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THE DEVELOPMENT OF HOTS-BASED FINANCIAL MATHEMATICS QUESTION TO SUPPORT STUDETS' MATHEMATICAL COMMUNICATION SKILL

Sahrul Ramadhan[1*], Elly Arliani[2], Mayang Purbaningrum[3], Nur Lailatul Azizah[4]

[1,2,3,4] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia
*Corresponding author. Yogyakarta, Indonesia.
E-mail: sahrulramadhan.2022@student.uny.ac.id [1*)]
arlianielly@uny.ac.id [2)]
mayangpurbaningrum.2022@student.uny.ac.id [3)]
nurlailatul.2022@student.uny.ac.id [4)]

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Abstract

Communication skills and high-order thinking skills or HOTS need to be honed in this era, so the aim of this research is to develop financial mathematics HOTS questions to support the mathematical communication skills of grade 11 Vocational High School students. The research method used is development research with a formative research type model. The subjects of this study were 3 grade 11 SMK Negeri in Yogyakarta. The research instrument uses tests and interview guidelines. Data collection techniques using documentation, walkthroughs, tests, and interviews. Data analysis techniques using descriptive techniques. The research results obtained were 15 HOTS questions of mathematical communication on financial mathematics material. The resulting questions have very valid criteria with a validity level of more than 0.8. The questions have a reliability coefficient of more than 0.6 so the questions are very reliable. The questions have differentiating power in the good category. The difficulty level of the questions has 2 categories, namely medium and easy. The distractor on the resulting problem works well. The average test result is in the very good category with a value of 73.13. Based on this research, it is hoped that there will be follow-up in compiling questions for mathematical communication skills in other materials.

Keywords: HOTS; mathematical communication; question development.

Abstrak

Kemampuan komunikasi dan kemampuan berpikir tingkat tinggi perlu diasah di era ini, sehingga tujuan penelitian ini yaitu mengembangkan soal HOTS matematika keuangan untuk menunjang kemampuan komunikasi matematis siswa SMK kelas 11. Metode penelitian yang digunakan yaitu penelitian pengembangan dengan model tipe formative research. Subjek penelitian ini 3 kelas 11 SMK Negeri in Yogyakarta. Instrumen penelitian menggunakan tes dan pedoman wawancara. Teknik pengumpulan data menggunakan dokumentasi, walkthrough, tes dan wawancara. Teknik analisis data menggunakan Teknik deskriptif. Hasil penelitian yang diperoleh yaitu 15 Soal HOTS komunikasi matematis pada materi matematika keuangan. Soal yang dihasilkan memiliki kriteria sangat valid dengan tingkat validitas lebih dari 0,8. Soal memiliki hasil koefisien reliabilitas lebih dari 0.6 sehingga soal sangat reliabel. Soal memiliki daya pembeda pada kategori baik. Tingkat kesulitan soal memiliki 2 kategori yaitu sedang dan mudah. Distraktor pada soal yang dihasilkan berfungsi dengan baik. Rata-rata hasil tes pada kategori sangat baik dengan nilai 73,13. Berdasarkan penelitian ini, diharapkan ada tindak lanjut dalam menyusun soal untuk kemampuan komunikasi matematis pada materi lainnya.

***Kata kunci**: HOTS; komunikasi matematis; pengembangan soal.*

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INTRODUCTION

Implementation of the assessment of student learning outcomes is guided by educational assessment standards. Educational assessment standards are criteria for identifying the scope, objectives, benefits, principles, procedures, processes, and instruments used to measure student learning outcomes. The assessment is expected to be able to support students in improving their abilities higher Order Thinking Skills (HOTS) because, with HOTS skills, students can study the subject matter (Gustiningsi & Somakim, 2021). This is in line with the research of Widodo & Kadarwati (2013) who said that students are capable of HOTS interpreting concepts and ideas well and broadly. HOTS can be described as a learner's capacity to use knowledge and ability to apply ideas that were not previously understood (Heong et al., 2011).

