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Higher Order Thinking Skills: The Process of Developing Questions with Kahoot Asisted

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Abstract

This study aims to produce questions based on Higher Order Thinking Skills (HOTS) that are valid, practical, and have potential effects using Kahoot application. This research is a design research type of development study. Subject were 32 students of Mathematics Education. Data collection instruments used walkthrough, interviews, and questionnaires. The data were analyzed descriptively using anates software version 4.0.9. This study resulted in 16 multiple choice questions on exponential and logarithmic functions, sequences and series, and trigonometry which are suitable using Kahoot application. The results showed that the developed HOTS-based questions reach the criteria of being valid, practical, and effective to support Matematics Eduaction student' higher order thinking skills of Mathematics Education.
Keywords: Item Analysis, Assessment Instrument, HOTS, Advanced Mathematics.

Abstrak

Penelitian ini bertujuan untuk menghasilkan soal berbasis *Higher Order Thinking Skills* (HOTS) yang valid, praktis, dan memiliki efek potensial dengan bantuan aplikasi Kahoot. Jenis penelitian merupakan *design research* tipe *development study*. Subjek penelitian sebanyak 32 mahasiswa Pendidikan Matematika. Instrumen pengumpulan data menggunakan lembar angket dan wawancara. Teknik pengambilan data menggunakan *walkthrough*, wawancara, dan angket. Data dianalisis secara deskriptif dengan bantuan *software anates versi* 4.09. Penelitian ini menghasilkan 16 butir soal pilihan ganda pada materi matematika sekolah tentang fungsi eksponen dan logaritma, barisan dan deret, serta trigonometri yang layak digunakan dengan bantuan aplikasi Kahoot. Hasil penelitian menunjukkan bahwa soal berbasis HOTS yang dikembangkan memenuhi kriteria valid, praktis, dan efektif untuk menunjang kemampuan berpikir tingkat tinggi mahasiswa Pendidikan Matematika.
Kata kunci: Design Research, HOTS, Kahoot, Pengembangan Soal.

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INTRODUCTION

The development of science and technology in the 21st century requires various aspects to adapt, including the field of education. Learning in this century emphasizes critical thinking skills, connecting science with the real world, and skills in mastering information

technology. One of the efforts to deal with these demands is to develop critical thinking skills. In line with Mukhlis et al. (2018) which explains that critical thinking is an important aspect in mathematics that has a role in constructing the improvement of students' abilities in facing the era of globalization. Critical thinking skills can be grown through higher order thinking skills. This is similar to Budiman & Jailani (2014) which explains that critical thinking skills can be trained by applying an assessment instrument based on Higher Order Thinking Skills (HOTS).

Higher Order Thinking Skills (HOTS) is the ability to connect, manipulate, and change existing knowledge and experience critically and creatively in making decisions to solve problems in new situations (Dinni, 2018). In this century, 4C skills need to be mastered by students in which there are higher order thinking skills (Saraswati et al., 2021). Suherman et al., (2020) explained that the implementation of higher order thinking skills is an important aspect in learning mathematics.

Improving higher order thinking skills has become one of the priorities for learning mathematics in both schools and universities. Although higher order thinking skills in mathematics have a very important role but in fact there are still many low mathematical thinking skills including critical thinking (Kurniati et al., 2015). Based on observations during advanced mathematics lectures at the Mathematics Education Study Program of Hasyim Asy'ari University, it was found that students were less able to solve problems that required higher order thinking skills. The practice questions given only require the ability to solve procedurally. This causes students to be less trained in solving HOTS-based questions. As a result, students are not ready to become teachers who can apply HOTS-based assessment.

A course in Mathematics Education that requires a HOTS-based assessment is Advanced Mathematics. This course contains knowledge of school mathematics material. This course is given with the aim that Mathematics Education students have the ability to be able to master the material at the high school level as well as solve the problems. However, the assessment instrument for the Advanced Mathematics course of the Mathematics Education Study Program of Hasyim Asy'ari University is limited to routine questions that only require the ability to count. The assessment instrument given is not related to real life. In addition, students do not get the opportunity to work on reasoning questions, problem solving and questions that require them to think critically. As a result, students are unable to develop a higher frame of mind and apply information in new situations. Dinni (2018) explains that one indicator of a person being able to solve a problem if they are able to examine a problem and

use their knowledge in new situations. The ability to apply in various contexts is what is usually known as High Order Thinking Skills (HOTS).

