Development Instrument Test Based on Cogntive Level

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Development of Test Instrument Based on Cognitive Level (Revised Bloom's Taxonomy)

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ABSTRACT

The unequal amount of questions that test students' lower order and higher order thinking skills is a concern in mathematics learning evaluation. The unequal amount of questions resulted in poor cognitive levels among students. The purpose of this study is to develop questions that may be used to assess the cognitive ability of high school pupils and fulfill the requirements of being valid, practical, and effective. This is a development study that employs the formative evaluation approach. Validation sheets, student evaluation sheets, and examinations that measure students' cognitive capabilities are among the data gathering procedures employed. According to the researchers' findings, the questions generated matched the requirements of being valid, practical, and effective. The valid criteria are based on the validators' assessments, and both validators agree that the questions created are good and possible to utilize with a few adjustments. Student answer papers to the established questions serve as the basis for practical criteria. According to the response form, 85 percent of pupils answered positively to the questions. Effective criteria are based on pupils' abilities to answer the questions that have been established. According to the test findings, 85 percent of students satisfied the minimal completeness requirements for both questions testing lower order and higher order thinking skills, indicating that the questions were effective.

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A. INTRODUCTION

Mathematics is one of the disciplines included in the 2013 curriculum from elementary to high school levels, hence it plays a crucial role. However, mathematics is not only vital for students to grasp in order to achieve satisfying learning outcomes in school but it is also important for students to be able to utilize mathematics to solve issues encountered in everyday life. Therefore, mathematics will be very meaningful if the problem used is a contextual problem to provide perpective for students that mathematics can be used in everyday life.

In learning mathematics, there are three aspects that must be mastered by students, namely cognitive, affective, and psychomotor aspects (Santrock, 2011). Cognitive related to student learning outcomes after studying the material. Affective related to the character that can be generated during or after studying mathematics, which can be in the form of motivation, self-confidence, disposition, and so on. Psychomotor is related to student activity in participating in learning that involves movements such as drawing graphs, making diagrams, taking measurements, and so on.

Cognitive parts of the 2013 curriculum are addressed in Minister of Education and Culture Regulation Number 22 of 2018. Students' skills to remember, understand, apply, analyze, evaluate, and create are among the cognitive characteristics addressed in the Minister of Education and Culture Regulation. (Peraturan Menteri Pendidikan Dan Kebudayaan Nomor 22 Tahun 2016 Tentang Standar Proses Pendidikan Dasar Dan Menengah, 2016). This cognitive element relates to Bloom's cognitive level, which was later refined by Anderson and Krathwohl. Anderson and Krathwohl divided cognitive abilities into two categories: lower order thinking skills and higher order thinking skills. (Anderson & Krathwohl, 2001). Lower order thinking skills include applying simple steps to routine problems (Abosalem, 2016) and algorithmic (Thompson, 2008) with indicators of remembering, understanding, and applying (Anderson & Krathwohl, 2001). The retrieval of relevant knowledge from long-term memory is the focus of remembering. Understanding relates through deriving meaning from instructional messages, which include oral, textual, and graphic communication. Using a process on an issue is referred to as applying. Higher order thinking is a problem-solving challenge for pupils who need to comprehend, analyze, or manipulate information (Abosalem, 2016) and non-algorithmic (Thompson, 2008) with indicators of analysing, evaluating, and creating (Anderson & Krathwohl, 2001). Analyzing is the process of breaking down a substance into its basic pieces and identifying how those parts connect to one another in order to establish a structure or purpose. Evaluation is the process of making decisions based on criteria or standards. Creating is the process of arranging pieces to form a new pattern or structure.

Students gain greatly from higher order thinking skills. Students that have higher order thinking skills will be better prepared to address difficulties in the twenty-first century (Brookhart, 2010; Moseley et al., 2005; Thompson, 2008). Furthermore, higher order thinking abilities need pupils to think critically, imaginatively, solve non-routine issues, communicate, and interact (Sadijah et al., 2021). Higher order thinking abilities have a positive link with student accomplishment in the educational context, therefore students who have higher order thinking skills also have high achievement (Sutrisno & Retnawati, 2018). Improving pupils' cognitive capabilities can be accomplished by posing high-level questions that develop students' critical thinking and creative thinking (Susanto & Retnawati, 2016).