In fact, schools still tend to give tests that test only aspects of memory that do not train HOTS, so that higher-order thinking results are still low(Gustiningsi & Utari, 2020). Research Pratama & Retnawati (2018) concluded several factors that caused students not to be familiar with HOTS questions are (1) the inability of teachers to create HOTS assessment tools and the scarcity of tasks specifically made to train HOTS , the fact that most teachers have not emphasized the HOTS problems in the learning process (Riadi & Retnawati, 2014), and the fact that poorly trained in solving problems that measure HOTS (Arifin & Retnawati, 2017). Due to this, Indonesian students found it challenging to solve HOTS issues (Hadi et al., 2018). Students need to be familiar with the exercises that teach HOTS, such as solving HOTS problems. The limited sources of questions that contained HOTS so that students rarely used HOTS questions during exams. Through mathematics lessons from several Competency Standards (SK) and Basic Competency (KD), HOTS questions can be developed so that the tests tested have the potential to raise educational and human resource standards (Budiman & Jailani, 2014)

21st-century skills focus on four abilities called 4C: critical thinking, creativity, communication, and collaboration. Asri (2019) added about the skills that must be possessed by students in 21st-century learning, namely Creativity and innovation, Communication and collaboration, Research and fluency of information, Critical thinking, problem solving and decision making, Digital Citizenship, Technology operations, and concepts.

Students can enhance their mathematical thinking, knowledge, and problem-solving skills through effective communication, thereby fostering the development of mathematical communication(Pratiwi, 2015). One of the mathematical materials that requires mathematical communication is financial mathematics. Financial mathematics material has a relationship with mathematical communication skills because the context of questions in financial mathematics takes from real life so that it makes it easier for students to communicate the results of solving the problems they get. So an assessment is needed to measure mathematical communication skills in financial mathematics.

The Framework Program for International Student Assessment (PISA) is related to HOTS, where PISA questions have a potential influence on 21st century abilities including critical thinking, communication, representation

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and collaboration skills(Oktiningrum et al., 2016). However, the assessment instruments used by teachers to evaluate students' cognitive learning outcomes are often in the form of questions from various textbooks, which can be in the form of multiple-choice or descriptive questions (Budiman & Jailani, 2014). Research Munayati et al. (2015) stated that the questions in the textbook only contained 46% that were appropriate framework PISA, the most questions at level C3 are 27%. While for levels C5 and C6 there is only 2,5% (Syarifah et al., 2020). The research that has been carried out is developing questions but based on mathematical literacy (Imamuddin et al., 2022; Mangelep & Kaunang, 2018; Nursakiah et al., 2022; Putra, 2018), problem solving test (Li et al., 2020), critical thinking test for undergraduate students which similar with HOTS test (Wardhani & Oktiningrum, 2022), however, the development of HOTS questions used to develop students' mathematical communication skills has not been researched, which on the other hand, mathematical communication skills and high level thinking skills are very necessary.

Based on the explanation that has been described, this research aims to develop financial mathematics HOTS questions to support the mathematical communication skills of grade 11 Vocational High School students. it is hoped that it will help educators and researchers create appropriate mathematical communication assessment that can can develop high-level thinking skills in financial mathematics material.

METHODS

The respondents of this study were 11th-grade students of SMK Negeri in Yogyakarta. This research is a type of development (R&D). The development model in this development research uses the development model type formative research which consists of 2 main stages via preliminary and level formative evaluation from Tessmer (1993). The first stage preliminary is divided into 2 stages, namely preparation and design. At stage formative evaluation is divided into 4 parts covering self-evaluation dan prototyping (expert reviews, one-to-one, small group, field test). The form of the flowchart in this development method is shown at Figure 1.

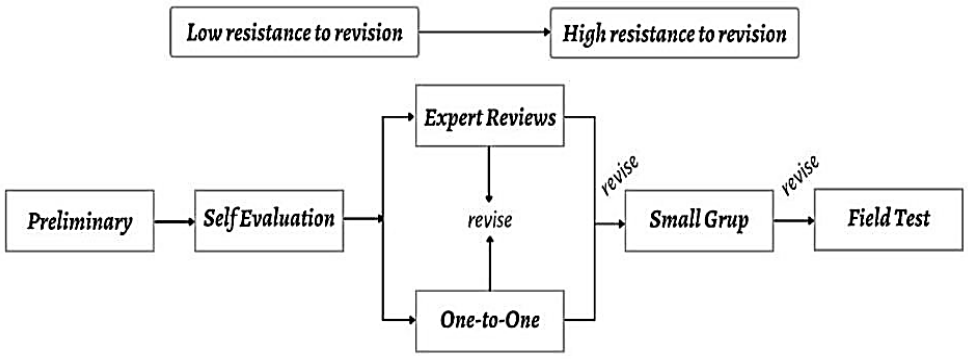

Figure 1. Formative evaluation flowchart from Tessmer (1993).