The development of the 21st century is a challenge for educators, especially lecturers, in producing a generation that is capable of technology and information. One application that can support the implementation of technology-based assessment is Kahoot. Kahoot is an online quiz application developed in the form of a game-show (Iwamoto et al., 2017). The Kahoot application is educational in nature which can be developed as an innovative and creative medium in learning (Ernalida et al., 2019). Kahoot is an educational platform that is integrated with learning needs in the 21st century because it is able to create a learning atmosphere that requires individuals to think critically, fun and competitively (Dellos, 2015).

Several studies on the development of HOTS questions have been carried out, such as Jannah & Pahlevi (2020) using the Kahoot application but in handling incoming mail, Phito et al., (2019) in the field of Physics but not based on IT, and Hanifah (2019) at the School level. Base. Similar research needs to be developed in other fields and levels by utilizing technology. The development of HOTS-based questions can be designed by formulating contexts that are relevant to real life, based on new phenomena, and their application in the real world.

Based on the explanation above, to train students' higher order thinking skills, it is necessary to apply HOTS-based assessment instruments in their learning. Therefore, this research is intended to produce HOTS-based questions assisted by the Kahoot application in advanced mathematics courses that are valid, practical, and effective to measure students' higher-order thinking skills accurately.

METHOD

The research type is a design research type of development study. This research is based on development through iterative cycles by applying formative evaluation (Plomp & Nieveen, 2013). The subjects were students of the Mathematics Education study program at Hasyim Asy'ari Tebuireng University who took the Advanced Mathematics course as many as 32 students.

This research was carried out in two phases, namely preliminary and formative evaluation which included self evaluation, expert reviews and one-to-one (low resistance to revision), small group and field test (high resistance in revision) as shown in Figure 1 below (Tessmer, 1993; Saraswati, et al 2021).

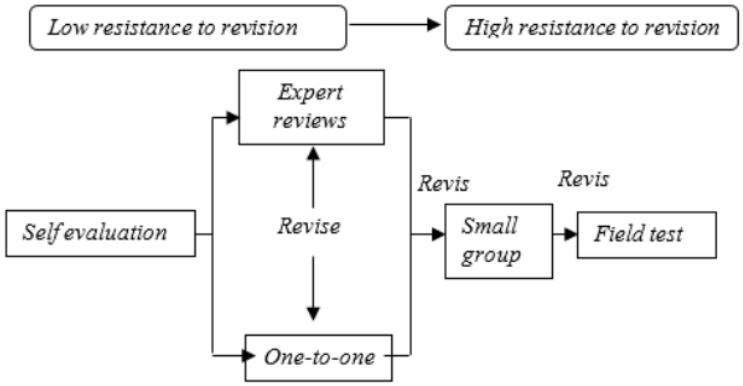

Figure 1. Formative Evaluation Design

a. Preliminary

In this phase, the researcher reviewed some literature on assessment instruments, Higher Order Thinking Skills (HOTS), and RPS for advanced mathematics courses. Next, design the initial prototype in the form of grids, questions, scoring rubrics, and prepare kahoot media.

b. Prototyping Phase with Formative Evaluation

In this phase, the researcher reviews the initial prototype draft. Furthermore, the prototype that has been reviewed is given to an expert review to be validated in aspects of materials and media. Along with the expert review, the researcher gave an initial prototype to 3 students individually (one-to-one) with the aim to get comments on the clarity of the meaning of the questions, proposing changes, investigating the difficulties of the developed assessment instrument. From the results of the revision based on input from expert reviews and one-to-one, then prototype 2 was tested on 10 students outside the subject. From the results of the revised prototype 2, it was then tested at the field test phase.

Data collection techniques using walkthroughs, interviews, and questionnaires. The data analysis technique was carried out descriptively by using the Anates software Version 4.0.9. Data from walkthroughs, interviews, and questionnaires were analyzed based on the formative evaluation cycle of Tessmer (1993).

