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DEVELOPMENT OF MATHEMATICS LITERACY QUESTIONS ON TRIGONOMETRY

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Abstract

The 2022 Education Report reveals that high school-equivalent students scored 50.74% in numeracy literacy, below the minimum competency. Emphasizing mathematical literacy is crucial, yet such problems are scarce in classrooms. The research aims to develop mathematical literacy questions. The trigonometry material was chosen for the reason that this material should enable literacy activities related to material concepts. Following the ADDIE (Analysis, Design, Implementation, and Evaluation) model, the study employs expert validation and student responses as instruments, involving 20 students in small and large-scale test phases. It yields four trigonometry essay questions for high school. The research results show that the Mathematical Literacy test developed has quite valid categories in terms of content, construct and language. The questions are declared reliable. All types of questions are difficult. Discrimination index of questions, 1 question in the average category, and 3 questions in the low category. The developed questions are in the difficult category because at the mathematical literacy level, the abilities that are developed are not at the level of low-level thinking. This research supports efforts to increase student competency in mathematical literacy at the high school level.

Keywords: High school, Mathematical literacy, Trigonometry.

Abstrak

Hasil raport Pendidikan tahun 2022 kemampuan literasi numerasi atau literasi matematika siswa jenjang SMA sederajat menunjukkan hasil 50,74% dibawah kompetensi minimum. Penting untuk membiasakan siswa dalam mengerjakan soal yang berbasis literasi matematika. Sayangnya soal serupa belum banyak ditemukan pada saat pembelajaran di kelas. Penelitian bertujuan mengembangkan soal literasi matematika. Materi trigonometri dipilih dengan alasan, pada materi ini harusnya bisa dibuat kegiatan literasi yang berhubungan dengan konsep materi. Jenis Penelitian pengembangan dengan model pengembangan ADDIE (Analisis, Desain, Implementasi, dan Evaluasi). Instrumen yang digunakan adalah angket validasi ahli dan respon siswa. Subjek dalam penelitian berjumlah 20 siswa, terdiri atas 5 siswa tahap uji skala kecil dan 15 siswa uji skala besar. Hasil penelitian berupa empat buah soal literasi matematika materi trigonometri jenjang SMA dengan jenis soal esai. Hasil penelitian menunjukkan tes Literasi Matematis yang dikembangkan memiliki kategori cukup valid baik dari konten, konstruk maupun bahasa. Soal dinyatakan reliabel. Jenis soal sukar semua. Daya pembeda soal, 1 soal kategori rata-rata, dan 3 soal kategori rendah. Soal yang dikembangkan pada kategori sukar karena memang pada jenjang literasi matematika, kemampuan yang dikebangkan bukan pada level berpikir tingkat rendah. Penelitian ini mendukung upaya peningkatan kompetensi siswa dalam literasi matematika pada jenjang SMA.

Kata kunci: *Literasi matematis, SMA, Trigonometri*.

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INTRODUCTION

The concept of mathematical literacy has recently become the subject of much research in the field of education. Mathematical literacy is also an important basic ability and is included in the basic competencies of the 21st century by the Ministry of Education and Culture. This competency began to emerge in Indonesia since Indonesia became a participant in the PISA survey conducted by the OECD Institute. In general, mathematical literacy is defined as the same as numeracy literacy, which is an ability that students must have to solve problems in their lives.

Mathematical literacy has the characteristic that students have mathematical literacy abilities if they can solve problems in everyday life that are related to mathematics (Khotimah, 2021). Numeracy is the ability to think using concepts, procedures, facts and mathematical tools to solve everyday problems in various types of contexts that are relevant for individuals as Indonesian citizens and global citizens (Kemdikbud, 2021). Mathematical literacy ability is a child's ability to formulate, use and interpret mathematics in various contexts (Kuswindi, 2017). Mathematical reasoning abilities such as using concepts, procedures, facts to describe, explain and predict events are also included in metametric literacy abilities. Furthermore, the Numeracy Literacy Module issued by the Ministry of Education and Culture and Research and Technology states that the scope of numeracy literacy is very broad, not only in mathematics lessons, but also related to other literacies, for example culture or citizenship. The components of numeracy literacy within the scope of Mathematics, namely: numbers, operations and calculations, geometry and measurement, data processing, statistical interpretation, spatial reasoning, and patterns (Kemdikbud, 2021).

