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DEVELOPMENT OF MATHEMATICAL LITERACY SKILL INSTRUMENTS ON CIRCLE MATERIAL FOR JUNIOR HIGH SCHOOL STUDENTS

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ABSTRACT

The importance of mathematical literacy skills is often not matched by the availability of supportive questions that aid in improving these abilities. Therefore, this study aims to develop valid and practical mathematical literacy questions specifically on the topic of circles, suitable for eighth-grade junior high school students. Employing the ADDIE model of research and development (R&D), which includes analysis, design, development, implementation, and evaluation, the research involved 32 eighth-grade students as subjects. Instruments utilized included expert validation sheets, student response questionnaires, and a mathematical literacy test. Data analysis techniques encompassed both quantitative and qualitative analyses. Results from expert validation and student response questionnaires indicated that the developed instruments are both valid and practical. Expert validation tests achieved an 86% success rate overall, with 88% validity for material aspects, 88% for construction aspects, and 83% for language aspects. Validity testing, reliability testing, and item discrimination analysis confirmed the questions' validity, reliability, and appropriateness. The student response questionnaire yielded an 87% success rate, indicating high practicality for educational use. These findings demonstrate the effectiveness and applicability of the developed mathematical literacy questions in enhancing students' mathematical literacy skills and suggest their suitability for integration into the teaching process.

Pentingnya kemampuan literasi matematis tidak diimbangi dengan ketersediaan soal-soal yang menunjang peningkatan kemampuan tersebut. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan soal-soal kemampuan literasi matematis pada materi lingkaran yang valid dan praktis, sehingga dapat diterapkan dalam proses pembelajaran siswa kelas VIII SMP. Penelitian ini menggunakan model penelitian dan pengembangan (R&D) ADDIE, yang terdiri dari tahap analisis, desain, pengembangan, implementasi, dan evaluasi. Subjek penelitian ini terdiri dari 32 siswa kelas VIII. Instrumen yang digunakan meliputi lembar validasi ahli, angket respon siswa, dan instrumen tes kemampuan literasi matematis. Teknik analisis data yang digunakan adalah analisis kuantitatif dan kualitatif. Berdasarkan hasil pengujian validasi ahli dan angket respon siswa, instrumen yang dikembangkan terbukti valid dan praktis. Pengujian validasi ahli menunjukkan tingkat keberhasilan sebesar 86%, yang berarti sangat valid, dengan 88% untuk ranah materi, 88% untuk ranah konstruksi, dan 83% untuk ranah bahasa. Hasil uji validitas, uji reliabilitas, dan daya pembeda menunjukkan bahwa soal-soal tersebut valid, dapat diandalkan, dan

dapat diterima. Angket respon siswa menunjukkan tingkat keberhasilan sebesar 87%, yang berarti instrumen ini sangat praktis untuk digunakan. Temuan ini menunjukkan bahwa soal-soal yang dikembangkan efektif dan aplikatif dalam meningkatkan kemampuan literasi matematis siswa, serta cocok untuk diintegrasikan ke dalam proses pembelajaran.

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1. INTRODUCTION

Literacy is a competency that is currently popular and considered important in supporting the learning process in educational units (Rachmaningtyas et al., 2022; Nurmasari et al., 2023; Salsabila et al., 2023). In the context of mathematics education, the most influential form of literacy is mathematical literacy (Fitni et al., 2023; Setyaningsih & Azizah, 2023; Goos & O'Sullivan, 2023). Mathematical literacy is the ability to formulate, use, and interpret mathematics in solving real-world problems. This literacy helps students make decisions based on concepts, procedures, facts, and predictions of events (OECD, 2023). Mathematical literacy not only includes basic mathematical understanding and the use of various methods but also involves applying mathematical processes in various contexts to provide general ideas or insights (Prabawati et al., 2019). According to Abidin et al. (2018), mathematical literacy supports the five mathematical capabilities outlined by NCTM (2000), namely problem-solving, reasoning, communication, connections, and representation.