The validity of the developed product is obtained based on the results of qualitative validation by experts (expert reviews). Meanwhile, quantitative validity refers to the results of the validation of the question components. The practicality of the products developed is known when one-to-one and small groups through questionnaires and interviews with the subject. While the criteria for potential effects refer to the results of the evaluation at the field test stage based on the results of questionnaires and interviews.

RESULT

The process and results of developing a HOTS-based assessment instrument emphasizes an iterative cycle that uses formative evaluation. This development phase consists of a preliminary and a prototyping. The following is an explanation of each phase of its development.

1. Preliminary

In the preliminary phase a study was obtained about the development of HOTS questions, the characteristics of HOTS questions, the suitability of the material in the RPS for advanced mathematics courses. In designing HOTS-based questions, steps are taken, namely: 1) Analyzing Basic Competencies. The description of the advanced mathematics course contains the students' ability to solve high school level questions. Therefore, the development of the HOTS assessment instrument is based on basic competencies in school-level mathematics. Competency analysis begins with determining the basic competence at the Junior High School level contained in Permendikbud no. 37 of 2018. Furthermore, the basic competence was analyzed according to their cognitive level which was the categories C4 (analyzing), C5 (evaluating), and C6 (creating); 2) Compile the Question Grid. The grid is prepared by determining the scope of material related to basic competence being tested, formulating question indicators, determining question numbers, determining cognitive levels and dimensions of thinking processes, and determining the form of questions used, namely multiple choice forms with 4 answer choices. This determination is based on limitations in the Kahoot application which can only display 4 answer choices; 3) Choosing contextual stimulus accurately. Stimulus used in developing HOTS questions refers to the application of each material in daily life; 4) Write the items according to the grid. The items are written referring to the rules of multiple-choice questions; 5) Create scoring guidelines. Scoring guidelines are prepared as a reference in determining the answer key in the question. Each question contains only one correct answer, while the others act as distractors. The score of each question is 2. The distribution of questions can be seen in Table 1.

Table 1. Distribution of Questions according to Basic Competence

No. KD	Material	Class	Cognitive Dimension	Number of Question
4.9	Trigonometry	X Required Mathematics	C4, C5, C6	4
3.1	Exponential and Logarithmic Functions	X Specialization Mathematics	C4	1
4.1			C5, C6	5
3.6	Arithmetic and Geometric Sequences	XI Required Mathematics	C5	3
4.6			C4, C5	3

Based on Table 1, it is known that the questions developed were 16 items. The HOTS-based assessment items or instruments that have been designed then tested on students at the prototyping phase.

2. Prototyping

This phase is a continuation of the initial prototype using formative evaluation consisting of self-evaluation, expert review, one-to-one, and field test. The following is an explanation for each phase.

a. Self-Evaluation

At this phase, the researcher reviews the initial prototype design as well as prepares research instruments related to the development process. The study was carried out by checking the suitability of the question design with the characteristics of the HOTS questions and the balance of the distribution of questions according to cognitive levels and processes. Furthermore, the set of questions that have been studied at this phase is called prototype 1.

b. One-to-one and Expert Review

In the self-evaluation phase, the initial prototype that has been developed is then given to expert review and students (one-to-one) simultaneously (parallel). The validation results from each expert review can be seen in Table 2 and 3.

Table 2. The Result of Material Expert Review

No.	Aspect	Average Value	Category
1	Material	4,68	Good
2	Construction	4,85	Very Good
3	Language	5,00	Very Good
	Average	4,84	Very Good

Based on Table 2, the results of the validation in material reached an average of 4.84 with a very good category. Material experts stated that the questions developed were worthy of being tested. While the results of media expert validation can be seen in Table 3.

Table 3. The Result of Media Expert Review

No	Aspect	Average Value	Category
1	Graphics	4,50	Good
2	Media Accessibility	4,23	Good
3	Visual Communication	4,40	Good
	Rata-rata	4,38	Good

At this phase, suggestions and comments from media and material experts were also obtained to be used as basic for revision of prototype 1. In addition, the results of the designed prototype 1 were also given to 3 students (one-to-one) outside the research subject with the

aim of seeing the legibility of the item formulation of questions, the suitability of the items with the material being taught, the ease of access and the use of Kahoot as a medium in working on the items developed.