The importance of mathematical literacy skills is revealed in various research results. In mathematical literacy skills, students are not only able to do procedural calculations, but logical and critical thinking skills are needed for problem solving. This ability is important so efforts must be made, especially in learning, to develop mathematical literacy skills (Lindawati, 2018). Next, it is stated that contextualization in mathematical literacy skills is important. This is what connects the mathematics learned in class with real situations (Masjaya & Wardono, 2018). A child with good mathematical literacy skills will be sensitive to relevant mathematical concepts in existing phenomena. This enables them to apply mathematical concepts in problem-solving (Sari, 2015).

The importance of mathematical literacy skills must be balanced with efforts to develop them. The results of the high school/equivalent education report card for 2022 state that less than 50% of students have achieved the minimum competency for numeracy. Even though most students have achieved minimum competency in literacy, efforts are still needed to improve it (Pusmendik, 2022). Indonesia's latest PISA results released in 2023 show that Indonesia's ranking in mathematical literacy has increased by 5 positions compared to PISA 2018. However, in terms of scores, Indonesia has experienced a decrease of 13 points. This decline is still better than the average decline in international scores, namely 21 points (OECD, 2023). The results of observations at one high school in Pangkalpinang City show that some of the mathematics questions presented in learning do not support efforts to develop mathematical literacy. This must change. Remembering that mathematical literacy skills are important. Without ignoring the research results which state that high school/equivalent level students still experience difficulties in understanding mathematical problems (Silaban, Simbolon, & Lumbantoruan, 2022).

Several things can be done to develop students' literacy abilities. Students can gain experience for mathematical literacy skills through various learning methods (Sari, 2015). It was further stated that there are many learning methods and approaches that can be presented so that students experience mathematical literacy, one of which is a realistic approach to mathematics (Wardono & Budiono, 2014). Teachers can be motivated to change the content of the material presented in class (Lindawati, 2018). The material content in it also contains the questions presented. Changing the content of this material can be interpreted as developing mathematical literacy skills by getting students used to doing or working on mathematical literacy-based problems.

Several conditions in the field indicate that mathematical literacy skills have not been trained optimally. Husna's observations in 2014 showed that there were several sources of obstacles faced by teachers in assessing mathematical literacy, namely: first, teachers' lack of knowledge about mathematical literacy competencies; secondly, there is no format for assessing mathematical literacy, and schools rarely include students in mathematical literacy competition activities so that learning in class does not facilitate mathematical literacy material and questions (Pulungan, 2014). This format for mathematical literacy assessment is derived from questions that can be presented to students in the classroom.

Regarding difficult subject matter at high school level. Several research results state that one of the material contents that many students still find difficult is trigonometry. Initial observation results at a high school in Aceh in 2017 stated that many students had difficulty learning mathematics, especially regarding trigonometry. Students experience difficulties in applying formulas in solving Trigonometry problems, students only reach the stage of memorizing the formulas (Fajri & Nida, 2019; Fajri & Nida, 2019). It was further stated that the difficulties experienced by students in learning trigonometry were related to the abstract nature of the material (Mensah, 2017). However, it is important for students to understand the concept of trigonometry, according to Steckroth, when students have difficulty understanding the concept of trigonometry, it will have an impact on the subsequent interpretation of mathematical concepts (Tutak, 2017).

This research aims to produce mathematical literacy questions on trigonometry material for high school level. The results of the research above state the importance of developing mathematical literacy questions to help teachers develop mathematical literacy skills during learning. Because of that, this research was focused on developing that. Considering that trigonometry is one of the basic materials in high school, this material was chosen as the content that will be developed in the questions.