Students must initially develop lower order thinking abilities in order to develop higher order thinking skills. According to Anderson and Krathwohl, the cognitive level is hierarchical, thus teachers should not provide tasks that need higher order thinking abilities, but based on the signs, students' lower order thinking skills have not been reached as a whole (Anderson & Krathwohl, 2001). As a result, lower order thinking abilities play a crucial role in raising pupils' cognitive levels toward higher order thinking skills.

Although it is critical for students to master cognitive levels, including lower order and higher order thinking abilities, there are issues that arise in schools, namely pupils' lower order thinking skills. The results of the PISA testing from 2000 to 2018 show that the mathematics success score of Indonesian pupils never hit 400. Based on these findings, it can be concluded that Indonesian pupils can only answer math problems at a cognitive level of remembering. Students at this level can only recall knowledge stored in long-term memory, which is then utilized to solve issues, therefore they rely solely on memory.

Previous research also revealed that students' cognitive levels were still dominated by low cognitive levels, especially at the level of remembering and understanding (Barut & Wijaya, 2021) while the cognitive level of analyzing, evaluating, and creating is still very low (Ayu Rahayu, 2018). The same thing was conveyed by previous research which stated that the high cognitive level of students was still a concern. Research conducted by Megawati et al. (2019) shows that the overall high cognitive level of students is very concerning where the analysis indicator is in the low category while the indicator evaluates and creates in the very low category. These results are the same as the research results obtained by Ichsan et al. (2019). Furthermore, research conducted by Mandini & Hartono (2018) gives the result that the high cognitive level of students is included in the moderate criteria where students still have difficulty making generalizations. Situmorang et al. (2020) also states that students have difficulty when faced with questions at the level of evaluating and creating so that the cognitive level of evaluating and creating students is still lacking. Megawati et al. (2019) and Rahayu et al. (2021) revealed that students' high cognitive level was still low, especially for evaluation and creation indicators.

The low cognitive level of students, especially for higher order thinking skills, is caused by some factors so students find it difficult to solve problems with high cognitive levels. Questions that measure high order thinking skills are contextual questions based on everyday life (narrative questions) but this becomes an obstacle for students where students do not like narrative questions (Alhassora et al., 2017; Hadi et al., 2018; Retnawati et al., 2017). In addition, the obstacles faced by students are difficulties in planning to solve problems, difficulties in developing mathematical models using contextual problems, difficulties in determining which formulas are suitable for solving problems, difficulties in applying formulas, difficulties in connecting information and applying strategies to solve problems, difficulties in manipulating, and limitation in information literacy (Abdullah et al., 2017; Hadi et al., 2018; Tanudjaya & Doorman, 2020).

The low cognitive level of students is also caused by the teacher rarely giving questions that measure higher order thinking skills. The practice questions given by the teacher are the questions in the mathematics textbook. Previous research stated that students' mathematics textbooks were dominated by questions that measured lower order thinking skills, namely applying (Klorina et al., 2021) so that the distribution of questions based on cognitive level is not proportional. Furthermore, Cahyono & Adilah (2016) discovered that 16.98 percent of the questions in students' mathematics textbooks were questions with a cognitive level of remembering, 53.77 percent were questions with an applied cognitive level that were part of lower order thinking skills, and 29.25 percent were questions with a cognitive level of reasoning that were part of higher order thinking skills.

The disproportionate amount of questions that can evaluate lower and higher order thinking skills is not complemented by instructors' capacity to construct examinations that measure higher order thinking skills. The instructor understands how vital it is to train students on higher order thinking skills questions, but there are still misunderstandings about how to create higher order thinking skills questions (Retnawati et al., 2018). Based on the teacher's perspective, questions that measure high cognitive levels must be difficult questions. However, this misunderstanding is not accompanied by the teacher's concern for studying and designing higher order thinking skills questions (Ramdiah et al., 2019). In addition, teachers also have difficulty in designing questions of high cognitive level. This difficulty is shown by the daily test questions made by the teacher that only meet the cognitive level of remembering, understanding, and applying (Amelia et al., 2016; Himmah et al., 2019). In addition, research conducted by Meldawati et al. (2020) and Febrilia (2019) shows that the questions made by the teacher are dominated by questions that measure low cognitive levels. However, not only in-service teachers but pre-service teachers also experience problems in designing questions that can measure high cognitive levels (Listiani & Sulistyorini, 2020; Samo, 2017; Tanujaya & Mumu, 2020). Therefore, conducting assessments that measure low cognitive levels is still an obstacle for teachers (Afifah & Retnawati, 2019; Retnawati et al., 2016).