Some suggestions and comments from experts and students were then used as the basis for revising prototype 1. The suggestions and comments are described in Table 4 and Table 5 below:

Table 4. Expert Review and One-to-One Suggestions/Comments from the Media Aspect

Validation		Suggestions/Comments	Revision
Expert Review		There are some questions that are advertised in image format, so it doesn't look clear.	Clarify the appearance of questions in the form of image formats on Kahoot media.
		There are no instructions in working on the questions on the Kahoot home page.	Added instructions for working on questions on the page that contains initial information about the questions being worked on. And add instructions for working on multiple choice questions on the assessment instrument given to students.
		In no.10, it should be clarified by adding the question table no.9	Add a table in question no. 10 to strengthen the information in working on the given problem.
		If possible, videos related to material related to the problem can be added to make it interesting, not just pictures.	Adding information related to the context of the question in the form of a video.
		In questions no. 13 and 15, images should be added so that the display of the questions in the kahoot does not only contain text.	Adding a picture of a ship that applies a three-digit direction to problem no.13, and adding a picture of a ship to problem no.15
One-to-one	R-1	There are some questions that are blurry	Deleting the image in question no.6
	R-2	The sound of the music makes you panic and unfocused	Turn off music while doing questions.
	R-3	The time for processing the questions is still not enough	Increase the duration of working on questions and change the questions as a form of assignment.

Table 5. Expert Review & One-to-One Suggestions/Comments from the Material Aspect

Validation	Suggestions/Comments	Revision
Expert Review	In question no. 1, the picture doesn't really work because there is already a written explanation in the problem related to the pH range.	Delete the explanation in the question text, and keep the image.
	In question no.1, there is a concern that orange juice is an acid solution from their	Change the explanation in the problem about orange juice

		previous knowledge, so that students do not perform mathematical analysis of the pH equation. It would be better if they were both bottled solutions in general.	into a solution of bottle B.
		The cognitive level in questions number 2 and 3 is too high to be categorized in question C6.	Lowering the cognitive level on questions number 2 and 3 to level C5
		The answer choices in question number 4 are less effective because students have to try each possible answer one by one.	Change the description in the answer choices into the question text.
		The cognitive level in question number 5 is too high, not in accordance with the question items.	Lowering the cognitive level on question number 5 to a C4 level category
		The answer choices in question number 5 should serve as a distractor	-
		In question number 5, it is better to explain what TI stands for	Clarify information about the abbreviation of TI (Intensity Level).
		In item number 10, the information in the questions should be presented in tables or pictures. And if it's still related to number 9, it's best if the context title precedes the questions.	Presenting and converting the information in the question into a tabular form and adding a context title to the question is the same as question number 9.
		In the answer key to question number 11, write the currency and Rp. 35,750,000.00.	Write down the currency according to the suggestions/inputs.
		In question number 13, because it tests mathematical literacy, the answer choices should also refer to the original size in decimal form, not roots.	Change the answer choices from root form to decimal form.
		The answer choices in question number 14, the use of the sign does not adequately represent the range referred to in the answer because the possible tolerance limit for one answer choice becomes the limit of the other answer choices.	Remove the mark ± in the answer choices.
		In question number 16 it is not clear what will be measured.	Changed the question description.
One-to-one	R-1	- The picture in question no. 6 is not very important and does not match the question - In question no 12 there are too many definitions of annuities	Deleting the image in question no.6
	R-2	Question number 12 is confusing.	Clarify the information in question no. 12 by simplifying the notion of annuity.
	R-3	Confused about what is meant by question number 16	Change the sentence of the question in question number 16.

Based on inputs and suggestions from expert reviews and one-to-one related materials and media, a revision was made to prototype 1. Some of these revisions were as follows:

1) Figure 2, Removed the description of the pH range and changed the solution to both a bottled drink.

(a)

(b)

Figure 2. Display of question number 1 before (a) and after (b) revision

2) Figure 3, Adding instructions for working on questions.