RESEARCH METHODS

This is development research (Research and Development/R&D). The development model used is the Tessmer formative evaluation type. This model was chosen because it develops learning tools. The research stages consist of the main stages, namely the preliminary study stage and the formative evaluation stage. The preliminary study stage consists of three stages, namely preparation, analysis, and design, while the formative evaluation stage includes self evaluation, prototyping (expert review, one-to-one, and small group), and field tests. Below is an illustration of the research design flow shown in Figure 1.

The preliminary study stage consists of three stages, namely preparation by searching for sources related to high school level mathematics questions and literature related to mathematical literacy, the analysis stage is carried out by making a needs table in the form of initial observation results which state the lack of mathematical literacy questions and students' difficulties in trigonometry material, stage An analysis of the indicators of

mathematical literacy that will be used in the research is also carried out. Next, trigonometry questions for high school level are designed in accordance with the mathematical literacy indicators that have been determined in the previous stage. The formative evaluation stage includes self-evaluation, prototyping (expert review, one-to-one, and small group), and field tests. Self-evaluation is carried out by analyzing the results of the questions given. Next, the prototype stage is validated by mathematics material experts and small-scale trials. Then it is analyzed and revised based on suggestions and finally the large-scale trial stage. The data collection techniques used by researchers are observation and questionnaires. The instruments used were expert validation questionnaires, student response questionnaires, and observation sheets. The test subjects in this research were class XI students at SMAS Setia Budi Sungailiat consisting of 5 students in the small-scale test and 15 students in the large-scale test.

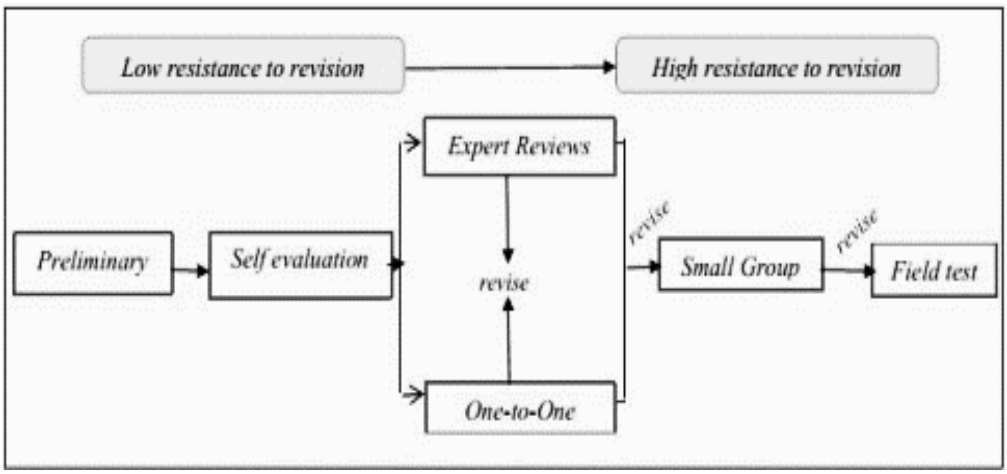

Figure 1. Research Flow

The analysis technique used in this research is a qualitative analysis technique which includes analysis of expert validation results and student suggestions. Analysis of expert validation results using percentages derived from the comparison between the number of expert assessments and the total score of the ideal. As well as quantitative data analysis including the results of student questionnaires and the results of test questions which were analyzed for validation, reliability, difficulty index (*DIF*), and discrimination index (*DI*). Validation test uses the Pearson correlation formula. The evaluation criteria are presented in Table 1.