1. Preliminary

At the level of preliminary carried out curriculum analysis, determined the material, and analyzed the needs of teachers as well as developed procedures for conducting research in schools. Next is the design or design stage, the researcher designs an

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assessment instrument in the form of making grids, looking for problems that match content, constructs, and language as well as indicators of mathematical communication skills that produce prototype 1 on financial mathematics material as many as 15 questions with 12 multiple choice questions and 3 essay questions. The existence of multiple choice questions and essays is intended to measure various cognitive levels. Multiple choice questions can cover basic levels of understanding and application of knowledge, while essay questions can examine students' ability to analyze, assess, synthesize information and communicate understanding. Furthermore, with only 15 questions, the exam can be completed in a reasonable time, allowing students to answer each question attentively, thoroughly and minimizing fatigue and stress. The design of this prototype is then developed according to the formative evaluation stage.

2. Formative Evaluation

At the level of formative evaluation, the results of the research are evaluated related to the analysis and design of mathematical communication problems. Furthermore, the product developed is validated by expert review, one-to-one, and small groups before being tested in the field. The expert reviewers consisted of 2 vocational high school teachers with master's degrees and a vocational high school teacher with a doctoral degree. One to one subject consist of 3 students with high, medium, and low ability criteria were obtained based on the results of the Mathematics Mid Semester Assessment (PTS). The results of the expert review validation and comments from the one-to-one group were used as material for revision in prototype 2.

The results of prototype 2 were then tested against a small group with many subjects 12 students who have high, medium, and low abilities based on the results of PTS mathematics. Furthermore, students were also asked for their comments on the questions. The third prototype underwent alteration based on the test results and student feedback.

After being revised, the results of prototype 3 were tested on 3 grade 11 SMK Negeri 2 Depok. Based on the test results, an estimate was made of the reliability of the items, discriminating power, level of difficulty, distractors, and potential effects on mathematical communication skills. The validation of the test items for this study used content validation with Aiken's V analysis. While the reliability test uses the coefficientscronbach's Alpha and analysis of discriminating power, level of difficulty, and function of the distractor using AnBuso version 8. The distractor criterion is said to be good if the choice is answered at least 5% by the test takers (Muhson, 2017).

The category of validity index level according to Retnawati (2016) are presented in Table 1.

Table 1. Validity category

Interval	Validity Level
$x \geq 0.8$	High
$0.4 < x < 0.8$	Medium
$x \leq 0.4$	Low

Meanwhile, Ghozali (2013) said that if the reliability value is more than 0.6, then the reliability category is high. Then there are categories of levels of discrimination and level of difficulty of questions according to Muhson (2017) are presented in Table 2 and Table 3.

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Table 2. Differentiating power category

Interval	Category
$x > 0.3$	Good
$0.2 < x \leq 0.3$	Pretty good
$x < 0.2$	Not good

Table 3. Category difficulty level

Interval	Category
$x > 0.7$	Easy
$0.3 < x \leq 0.7$	Medium
$x < 0.3$	Difficulty

As for the value interval on students' mathematical communication abilities according to Fatkhiyyah et al. (2019) are presented in Table 4.

Table 4. Category of mathematical communication skill

Interval	Kategori
$x > 50$	Very good
$33{,}4 < x \leq 50$	Good
$16{,}7 < x \leq 33{,}3$	Pretty good
$x \leq 16{,}6$	Not good

Data collection techniques in this research used: 1. Documentation, involving collecting data from documents or written notes related to the research. 2. Walkthrough, involving direct observation or detailed examination of a particular system, process or environment. 3. Tests, involving direct measurement or assessment of certain abilities or characteristics. 4. Interviews, involving direct interaction between researchers and research subjects.

This study's data analysis methods included descriptive analysis. Data analysis was done using a descriptive approach after validation by revising the prototype based on suggestions and comments from expert reviews, one-to-one, and small groups, and to produce results of validation, reliability, level of difficulty, differentiating power, and distractors.

After collecting data from expert reviews, one-to-one, and small groups, descriptive analysis was used to detail the findings and suggestions provided by the experts. This includes an understanding of the extent to which the prototype financial mathematics HOTS questions have been successful and which problems require improvement. Next, evaluating the validation results and reliability of the questions, apart from that, the level of difficulty, distinguishing power, and effectiveness of distractors in the questions are also analyzed. Until the final stage of identifying questions that require further improvement or revision on HOTS mathematics finance questions.