Mathematical literacy is crucial as it helps students understand the role and application of mathematics in everyday life (Muzaki & Masjudin, 2019; Maslihah et al., 2020; Safitri & Khotimah, 2023). This literacy is also essential in the 21st century as an alternative to addressing the problems and challenges of modern development (Anwar, 2018). Additionally, this capability helps students realize that mathematics is vital for all aspects of life, including making rational, participatory, and introspective decisions (Pernandes & Asmara, 2020). Therefore, mathematics education in educational units should be designed not only to enable students to perform calculations but also to facilitate their mathematical literacy skills. However, the importance of mathematical literacy is not yet reflected in practice. Training in mathematical literacy is still suboptimal, the questions designed to measure students' literacy skills are insufficient, teachers' understanding of mathematical literacy competencies is limited, and the format for assessing mathematical literacy has not been developed (Fatwa et al., 2019). These factors contribute to the low mathematical literacy skills of middle school students in Indonesia (Muzaki & Masjudin, 2019; Pratama Mahiuddin et al., 2019; Masfufah & Afriansyah, 2021).

One of the topics related to mathematical literacy skills at the middle school level is circles. The topic of circles is closely related to other topics, such as the surface area of cylinders, the surface area of cones, the volume of cylinders, the volume of cones, and the surface area of spheres, all of which use the formula for the area of a circle. Nevertheless, in the topic of circles, there are still some students with moderate numeracy skills who

have not yet achieved the indicators of mathematical literacy, such as reasoning and providing explanations. Students with low numeracy skills have also not achieved the indicators of mathematical literacy in using symbols and calculations as well as reasoning and providing explanations (Nuringtyas & Setyaningsih, 2023).

Several previous studies support the need for this research. Observations by Tabun et al. (2020) showed that the questions given to students are still routine and less related to real life, thus failing to develop students' mathematical literacy skills. Masfufah & Afriansyah (2021) concluded that mathematical literacy skills are relatively low and suggested the creation of more varied questions. Asmara & Sari (2021) developed social arithmetic questions based on mathematical literacy and recommended further research on other topics. Wibowo et al. (2020) developed an instrument to test mathematical literacy skills on the topic of cubes.

Based on the findings of previous research, this study aims to develop an instrument to assess mathematical literacy skills on the topic of circles for middle school students.

2. METHODS

This research employs the Research and Development (R&D) method using the ADDIE design, which includes five stages: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation (Rayanto, 2020). In the analysis stage, problems occurring in middle schools are identified, and solutions that can be applied to address these issues are found. The design stage involves creating a blueprint for a mathematical literacy ability test instrument, which includes learning objectives, indicators of mathematical literacy ability, question indicators, question forms, question numbers, and question narratives. Additionally, in this stage, non-test instruments such as expert validation sheets and student response questionnaires are designed, covering material, construction, and language aspects. The development stage involves developing the mathematical literacy ability test instruments designed in the previous stage, followed by expert validation of the created instruments. Expert validation is carried out by three validators who are middle school mathematics teachers. The implementation stage involves applying the validated test instruments to students according to their educational level, followed by distributing student response questionnaires regarding the completed test instruments. The evaluation stage consists of evaluating the test instruments based on student response questionnaires to ensure that the instruments are effective and aligned with the research objectives.

2.1. Research Subject

The subjects of this study consisted of 32 eighth-grade students at a public school in Serang Regency. This study aims to develop an instrument suitable for measuring the mathematical literacy skills of junior high school students on the topic of circles.

2.2. Data Collection

This research involves two types of instruments: non-test instruments (questionnaires) and mathematical literacy ability test instruments. The indicators of mathematical literacy ability used in this study refer to the definition from OECD (2023), which consists of three main aspects: (1) Formulate, which involves formulating problems mathematically, (2) Employ, which involves applying mathematical concepts, and (3) Interpret, which involves interpreting the results of mathematical solutions in solving real-world problems. The procedure for developing the mathematical literacy ability test

instrument is systematically illustrated in the following flowchart.