Previous research has developed many questions that can measure students' cognitive level, but the questions developed are only for junior high school students (Husna et al., 2018; Muklis et al., 2018). In addition, the development of questions that measure higher order thinking skills of students has also been carried out, but the questions developed are also for junior high school students too (Fadlila & Sagala, 2021; Kusaeri et al., 2018; Yunita et al., 2018). The difference between the research that has been done and this research is that this research develops questions that can measure the cognitive level of senior high school students, especially in the composition function material. Because of the teacher's difficulties and the lack of producing questions geared to the updated Bloom's taxonomy on the composition function material, the researchers created questions oriented to the revised Bloom's taxonomy on the composition function material.

B. METHODS

Research and development with a formative assessment model was employed as the research approach. Questions are developed in two stages: the preparatory stage and the formative evaluation stage. This study employed the formative assessment step provided by (Tessmer, 1998), which includes (1) self-evaluation, (2) prototyping (expert review, one-to-one, and small group), and (3) field testing.

The first stage that the researcher went through was preliminary. By contacting the mathematics instructor to tailor the research timetable to the mathematics learning schedule, the researcher decides the location and study subject. The formative evaluation step of the research was completed.

Self-assessment is the first stage in the formative evaluation process. At this step, the researcher examines the students' characteristics, the curriculum, the resources utilized, and the questions to be tested. Prototype 1 refers to the questions that have been created at this level. Following the creation of the questions to be tested, the researcher undertakes the prototype stage, which includes expert review, one-on-one, and small group sessions. Based on expert opinion, an expert review was done to establish the degree of validity of the questions. Experts evaluate questions developed in terms of substance, structure, and language. Furthermore, the professionals make ideas to improve the questions that have been produced.

In addition to the expert evaluation, the researcher performed a one-on-one study with three non-research volunteers. The three pupils are from one of Tebing Tinggi's public senior high schools, and they include one student with strong mathematical ability, one with moderate mathematical ability, and one with low mathematical ability. Students are expected to work on all of the provided questions and submit feedback or comments on these questions. Suggestions from professionals and students are utilized as material for consideration in order to fix the problem, prototype 1, so that prototype 2 can be developed.

Following the creation of prototype 2, the researchers tested it on six pupils. This is referred to as a small group stage. At this stage, the students involved were students from one of Tebing Tinggi's public senior high schools who were not the subject of the study, and they included two students with high mathematical ability, two students with moderate mathematical ability, and two students with low mathematical ability. At this step, students are required not just to answer the issue, but also to offer feedback on the problems they are working on. After receiving ideas from the students, the researchers updated prototype 2 such that the end product was known as prototype 3. Prototype 3 was tested on 25 students from class X at one of Tebing Tinggi's public senior high schools, who served as study subjects. The field test is the name given to this stage. At this point, students are requested to complete the amended questions as well as provide feedback on the work of the questions.

The development criteria used in this study are valid, practical, and effective (Akker, 1999). The developed questions are said to be valid if there is a strong theoretical rationale and there is internal consistency. The data collection instrument used to determine the validity of the questions developed was a validation sheet by experts. Effectiveness is the potential effect that students get after working on the developed questions. The data collection instrument used to determine the effectiveness of the questions was a test. The effectiveness criteria used are 85% of students meet the criteria for mastery learning both for low cognitive levels and high cognitive levels. Practicality relates to the positive response given by students regarding the questions being tested. The data collection instrument used to determine the practicality is the student response sheet. The practicality criteria used are 85% of students have a positive attitude towards the questions being tested.

C. RESULT AND DISCUSSION

1. Preliminary

At this point, the researchers asked a mathematics teacher from one of Tebing Tinggi's senior high schools whether he would be prepared to do study on the class that would be utilized. The study took place in the even semester of the 2020/2021 academic year, with students from class X MIPA 1 as research participants.

2. Self-Evaluation

At this point, the researchers examined the characteristics of the students, the school's curriculum, the books utilized, and the design of the questions. The composition function learning was done by the students in this study. The school follows the 2013 curriculum, and the textbook is a mathematics textbook for class X SMA/MA produced by the Ministry of Education and Culture. Following the analysis, the researchers created the exam questions. Before being validated by experts, the researchers' design is referred to as the initial product (prototype 1), which comprises of 15 questions (12 multiple choice questions and 3 essay questions). The following is an example of a question created as prototype 1 by the researchers.