RESULT AND DISCUSSION

This research is divided into four stages: preliminary, self-evaluation, expert review, and one-to-one, small group. The stages of developing questions in this study:

1. Preliminary

At this stage several analyzes were carried out, namely curriculum analysis where in grade 11 SMK Negeri 2 Depok, the Merdeka curriculum was used. The scope of grade 11, especially mathematics, is in F phase. Furthermore, in determining the material, according to the core competencies and basic competencies, financial mathematics material which is in phase F in the independent curriculum was choosen by researcher. The researcher analyzed the needs of grade 11 students' mathematical communication tests, then the teacher revealed that there was a lack of training on mathematical communication-based questions so that the questions needed to be developed based on competency in the independent curriculum based on mathematical communication. Then, create a collabo-

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ration schedule with the school to carry out research.

Furthermore, in the design stage, the researcher made an initial prototype design by compiling a grid with an analysis of the syllabus and financial mathematics material in grade 11 semester 2, determining indicators, and creating 15 questions that support mathematical communication skills.

2. Self Evaluation

At this stage prototype 1 was obtained which was designed based on material and indicators totaling 15 items consisting of 12 multiple choice items and 3 descriptive items which were repaired independently in terms of material, construction, and language in order to determine mathematical communication skills.

3. Expert review and one to one

The results of the development in the form of a student communication skill test instrument that had been designed at this stage were validated by expert reviews in terms of content, construction, and language. Proof of the validity of the items was carried out using V-Aiken and obtained the validity of the items developed from 0.87 to 0.94. It was concluded that all instrument items had good content validity.

Furthermore, in the one-to-one stage, it was carried out on 3 research subjects based on the criteria of high, medium, and low ability. The comments from students as a whole on the problem are presented in Table 5.

Table 5. Student comments and suggestions at stage one to one

Comments and suggestions	Follow-up
Student A: questions can be understood	-
Student B: I understand the problem, but I'm confused about how to calculate it	The number has been revised in the question
Student C: the questions are less understandable and difficult	The difficulty level has been revised

Information: Student A: high ability; Student B: moderate ability; Student C: low ability.

Results expert review and one-to-one then revised so as to produce prototype 2 which is 15 items of financial mathematics to measure students' mathematical communication skills.

4. Small group

After producing prototype 2, prototype 2 was then tested on a small group with 12 students who had high, medium, and low abilities, as seen from the results of mid-semester assessment mathematics. The researcher observed one of the students' answers based on the research results in Figure 2.

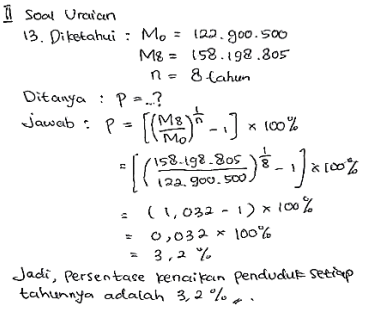
II Soal Uraian
13. Diketahui : $M_0 = 122.900.500$
$M_8 = 158.198.805$
$n = 8$ tahun
Ditanya : $P = ...?$
Jawab : $P = \left[\left(\frac{M_8}{M_0}\right)^{\frac{1}{n}} - 1\right] \times 100\%$
$= \left[\left(\frac{158.198.805}{122.900.500}\right)^{\frac{1}{8}} - 1\right] \times 100\%$
$= (1,032 - 1) \times 100\%$
$= 0,032 \times 100\%$
$= 3,2\ \%$
Jadi, persentase kenaikan penduduk setiap tahunnya adalah 3,2 %.

Figure 2. Student answers

Based on these answers, this research conducted interviews with students for the purpose of knowing the responses and student comments, as for the results of the interview excerpts are presented in Table 6.

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Table 6. Interview excerpts

Subject	Questions and Answers
Interviewer	What are your advantages of doing this problem? What do you think?
Student 1	The questions contain questions and problems that are easy to understand, the advantage I get is being able to foster creative thinking in modeling mathematical ideas
Student 2	The questions are easy to understand, and enable me to communicate the results of ideas in written form using a mathematical model
Student 3	By using everyday problems I can understand the problem in the problem, so I can express it in mathematical symbols

Based on the results of interview excerpts and observations from Table 6, a small group of students can work according to the instructions given. So that it can be concluded that the instructions for the questions are clear and most students can answer the questions correctly which indicates that students are able to understand the problem. This means that on prototype 2 there was no revision, so prototype 3 was produced. Furthermore, prototype 3 was tested on a large group (field test).