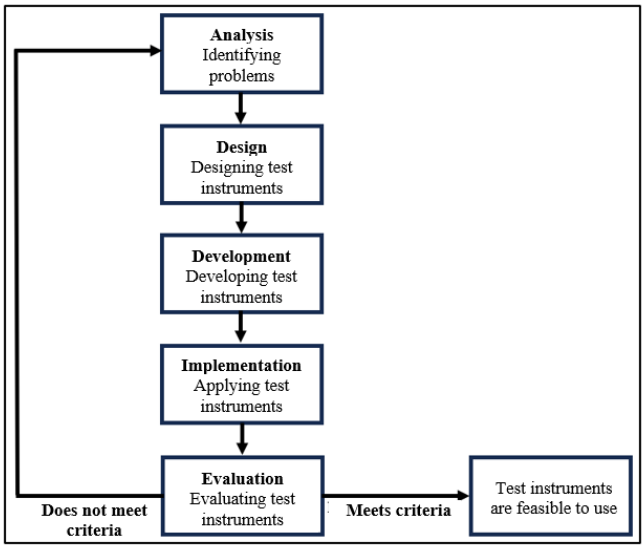

Figure 1. The procedure for developing assessment instruments

2.3. Data Analysis

This study involves two data analysis techniques: qualitative data analysis derived from comments and suggestions of validators, and quantitative data analysis obtained from validation calculations of the mathematical literacy instrument. Expert validation employs a Likert scale encompassing content, construction, and language domains, administered to three validators who are mathematics teachers at junior high schools. Subsequently, this paper presents the categories of expert validation regarding the mathematical literacy instrument.

Table 1. Expert Validity Categories

Percentage Score (%)	Validity Category
$P \leq 21$	Very invalid
$21 < P \leq 40$	Invalid
$41 < P \leq 60$	Sufficiently valid
$61 < P \leq 80$	Valid
$81 < P \leq 100$	Very valid

(Rizqiyani et al., 2022)

The Likert-scale student response questionnaire encompasses domains of content, construction, and language, targeting students who have completed the mathematical literacy assessment instrument. The following presents criteria for the practicality of the mathematical literacy assessment instrument based on student response surveys.

Table 2. Criteria of Student Response Questionnaire

Practicability Criteria (%)	Level of Practicability
$P > 80$	Very practical
$60 < P \leq 80$	Practical
$40 < P \leq 60$	Fairly practical
$20 < P \leq 40$	Less practical
$P \leq 20$	Very less practical

(Hilaliyah et al., 2019)

3. RESULTS AND DISCUSSION

3.1. Results

1). Analysis

In the analysis phase, the researcher undertakes a systematic series of steps. First, interviews are conducted with mathematics teachers to identify issues related to mathematics learning processes and potential solutions. Subsequently, interviews are conducted with students to understand their perspectives on mathematics topics that are commonly perceived as difficult. The next step involves an in-depth literature review on current issues in mathematics education, particularly at the middle school level. The researcher also gathers information from previous studies to find relevant solutions to the formulated problems. Finally, the researcher determines the research subjects to be studied. Overall, this analysis phase results in clear formulations of problems, possible solutions, and the chosen research subjects.

2). Design

In the design phase, the process begins with drafting the framework of instruments to measure mathematical literacy skills, followed by expert validation and student response collection through questionnaires. The framework for mathematical literacy instruments is detailed in the following table.

Table 3. Framework of Mathematical Literacy Skills Instruments

Learning Objectives	Mathematical Literacy Skills Indicators	Question Indicators	Question Format	Question Number
The students can explain how to determine the area and circumference of a circle and solve contextual problems related to them.	*Formulate* (formulating problems systematically)	Determining the length of the fence surrounding a circular garden given its diameter.	Description	1a
	Employ (applying mathematical concepts)	Determining the number of teak trees that can be planted around the fence with each tree spaced 9 meters apart.		1b
	Interpret (interpreting mathematical solution outcomes)	Providing reasons regarding the solution to problem 1b.		1c
	Formulate (formulating problems systematically)	Determining the diameter of a circular swimming pool if its surface area is known.	Description	2a
	Employ (applying mathematical concepts)	Determining the area of a square surrounding the pool if the side length of the square equals the diameter of the circle.		2b
	Interpret (interpreting mathematical solution outcomes)	Determining the area outside the pool but still within the square.		2c

3). Development

The development stage is the third stage of this research aimed at preparing questions for implementation. In this stage, the validation results are analyzed and presented in the form of structured comments and suggestions in a table.

Table 4. Comments/Suggestions from Validator

No. Question	Validator	Domain	Comments/Suggestions
1a	Validator 1	Construction	The image used lacks a clear source.
	Validator 2	Language	Add conjunctions to make it easier for students to understand.
	Validator 3	Language	There are still errors in spelling.
1b	Validator 1	Valid items	None.
	Validator 2	Valid items	None.
	Validator 3	Content	Add the name of the tree.
1c	Validator 1	Language	Clarify the question sentence to make it easier for students to understand.
	Validator 2	Valid items	None.
	Validator 3	Valid items	None.
2a	Validator 1	Construction	The image used lacks a clear source.
	Validator 2	Language	Improve the sentence structure in the question.
	Validator 3	Valid items	None.
2b	Validator 1	Content	Provide a stimulus stating that the length of the square's side is equal to the diameter of the circle.
	Validator 2	Construction	Use thicker lines for the pool and square in the picture.
	Validator 3	Language	Pay attention to the use of periods and commas.
2c	Validator 1	Construction	Shade the area in the picture that is being asked about.
	Validator 2	Language	Improve the sentence structure in the question.
	Validator 3	Valid items	None.