Suatu pabrik kertas berbahan dasar kayu memproduksi kertas melalui dua tahap. Tahap pertama dengan menggunakan mesin I yang menghasilkan bahan kertas sengetah jadi dan tahap kedua dengan menggunakan mesin II yang menghasilkan kertas jadi. Dalam produksinya, mesin I menghasilkan bahan setengah jadi dengan mengikuti fungsi $f(x) = 2x - 1$, mesin II dinyatakan dengan $g(x)$, dan banyaknya kertas yang dihasilkan oleh produksi tersebut adalah $(h)(x) = 4x^2 - 10x + 4$ dengan x merupakan banyak bahan dasar kayu dalam satuan ton. Fungsi yang menyatakan banyaknya kertas jadi yang dihasilkan oleh mesin II adalah …..

A. $x^2 + 3x$
B. $2x^2 - 5x + \frac{5}{2}$
C. $4x^2 - 8x + 3$
D. $8x^2 - 20x + 7$
E. $16x^2 - 36x + 18$

Figure 1. One of the Questions in Prototype 1

3. Expert Reviews

Validators, especially two academics from Yogyakarta State University's Department of Mathematics Education, are involved in this step. The verification procedure is conducted out over Whatsapp. The following are the outcomes of expert validation.

Table 1. Validation of Instrument Validation

Validator	Scores	Criteria
Validator 1	4.7	Valid
Validator 2	4.5	Valid
Average	4.6	Valid

The validator not only evaluates the produced questions, but also makes ideas to researchers about the questions. The following are validator recommendations for researchers.

Table 2. Validators' Suggestion

Validator	Suggestions	After Revision
Validator 1	The use of the term must be the same in the question	The word illustration is changed to a picture
	Double-check the calculations on the completion sheet	Errors in the completion sheet are corrected
Validator 2	Questions that use context are illustrated so that students don't feel confused	Adding an illustration to the problem according to the story that was made

4. One-to-One

While verifying with experts, the researchers tested prototype 1 on three students who were not study subjects: one with strong mathematical aptitude, one with moderate mathematical ability, and one with low mathematical ability. In addition to solving these questions, students also provide comments or suggestions on the questions being tested. After getting comments from validators and students, the researcher revised prototype 1. The revised prototype 1 was called prototype 2. The results of prototype 2 were as follows.

Suatu pabrik kertas berbahan dasar kayu memproduksi kertas melalui dua tahap. Tahap pertama dengan menggunakan mesin I yang menghasilkan bahan kertas sengetah jadi dan tahap kedua dengan menggunakan mesin II yang menghasilkan kertas jadi. Dalam produksinya, mesin I menghasilkan bahan setengah jadi dengan mengikuti fungsi $f(x) = 2x - 1$, mesin II dinyatakan dengan $g(x)$, dan banyaknya kertas yang dihasilkan oleh produksi tersebut adalah $(h)(x) = 4x^2 - 10x + 4$ dengan x merupakan banyak bahan dasar kayu dalam satuan ton. Fungsi yang menyatakan banyaknya kertas jadi yang dihasilkan oleh mesin II adalah …..

A. $x^2 + 3x$
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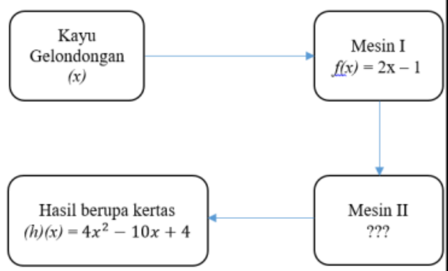

Figure 2. One of the Questions in Prototype 2

5. Small Group

Prototype 2 is then tested on six non-research individuals, including two students with strong mathematical ability, two students with intermediate mathematical ability, and two students with low mathematical ability. The researchers asked the six students to solve prototype 2 questions and also provide comments or suggestions on the questions given. The following are the results of testing prototype 2 in a small group.