Field test carried out in 3 grades 11 at SMK Negeri in Yogyakarta with a total of 103 students. The test results are used to determine the potential effect on mathematical communication skills, reliability, discriminating power, level of difficulty, and distractors. The following are reliability, discriminating power, level of difficulty, distractors, and potential effects of questions on the mathematical communication skills of vocational students.

a. Distribution of students' mathematical communication skills

Based on Table 7 and the calculation of the test results, it was obtained that the average grade of students at SMK Negeri 2 Depok Class 11 was 73.13 with the criteria of very good mathematical communication ability.

Table 7. Value of Vocational High School Students' Mathematical Communication Skills

Score	Amount	Criteria
$x > 50$	70,87%	Very good
$33{,}4 < x \leq 50$	18,45%	Good
$16{,}7 < x \leq 33{,}3$	10,68%	Pretty good
$x \leq 16{,}6$	0	Not good

b. Reliability test

Reliability test results were obtained with the help of the IBM SPSS version 26 application with the results in Table 8.

Table 8. Reliability of multiple choice questions

Cronbach's Alpha	N of Items
.959	12

From Cronbach's Alpha (Table 8), the reliability value for multiple choice was obtained at 0.959. According to Ghozali (2013), items are said to be reliable if it is more than 0.6. It was found that the multiple-choice questions had a high level of reliability. Next, measuring the level of reliability in the description questions, the results in Table 9.

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Table 9. Reliability Test Results for description questions

Cronbach's Alpha	N of Items
.666	3

The items are reliable if the value of alpha is more than 0.6 (Ghozali, 2013). From Table 9, the Cronbach's Alpha value is 0.666, so it is said that the description questions are reliable. This means that, both multiple-choice questions and descriptions of the results are reliable.

c. Differentiating Power Category

For the differentiating power category, the results from AnBuSo version 8 are categorized based on Table 2. The results show that all questions are in the good category because greater than 0,2 for the coefficient. Table 10 presents an analysis of the differentiating power of the items.

Table 10. Differentiating power category

Item Number	Difference Power	
	Coefficient	Information
(1)	(2)	(3)
1	0,835	Good
2	0,841	Good
3	0,835	Good
4	0,896	Good
5	0,896	Good
6	0,888	Good
7	0,729	Good
8	0,881	Good
9	0,663	Good
10	0,623	Good
11	0,905	Good
12	0,885	Good
13	0,659	Good
14	0,557	Good
15	0,500	Good

From Table 10 it can be interpreted that all the questions can be used to differentiate students with good, medium and high abilities in mathematical communication skill.

d. Degree of difficulty

For the degree of difficulty category, the results from AnBuSo version 8 are categorized based on Table 3. The results of the analysis of the difficulty level in Table 11.

From Table 11, there are 10 questions at the medium difficulty level and 5 questions at the easy level. It can be said, for the 10 questions in the medium category, students who have low, medium or high abilities require analysis in working on them, but students do not find it difficult. In contrast to the 5 questions which are in the easy category, students do not need analysis to do them. Easy questions do not allow students to develop their thinking.

Table 11. Degree of difficulty

Item Number	Degree of difficulty	
	Coefficient	Information
(1)	(2)	(3)
1	0,680	Medium
2	0,689	Medium
3	0,670	Medium
4	0,699	Medium
5	0,699	Medium
6	0,748	Easy
7	0,670	Medium
8	0,699	Medium
9	0,641	Medium
10	0,650	Medium
11	0,767	Easy
12	0,777	Easy
13	0,879	Easy
14	0,749	Easy
15	0,685	Medium

e. Distractors

Based on the results of the analysis using AnBuso version 8 which refers to Muhson's (2017) theory it is known that the distractor results are in the good category for all multiple-choice questions.

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Overall based on the results of the study, it was found that 15 items tested students' communication skills as valid and reliable. The development of the test questions uses the type development model formative research from Tessmer (1993).

This research goes through stages of preliminary and level formative evaluation. At the level of preliminary through the curriculum analysis stage, determining the material, and analyzing teacher needs as well as developing procedures for carrying out research in schools. Furthermore, designing research instruments.