FIELD TEST TAHAP 1

PENGEMBANGAN INSTRUMEN PENILAIAN BERBASIS *HIGHER ORDER THINKING SKILLS* (HOTS) BERBANTUKAN APLIKASI KAHOOT UNTUK MENUNJANG LITERASI MATEMATIS MAHASISWA

Program Studi	: Pendidikan Matematika
Mata Kuliah	: Matematika Lanjut
Semester/ SKS	: III/ 2 SKS
Penyusun Soal	: Sari Saraswati, M.Pd
Deskripsi MK	: Pada mata kuliah ini mahasiswa mengkaji tentang konsep matematika sekolah yang meliputi konsep koordinat, titik, dan garis, bentuk akar, pangkat dan logaritma, fungsi dan grafik, kuadratik, persamaan dan pertidaksamaan, aturan pencacahan, barisan dan deret, trigonometri, serta mampu menyelesaikan soal-soal tingkat SMA.
Jumlah Butir Soal	: 6 item
Materi	: Eksponen dan Logaritma
Bentuk Soal	: Pilihan Ganda
Alokasi Waktu	: 120 menit

(a)

FIELD TEST TAHAP 1

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Penyusun Soal	: Sari Saraswati, M.Pd
Deskripsi MK	: Pada mata kuliah ini mahasiswa mengkaji tentang konsep matematika sekolah yang meliputi konsep koordinat, titik, dan garis, bentuk akar, pangkat dan logaritma, fungsi dan grafik, kuadratik, persamaan dan pertidaksamaan, aturan pencacahan, barisan dan deret, trigonometri, serta mampu menyelesaikan soal-soal tingkat SMA.
Jumlah Butir Soal	: 6 item
Materi	: Eksponen dan Logaritma
Bentuk Soal	: Pilihan Ganda
Alokasi Waktu	: 120 menit

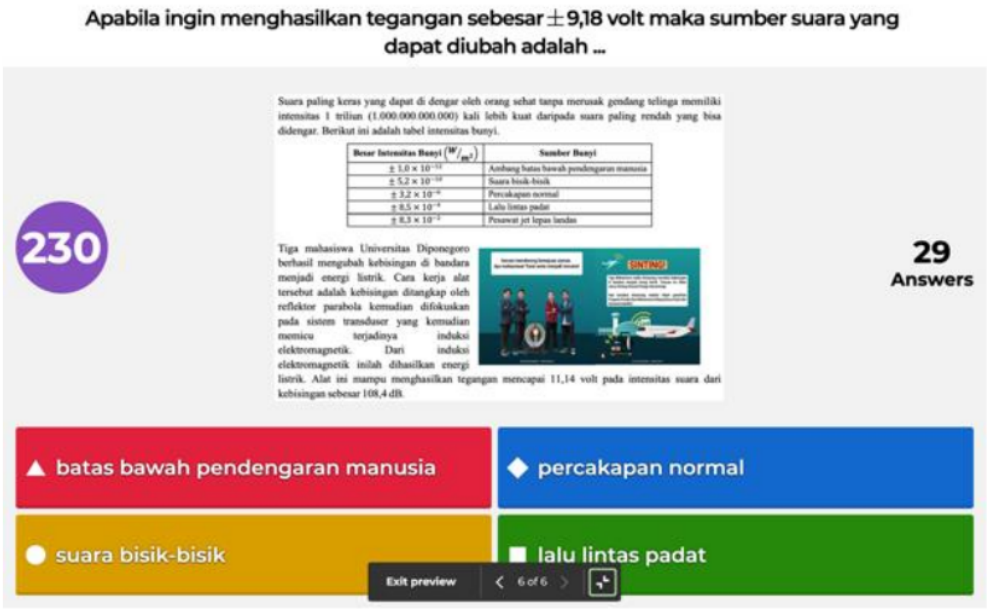
Petunjuk:

1. Kerjakan soal berikut dengan menyertakan cara/langkah penyelesaian pada lembar kertas/buram. Selanjutnya foto lembar jawaban tersebut dan kirimkan melalui WA.
2. Hasil pilihan jawaban masing-masing soal selanjutnya dapat diisikan melalui aplikasi **Kahoot.it** melalui link berikut: https://kahoot.it/challenge/02203973?challenge-id=c75ce6d7-4f92-4602-bf0a-f286af002aec_1629501147740
3. Setelah membuka link diatas, silahkan isi Nickname dengan Nama Lengkap anda. Lalu mulai mengerjakan.
4. Durasi pengisian jawaban dalam aplikasi kahoot adalah 4 menit pada masing-masing soal.