Table 3. Students' Cognitive Level Score in Small Group

No	Students' Code	Low Order Thinking		High Order Thinking	
		Score	Category	Score	Category
1	S1	94	Very Good	92	Very Good
2	S2	92	Very Good	86.5	Good
3	S3	90	Good	86	Good
4	S4	85.5	Good	84	Good
5	S5	84	Good	79.5	Enough
6	S6	80	Enough	78	Enough

6. Field Test

The field test was the final stage that the researcher went through. At this point, the researchers put prototype 2 through its paces on test patients. The purpose of the field test is to examine the applicability and efficacy of math problems generated on the composition function material on the cognitive level of children. At the field exam stage, students completed as many as 15 questions, which included 12 multiple choice questions and 3 essay questions. Student scores are used as data to determine whether the questions developed are effective or not. The effective criteria in this research is that there are at least 85% of students have a score of more than 75. The results of the field test are as follows.

Table 4. Category of Students' Cognitive Level

No	Score	Category	Low Order Thinking		High Order Thinking	
			Frequency	Percentage	Frequency	Percentage
1	$91.7 < x \leq 100$	Very Good	5	20%	4	16%
2	$83.3 < x \leq 91.7$	Good	10	40%	8	32%
3	$75 < x \leq 83.3$	Enough	7	28	10	40%
4	$x < 75$	Bad	1	4%	3	12%

In addition to solving the problems that have been developed, students fill out a student assessment sheet questionnaire on the developed questions. Student response data is used to assess whether the questions developed are practical or not. The questions developed are said to be practical if students who have a positive response are at least 85%. The students' responses to the questions given are as follows.

Tabel 5. Category of Students' Response

No	Score	Category	Frequency	Percentage
1	$3 < x \leq 4$	Positive	22	88%
2	$2 < x \leq 3$	Positive Enough	3	12%
3	$1 < x \leq 2$	Negative Enough	0	0%
4	$x < 1$	Negative	0	0%

7. Discussion

This study is development stage had four stages: preliminary, one-to-one, small group, and field test. Following the completion of the development process, 15 questions were collected, with 12 multiple choice questions and 3 description questions. All questions built on the composition function material that may test cognitive level have been pronounced valid, practical, and effective.

The validity of the questions generated was determined based on the assessments and comments provided by validators, particularly in terms of gauging students' cognitive skills. According to the validators, the product that tested cognitive level was satisfactory in terms of content, construct, and language.

The prototype questions that are considered to be valid for measuring the cognitive level of pupils are then tested on study subjects, specifically students from class X MIPA 1, one of the Tebing Tinggi senior high schools, with a total of 25 students. After students have completed the composition function content, they are given questions that assess their cognitive level.

After the test was carried out, the researcher analyzed the student assessment sheets and test answers to determine the practicality and potential effects of questions measuring students' cognitive levels. From the results of the field test, it was found that 85% of students had a positive response to the questions developed. As a result, questions that assess students' cognitive skills are simple to use, do not result in numerous interpretations, and can be utilized by all students. According to the findings of the field test, 85 percent of pupils completed both lower order and higher order thinking skills. Based on these findings, it is possible to conclude that asking students questions about their cognitive levels can help them improve their cognitive levels.

Previous study has also demonstrated that the questions devised to assess students' cognitive level fit the requirements of being valid, practical, and effective (Budiman & Jailani, 2014; Husna et al., 2018; Muklis et al., 2018). In addition, research that develops questions to measure students' higher order thinking skills also meets valid, practical, and effective criteria (Arifin & Retnawati, 2017; Fadlila & Sagala, 2021; Gusdinata & Somakim, 2020; Kusaeri et al., 2018; Nursalam et al., 2018; Oktaviana & Susiaty, 2020; Prabowo et al., 2021; Sagala & Andriani, 2019; Wulandari et al., 2020; Yunita et al., 2018; Zaki et al., 2020). This shows that quite a lot of questions have been developed, but not all mathematical material has been developed that measures students' cognitive level.

D. CONCLUSION AND SUGGESTIONS

According to the study's findings, the questions generated matched the requirements of being valid, practical, and effective. The expert's appraisal of the questions that have been established demonstrates validity. The questions generated are divided into three categories: content, construct, and language. It is clear from the student's assessment form on the generated questions. The practical requirements were satisfied by 85 percent of the students who responded positively to the questions. The amount of pupils who fulfill the minimal completion criterion demonstrates effectiveness. Because 85 percent of the students achieve the minimal completeness criterion, the questions created meet the effective criteria.

Suggestions can be made to other researchers in order to design questions that can test students' cognitive levels, particularly higher order thinking skills, in different high school level materials. Furthermore, teachers should assign mathematical problems to students that include a number of questions that test lower order thinking abilities and higher order thinking skills proportionately, allowing students to gain higher order thinking skills.

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