on realistic mathematics education. Realistic mathematics education acts as the basis for research on the development of the HOTS test on spatial material. Therefore, realistic mathematics education that is carried out in class V in four different elementary schools must be in exactly the same way as the learning activities so that the HOTS questions of geometry developed start from the same basis.

Trial I. *Prototype*I was then tested on trial I in class V with a sample of 21 students. Before conducting the first trial, fifth grade students were given realistic mathematics lessons of

geometry for three meetings. The results of the first trial were then analyzed for validity using the Anates V.09 application for multiple choice questions and Anates V.04 for description questions. The results of the analysis showed that the test validity was 0.55 (medium), the test reliability was 0.71 (high). The results of the analysis of the descriptions showed that the test validity was 0.50 (medium), the test reliability was 0.67 (high).
Based on the results of the analysis of the results of the first trial as well as comments and suggestions from students, a revision was made to prototype I on questions that were declared invalid and needed improvement. The result of the revision of prototype I is called prototype II. Against Prototype II, trial II was then carried out because the validity of the test in trial I had not reached the target specified in this study.

Trial II. *Prototype*II was then tested in the second trial in class V with a sample of 20 students. Before conducting the second trial, the fifth grade students were given realistic mathematics lessons of geometry for three meetings. The results of the analysis showed that the test validity was 0.59 (medium), the test reliability was 0.74 (high). The results of the analysis of the descriptions showed that the test validity was 0.49 (medium), the test reliability was 0.66 (high). Based on the results of the analysis of the results of the second trial as well as comments and suggestions from students, a revision was made to prototype II on questions that were declared invalid and needed improvement. The result of the revision of prototype II is called prototype III. Against Prototype III then trial III was carried out because the validity of the test in trial II had not reached the target specified in this study.

Trial III. *Prototype*III was then tested in the third trial in class V with a sample of 26 students. Before conducting the third trial, fifth grade students were given realistic mathematics lessons of geometry for three meetings. The results of the third trial were also analyzed using the Anates application. The results of the analysis showed that the test validity was 0.61 (high), the test reliability was 0.76 (high). The results of the analysis of the descriptions show that the test validity is 0.72 (high), the test reliability is 0.84 (very high).
Based on the results of the analysis of the results of the third trial, it can be concluded that the HOTS test of geometry based on realistic mathematics education has reached the value of validity and reliability that has been determined in this study, namely the good category. However, because the other test quality indicators have not been met, namely the effectiveness of the test, it is necessary to revise the prototype III. Prototype III was revised based on the results of the analysis of test results III as well as comments and suggestions from students. The result of the revised prototype III is called prototype IV. Against Prototype IV, then conducted a trial IV.

Trial IV. *Prototype*IV was then tested on trial IV in class V with a sample of 25 students. Before conducting the IV trial, the fifth grade students were given realistic mathematics lessons of geometry for three meetings. The results of the IV trial were also analyzed using the Anates application. The results of the analysis showed that the test validity was 0.69 (high), the test reliability was 0.81 (very high). Of the 15 multiple choice questions tested, 11 of them were declared valid, namely questions number 3,4,5,6,7,8,9,10,11,12, and 13. Judging from the distinguishing power of the questions, from 11 items multiple choice questions which are declared valid, questions number 5 and 11 have differentiating power for questions in the low category. While questions number 3,4,6,9, and 13 have different power in the medium category and questions number 7 and 10 have high distinguishing power and questions number 8 and 12 have very high distinguishing power. Judging from the level of difficulty, questions number 5 and 11 have a very easy level of difficulty. While questions number 3 and 10 have an easy level of difficulty. For question number 4,6,

The results of the analysis of the descriptions show that the test validity is 0.69 (high), the test reliability is 0.82 (very high). Of the 5 essay questions tested, 4 of them were declared valid, namely questions number 1,2,3 and 5. Judging from the discriminating power of the questions, of the 4 essay questions which were declared valid, questions numbered 1, 2 and 3 had differentiating power. low category questions. While question number 5 has a different power with a very low category. Judging from the level of difficulty, questions number 1, 2 and 3 are categorized as moderate. While question number 5 has a very easy level of difficulty.

a. **The Validity and Reliability of the HOTS Test of Geometry Based on Realistic Mathematics Education**

The following is a recap of the validity and reliability of the tests from trials I – IV in the table below:

Table 2. Recap Validity and Reliability of Multiple Choice Questions HOTS Test of Geometry Test Room I – IV

Trial I		Trial II		Trial III		Trial IV	
V	**R**	**V**	**R**	**V**	**R**	**V**	**R**
0.55	0.71	0.59	0.74	0.61	0.76	0.69	0.81
Currently	High	Currently	High	High	High	High	Very high

In table 2. above, it can be seen that the target validity of the test on multiple choice questions has been achieved in the third trial, which is 0.61 while the test reliability target has been achieved from the first trial.