At the level of formative evaluation, through levels of self-evaluation, expert review, and one-to-one, small group. Self-evaluation is held to evaluate instruments that have been designed (prototype 1) independently regarding material, construction, and language. Then Prototype 1 is validated by experts review and tested on one-to-one groups to obtain student comments and suggestions. Validation results from expert review in this study obtained validity with a coefficient value of 0.87-0.94 based on the V-Aiken index. It was concluded that all of the instrument items had good content validity. Then the results of comments and suggestions experts review and students then revised and produced prototype 2. Then prototype 2 was tested in small groups, and comments and suggestions were used as a follow-up on prototype 3. So that the research instrument had passed the feasibility stage and produced prototype 3 to be tested on field tests.

The field test was held by trying out 15 financial math questions to 103 grade 11 students at SMK Negeri 2 Depok. The results obtained are questions of being able to integrate students' mathematical communication skills. After carrying out the tests, further tests were carried out for reliability, discriminating power, level of difficulty, and distractors.

In this study, the reliability test used Cronbach's Alpha. Reliability results for multiple choice questions get a coefficient value of 0.959 and for description questions get a reliability coefficient of 0.666 meaning that both multiple choice questions and descriptions can be said to be reliable (Ghozali, 2013).

The results of subsequent research, namely the discriminating power of the questions used, in this study the results of the analysis using AnBuSo assistance found that the discriminating power values for all questions, both multiple choice and description, got a coefficient of more than 0.3 so that all questions have discriminating power with the category Good. As for the level of difficulty in this study, the results were obtained that there were 3 questions with a coefficient value of more than 0.7 based on Table 3 for multiple choice questions and 2 description questions with a coefficient of more than 0.7 meaning that there were 5 questions in the easy category. Then there are 9 multiple choice questions and 1 description question with a coefficient value between 0.3 to 0.7 so that the question is in the medium category. Overall there are 67% of questions in the medium category and 33% in the easy category. Furthermore, the distractors for the 12 multiple choice questions functioned well, because all alternative distractors were selected by students so this was in line with Muhson (2017) who said that if the criteria for distracting good item alternatives were that these choices were answered by at least 5% of the test takers.

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The learning completeness obtained based on test results, namely 52% of students completed in learning with scores above 78, and 48% of other students have not completed which scores below 78. In the distribution of mathematical communication skills, the average test result is 73.13 in the very good category that valid questions can trigger good mathematical communication results. Based on the developments that have been carried out in the research, 15 financial mathematics questions were obtained that were valid, practical and reliable, on the other hand, also had good potential effects on students' mathematical communication skills. The results of this study are in line with research conducted by Nopiyani et al. (2018) where this study produced 15 valid, reliable, and practical math questions that support students' mathematical communication skills. This is also in line with Yuliani et al. (2022) who states that an instrument is said to be appropriate if it meets the criteria of being valid, and practical, namely being valid, indicating that the instrument accurately measures students' mathematical communication abilities.

The findings of this research are, based on students' answers at the field-test stage, it was found that the financial mathematics questions developed had a potential effect, namely bringing out students' mathematical communication skills in accordance with indicators of mathematical communication skills which include communication skills consisting of students being able to state a situation. or images into mathematical ideas or language, students can interpret and evaluate mathematical ideas both in writing and in other visual forms, students can explain problem solving and conclude them in mathematical language or symbols. The impact of this research is that financial mathematics HOTS questions are produced which can be used by teachers as student practice. Apart from that, students' mathematical communication skills can be seen when working on HOTS questions on financial mathematics material, so that teachers can explore these abilities so that they can be improved. The limitations of this research are that the research subjects for the trial instrument are still limited to one school, so the diversity of research results is still lacking.

CONCLUSION AND SUGGESTION

HOTS questions on financial mathematics to support mathematical communication meet valid, reliable, and practical (readable) criteria. Validity is obtained from the results of the assessment expert review. The development of the resulting test item instrument is feasible to use because it has a potential effect on students' mathematical communication skills. The development of questions for grade 11 students' mathematical communication skills is still limited to financial mathematics material. For further research, it is hoped that there will be follow-up in compiling questions for mathematical communication skills in other materials, but they should also pay attention to students' prerequisite abilities related to mathematical communication skills and analyze the curriculum to get a clear picture of the expected demands so that learning objectives are achieved.

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