Table 1. Evaluation Criteria

Score	Criteria	Score	Criteria
Validity		Difficulty index	
0.00 – 0.199	Very low	$DIF < 0.3$	Difficult
0.20 – 0.399	Low	$0.3 \leq DIF \leq 0.7$	Medium
0.40 – 0.599	Medium	$DIF > 0.7$	Easy
0.60 – 0.799	Good	Discrimination index	
0.80 – 1.000	Very good	$0.60 < DI \leq 0.80$	Very high
Reliability		$0.40 < DI \leq 0.60$	High
$0.80 < r_{11} \leq 1.00$	Very good	$0.20 < DI \leq 0.40$	Average
$0.60 < r_{11} \leq 0.80$	Good	$0.00 < DI \leq 0.20$	Low
$0.40 < r_{11} \leq 0.60$	Medium	$DI \leq 0.00$	Very Low
$0.20 < r_{11} \leq 0.40$	Low		
$-1.00 < r_{11} \leq 0.20$	Very Low		

RESULT AND DISCUSSION

The results of this research include several stages, namely: The preliminary study stage carried out in this research includes analysis of the needs for developing Numeracy Literacy test instruments, namely creating requirements in a table. In general, it was concluded that there were findings indicating that teachers had assessed cognitive, affective and psychomotor aspects but had not assessed mathematical thinking abilities, for example numeracy literacy. Researchers collected several references related to the development of test instruments with the characteristics of students' mathematical thinking abilities, namely in the form of theses, journals, articles, worksheets and books. This analysis produces indicators of mathematical literacy. The mathematical literacy questions developed consist of 4 questions, where each question refers to an indicator of mathematical literacy ability as presented in Table 4.

The next stage is self-evaluation, at this stage the questions are developed from the indicators that have been produced. Next, the prototype stage is tested by experts, small-scale tests and large-scale tests. Testing the validity of mathematical literacy questions on trigonometry material with material experts testing the design of this instrument in the form of a test instrument grid, question items, answer sheet, answer key and assessment rubric. The design of this question is designed by presenting the presentation of the problem in each question to stimulate students to think mathematically where real life will be the tone in the question. The following is an example of an item designed for mathematical literacy skills. The results of validation by expert judgment in the field of mathematics education are as follows.

Table 2. Expert Calculation Validation Results

Questions	Validity	Criteria
1	89%	Valid
2	90%	Valid
3	65%	Valid
4	59%	Valid

Table 2 shows that overall the Mathematical Literacy test instrument that the researchers developed can be categorized as valid. However, based on expert advice, several parts must be revised to be tested to the next stage. The revision includes literacy on every question that has not been read. For example, in question number 1. There is no literacy context story. Should be added. After revising according to expert advice, proceed to the Instrument Trial Phase. This stage is the field test stage, namely field trials on 5 students on a small scale and 15 students on a large scale.

Small scale results show 89% of students understand the questions. However, there is a suggestion that the illustrations in the questions are too long. So it takes time to read. At that time, a revision of the small scale results had been carried out by reducing the question illustrations.

The results of large-scale trials are as follows. A total of 4 questions are of good quality and all are valid. Meanwhile, the question reliability test shows that the questions are reliable. Differentiating power shows that question number 1 is in the high category, questions no. 2, 3 and 4 are in the low category. For the difficulty index, all questions show the difficult category. Table 3 is recapping the results of large-scale trials.

Table 3. Release of large scale test results

Evaluation criteria	Question number			
	1	2	3	4
Validity	0.8 (very good)	0.6 (good)	0.8 (very good)	0.6 (good)
Reliability	0.6 (medium)			
DIF	0.3 (medium)	0.1 (difficult)	0.07 (difficult)	0.06 (difficult)
DI	0.3 (average)	0.2 (low)	0.2 (low)	0.1 (low)

Based on Table 3, all the questions developed are in the valid category. This means that in theory and in field tests the questions are declared correct. This means that the questions created actually measure what should be measured, namely the mathematical literacy ability of high school level trigonometry material. Then for the reliability of the questions made in the medium category.