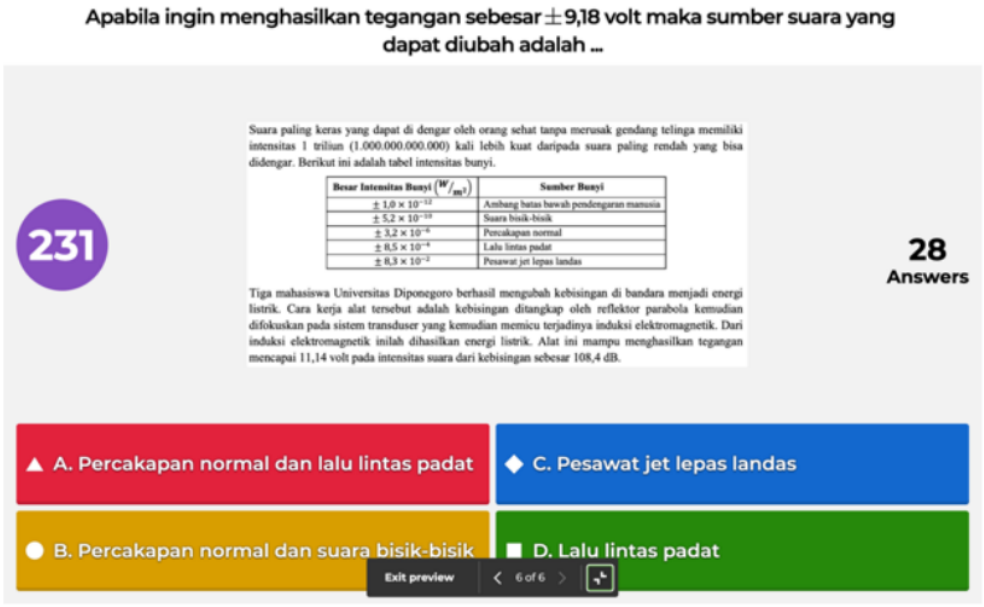
(b)

Figure 3. Instructions for working on questions before (a) and after (b) revision

3) Figure 4, Deleting the image in question number 6.



(a)



(b)

Figure 4. Display of question number 6 before (a) and after (b) revision

Based on a number of inputs at the expert review and one-to-one phases, a revision was made to prototype 1. The results of the revision at this phase produced prototype 2, which was then tested on students at the small group phase.

a. Small Group

At the small group phase, the HOTS-based questions were tested on 10 students of the Unhasy Mathematics Education Study Program. The students involved in the small group consisted of each 3 students with high, medium and low cognitive abilities. Based on the data from the questionnaires and interviews, it can be concluded that some general impressions of the small group subject students related to the questions developed, namely (1) questions related to daily life so that they can add insight, (2) problem solving requires more reasoning than directly using formulas, (3) questions require creativity to solve them, (4) this type of problem is rarely found in advanced mathematics courses, and (5) some complicated questions are done because they are convoluted.

Overall, based on the results of the scores and questionnaires above, the revision of the questions at the small group stage includes; 1) There needs to be additional information on commands to read general information that is used as important information in solving questions in one context unit, 2) Implementation time during the field test must be exactly as

planned, which is 120 minutes, and 3) Clarify picture information. and graphs and questions command sentences. Based on these inputs, the prototype 2 was revised to become prototype 3.

b. Field Test

The field test was carried out with the aim of seeing the potential effects of HOTS-based questions that had been developed based on revisions at the small group phase. This phase involved 32 students of Mathematics Education Study Program in advanced mathematics courses. The analysis of student answers was analyzed quantitatively using ANATES version 4.0.9. The level of constancy of the HOTS-based assessment instrument in the form of multiple choice can be seen from the calculation of the reliability value of the items. The recap of the reliability of the items can be seen in Table 6.

Table 6. Recap test reliability scores

Criteria	Value
Sum of item test	16
Average of score	3,88
Standard deviation	6,53
XY Correlation	0,77
Reliability of test	0,87

Based on Table 6, the average score is 3.88 with a standard deviation 6.53. XY correlation reached 0.77 with the reliability of the questions quantitatively obtained 0.87.