Table 3. RecapValidity and Reliability of Explanation Questions HOTS Test of Geometry Test Room I – IV

Trial I		Trial II		Trial III		Trial IV	
V	**R**	**V**	**R**	**V**	**R**	**V**	**R**
0.50	0.67	0.49	0.66	0.72	0.84	0.69	0.82
Currently	High	Currently	High	Tall	Very high	Tall	Very high

In table 3. above, it can be seen that the target validity of the test on the description questions has been achieved in the third trial, which is 0.72 while the test reliability target has been achieved from the first trial.

b.The Effectiveness of the HOTS Test of Geometry Based on Realistic Mathematics Education

The HOTS test of geometry based on realistic mathematics education is appropriate if it can have a positive impact on learning. For this reason, the HOTS test developed must meet the effectiveness criteria, namely:(1) a minimum of 75% of the achievement of learning objectives by a minimum of 65% of students; (2) students' mastery of classical learning, namely at least 80% of students who take part in learning are able to achieve a score of 70; (3) a minimum of 80% positive student responses; (4) efficient learning time or not exceeding ordinary learning [17].

Table 4. Recap of achieving learning objectives from trials I – IV

Trial I	Trial II	Trial III	Trial IV
62% Not Reached	55% Not Reached	62% Not Reached	72% Achieved

The achievement of learning objectives is calculated based on the number of learning objectives achieved by students. The learning objectives are achieved if at least 65% of the number of students achieve the learning objectives set at least 75%. From table 4. above, it can be seen that the learning objectives have been achieved in the IV trial with the achievement of learning objectives reaching 72% where the target to be achieved is 65 %.

Table 5. Classical Completeness Recap from Trials I – IV

Trial I	Trial II	Trial III	Trial IV
71% Not Reached	75% Not Reached	69% Not Reached	88% Achieved

Classical completeness is achieved if at least 80% of the number of students reach the KKM, which is 70. In other words, classical completeness is achieved if at least 80% of the number of students achieve individual completeness. From table 5. above, it can be seen that classical completeness has been achieved in trial IV of 88% .

Table 6. Recap of Data Analysis Results of Student Response Tests I – IV

Trial I	Trial II	Trial III	Trial IV
79% Not Reached	81% Achieved	83% Achieved	85% Achieved

From table 6. above, it can be seen that the target of positive student responses of 80% has been achieved in the second trial.

Table 7. Recap Learning Time and Time to Work on HOTS Questions of Geometry Test Room I – IV

Trial I		Trial II		Trial III		Trial IV	
PB	**T**	**PB**	**T**	**PB**	**T**	**PB**	**T**
3 x 70 minutes Not Exceeding Normal Time	60 Minutes Not Exceeding Normal Time	3 x 70 minutes Not Exceeding Normal Time	60 Minutes Not Exceeding Normal Time	3 x 70 minutes Not Exceeding Normal Time	60 Minutes Not Exceeding Normal Time	3 x 70 minutes Not Exceeding Normal Time	60 Minutes Not Exceeding Normal Time

Based on table 7. above it is clear that since the first trial the learning time and the time to do the test did not exceed the normal time.

c. Practicality of the HOTS Test of Geometry Based on Realistic Mathematics Educatin

Practicality data were obtained from the opinions of material experts, constructivists and linguists who stated that the HOTS test of geometry based realistic mathematics education was feasible and could be used in elementary schools. Practicality data from experts was obtained at the time of validation. After conducting each trial, the teacher's response questionnaire was also used to analyze the practicality of the developed test. The teacher's response questionnaire was used to determine the readability of the HOTS test questions for the given of geometry based realistic mathematics education.

Table 8. Recap of the Results of Teacher Response Analysis Trials I – IV

Trial I	Trial II	Trial III	Trial IV
89% Achieved	89% Achieved	89% Achieved	89% Achieved

Based on table 8. above, it is clear that since the first trial the teacher's response has been positive and has even reached the target set in this study, which is the teacher's positive response of 80%.

4. Conclusion

The HOTS test of geometry based on realistic mathematics education has been successfully developed, which consists of 15 questions consisting of 11 multiple choice questions and 4 essay questions. The multiple choice questions have a test validity value of 0.69 (high validity) and 0.81 reliability (very high reliability). While the validity of the description test is 0.69 (high validity) and 0.82 reliability (very high reliability).

The HOTS test of geometry based on realistic mathematics education has been successfully developed based on the effectiveness of the test, namely the learning objectives achieved 72% (minimum 65%), classical completeness reached 88% (minimum 80%), positive student responses reached 85% (minimum 80 %), efficient learning time (at least not exceeding normal learning time).

The HOTS test of geometry based on realistic mathematics education has been successfully developed which is practical to use. Practically based on the opinions of material experts, constructivists and linguists who stated that the HOTS test for realistic mathematics learning-based building materials was feasible and could be used in elementary schools. In addition, it is practical based on the positive response of teachers which reaches 89% (at least 80%).

Suggestion. For teachers, to use HOTS type questions both in learning and in formative and summative exams to train students' higher-order thinking skills. In addition, it increases the portion of C4 questions (analyzes) which are students' weaknesses. For students, to continue to improve higher-order thinking skills by thinking critically, solving problems and being creative in solving the problems given. For other researchers, to conduct research on the development of HOTS questions with an assessment model or based on other learning approaches in order to enrich the repertoire of knowledge, especially about HOTS questions.

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