Table 4. Mathematical literacy ability test on trigonometry material

Indicators	Questions
1. Students can use trigonometry knowledge to solve problems and solve contextual problems	In Bangka Belitung there is a special guava called Jambu Bandar. Behind Ali's house there is Bandar Guava which is ready to be picked from the tree. Ali will pick using a ladder. Guava fruit tree 4 m high. Place a ladder at an angle of 30° to the ground. Make a sketch of the problem, make an example from the sketch (x, y, z) according to the data known from the problem, then calculate the length of the ladder, and determine the conclusion!
2. Students can interpret problems using mathematics in accordance with trigonometry formulas	The cottage in Andi Bocor's Lada garden. So he had to climb the roof to repair it. With the help of a ladder Andi climbed. The ladder is propped against the wall (not upright). The ladder is 6 m long and leans against the wall forming an angle of 72° with the ground. If the ladder climber's feet push the ladder to form an angle of 53° with the ground, if we know sin 72° = 0.254; sin 53° = 0.396. Make an example of this problem using an example that adapts to the conditions in the problem, then calculate the displacement of the ladder on the ground!
3. Students can work effectively by interpreting and can choose different solutions and then relate a problem to everyday life	The Pangkalpinang Jami' Mosque has a tower. Joko stood in front of a Jami' Mosque minaret, the distance from the bottom of the tower to Joko's feet was 80 meters. Joko looked up so that an elevation angle of 30 degrees was formed. The distance between Joko's eyes and the ground is 160 cm. a. Draw a sketch that represents the problem. If there is a banner on the tower to commemorate Indonesia's independence day from the tip of the tower to the ground, the cost is assumed to be IDR 40,000 for a banner with a height of 1 meter. b. Determine the costs required to make the banner that will be installed on the tower?
4. Students can evaluate well in solving problems and are able to choose strategies in solving problems on questions	SMA A in Pangkalpinang City took a tour to Muntok City, this tour they will visit the Tanjung Kalian lighthouse. There the students will measure the height of the lighthouse tower without having to measure from the top of the tower, how do they do it? If they stand next to the tower 98m away, at an angle of 45°. So the height of the tower that they saw from the position they were standing was 98m. Is it true that the tower is 98m high? true / false Choose the right or wrong answer to the question.

This means that this question can be used by other subjects with similar characteristics. The difficulty index for all questions is included in the difficult category. Good questions should be at easy, medium and difficult levels. All of these questions are in the difficult category because for mathematical literacy skills the level is not easy. The discrimination index of a question in the high category means that the question is able to differentiate between students who answer correctly because they understand and students who don't understand. Furthermore, three low category questions mean that questions number 2, 3 and 4 are indeed low in distinguishing between students who answered correctly and incorrectly.

Table 4 is the results of the questions that have been developed and tested. This question has basic competency, namely explaining trigonometric ratios (sine, cosine, tangent, cosecant, secant and cotangent) in right triangles.

Mathematical literacy is an important part of developing mathematical abilities. The results of this research support previous research which states that most students find it difficult to solve questions with mathematical literacy indicators because in learning students are not accustomed to working on questions with PISA characteristics, which in this case are related to mathematical literacy (Selan, Daniel, & Babys, 2020).

The position of this research is an effort to test mathematical literacy skills through questions. This effort is considered important considering that in other research, high-level thinking abilities can be improved through questions developed based on high-level ability indicators (Kurniasi & Arsisari, 2020).

CONCLUSION

The conclusions in this research show that the results of the question criteria by expert validators show that the questions are valid with improvements. Based on field trials, it shows that all the questions are valid and reliable. The level of difficulty of the questions is difficult for all questions, average discrimination index for question number one, low for questions number 2, 3 and 4. The questions developed are based on indicators of mathematical literacy regarding trigonometry, a total of four questions. The questions are created to stimulate the mathematical literacy thinking process at high school level. It is hoped that it can add teacher references regarding mathematical literacy questions in trigonometry material. Small scale results show 89% percent of students understand the

questions. However, there is a suggestion that the illustrations in the questions are too long, so it takes time to read. At the time, a revision of the small scale results had been carried out by reducing the question illustrations.

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