Table 7. HOTS Item Analysis

No.	Question Level	Distinguishing Power (%)	Difficulty Level	Correlation	Criteria
1	C4	88,89	Medium	0,748	Very Significant
2	C5	88,89	Medium	0,770	Very Significant
3	C5	88,89	Medium	0,658	Very Significant
4	C5	44,44	Very Difficult	0,715	Very Significant
5	C4	44,44	Easy	0,477	Significant
6	C5	22,22	Very Easy	0,310	-
7	C5	66,67	Easy	0,513	Significant
8	C5	66,67	Easy	0,577	Very Significant
9	C5	33,33	Very Difficult	0,566	Very Significant
10	C6	55,56	Difficult	0,548	Very Significant
11	C4	33,33	Very Difficult	0,516	Significant
12	C4	44,44	Difficult	0,639	Very Significant
13	C5	100,00	Medium	0,692	Very Significant
14	C5	55,56	Difficult	0,582	Very Significant
15	C5	44,44	Difficult	0,525	Significant
16	C6	55,56	Medium	0,514	Significant

In the field test, Table 7, the results of a questionnaire related to HOTS-based questions were obtained which were developed for students' higher-order thinking skills in advanced mathematics courses. The student responses can be seen in Table 8.

Table 8. Percentage of Student Responses to HOTS-Based Questions

No.	Statement	Percentage of Student Response (%)
1	Write in-depth and analytical answers	92
2	Requires knowledge of other materials to be able to solve problems / questions	84
3	Identify the mathematical aspects of the context of the problem in the problem	89
4	Represent the situation/context of the problem in variables, symbols, diagrams, or mathematical models	82
5	Using concepts, facts, procedures, and reasoning to solve problems	86
6	Using rules, algorithms, formulas, mathematical structures to find solutions/answers	88
7	Make mathematical conclusions and interpret answers according to the context of the problem	81

Based on Table 8, it is known that student responses to the developed HOTS questions reached a percentage above 50%. This is reinforced from the results of interviews with several students, it was found that; 1) the questions developed motivate students to find solutions/answers and stimulate curiosity, 2) the context in the questions is relevant to everyday life, and 3) uses mathematical models, symbols, and patterns in solving the problems.

DISCUSSION

Based on the results of a qualitative study by expert judgment, it was found that 16 items had met the valid criteria. It can be seen from Tables 2 and 3 that the average results of material and media expert validation are 4.84 and 4.38, respectively, with very good and good categories. Furthermore, from these results, it can be determined that the average validation results from the two experts for the developed HOTS-based questions reached a value of 4.61 with a good category. This means that the questions developed have met the valid criteria based on material and media experts. While quantitatively the validity of each item can be seen in Table 7 with a test reliability of 0.87. Based on Jihad & Haris (2012) this value indicates that the HOTS questions developed have a very high interpretation of constancy or

consistency. In addition, the two experts stated that the questions developed were worthy of being tested so that the practicality criteria had been met.

The developed HOTS questions have a potential effect on students' higher order thinking skills. Based on Table 8, it is known that students have used their reasoning abilities, identified mathematical aspects in context and then represented them in the form of mathematics, symbols, and algorithms, as well as the ability to conclude results well. Kemendikbud (2019) revealed that one of the characteristics of HOTS questions is based on contextual problems where this contextual includes relating, experiencing, applying, communicating, and transferring. The contexts on the developed HOTS questions are able to stimulate students' higher-order thinking skills. This is relevant to the results of research by Ramos et al. (2018) that higher order thinking skills need to be mastered in the face of era and technological developments.

The development of HOTS-based questions assisted by the Kahoot application meets the valid, practical, and effective criteria. However, the application used is a free application, as a result, the form of questions that can be displayed in the Kahoot application is limited to complex multiple choice. Therefore, for similar research, the paid Kahoot application can be used so that it can be developed in the form of questions other than complex multiple choice.

CONCLUSION

Based on the results and discussion, it is concluded that the development in this study has produced a set of HOTS-based questions in the form of multiple choice assisted by the Kahoot application as many as 16 items that are valid, practical, and have potential effects. The developed questions have a potential effect on students' higher-order thinking skills. This means that the HOTS questions are used as an assessment instrument in advanced mathematics courses, so the questions given are not routine. Besides, this HOTS question can be applied to develop a higher frame of mind for students.

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