At this stage, a validity test is conducted by three validators who are mathematics teachers in junior high schools. This validation covers the domains of content, question construction, and language usage. The results of the expert validation are presented in the following table.

Table 5. Expert Validation Results

Domain	Score Persentage (%)			Average	Cateory
	V1	V2	V3		
Content	85	90	90	88	Very Valid
Construction	81	88	94	88	Very Valid
Language	81	81	88	83	Very Valid
Average	82	86	91	86	Very Valid

4). Implementation

The fourth stage of this research involves implementation, conducting a field test of the test instrument with 32 eighth-grade students from a public school in Kabupaten Serang. The test instrument trial is conducted to assess the validity of each test item. Subsequently, a student response questionnaire is administered to assess the practicality of the instrument's mathematical literacy abilities, covering content domain, construction, and language aspects.

5). Evaluation

The evaluation phase is the final stage involving the collection of data from instruments assessing students' mathematical literacy skills. The gathered data is then processed using statistical analysis (ANATES) to produce interpretable results

Table 6. Level of Difficulty, Discrimination Power, and Reliability

Item No.	Difficulty Level	Difficulty Level Criteria	Discrimination Index	Discrimination Index Criteria	Validity Test	Validity Test Criteria	Reliability Test
1a	77,78	Easy	0,31	Accepted	0,782	Very Valid	0,79
1b	64,44	Moderate	0,42	Good	0,686	Valid	
1c	40,00	Moderate	0,35	Accepted	0,664	Valid	
2a	68,89	Moderate	0,37	Accepted	0,741	Very Valid	
2b	51,11	Moderate	0,56	Good	0,635	Valid	
2c	34,44	Moderate	0,46	Good	0,656	Valid	

To assess the practicality of the mathematical literacy instrument in terms of content, construction, and language presented, student response survey results were also collected. The following table presents this information.

Table 7. Student Survey Response Results

No.	Domain	Practicability Criteria (%)	Criteria
1	Content	79	Practical
2	Construction	93	Very practical
3	Language	90	Very practical
Average		87	Very practical

Based on the survey results above, the instrument for mathematical literacy skills in the topic of circles is highly practical for middle school students, with a practicality score of 87%. Therefore, this mathematical literacy instrument can be applied effectively in mathematics education at schools.

3.2. Discussion

The analysis stage is the initial step undertaken by researchers to formulate the problem that serves as the background for this study. Based on interviews with mathematics teachers, it was found that a difficulty in mathematics learning occurs when students encounter word problems that require reading and understanding the problem text. Mathematical literacy, which includes the ability to read, comprehend, and apply mathematical concepts in real-life contexts, is highlighted (OECD, 2023). This indicates that based on interviews with mathematics teachers, information was obtained regarding students' low mathematical literacy skills, consistent with research (Masfufah & Afriansyah, 2021), which concluded that middle school students still have low mathematical literacy skills.

After conducting interviews with students, it was found that they are rarely given problems related to real-world issues. This has been identified as a factor contributing to the low mathematical literacy skills of students, as observed by Tabun et al. (2020), who stated that the low mathematical literacy skills of students are due to the lack of real-life related problems. Therefore, several studies recommend creating varied and non-routine problems and developing mathematical literacy instruments in middle schools (Asmara & Sari, 2021; Fatwa et al., 2019; Masfufah & Afriansyah, 2021; Wibowo et al., 2020).

Based on the above explanation and supported by research by Nuringtyas &

Setyaningsih (2023), which states that students' mathematical literacy skills on the circle topic are still relatively low, the appropriate solution to this problem is to develop mathematical literacy instruments on the circle topic for middle school students. This study involved 32 middle school students in Serang Regency.

The second stage of this research is the design stage, which involves creating a grid for the mathematical literacy instrument adapted from OECD (2023), which includes the indicators formulate, employ, and interpret. The problems are designed using attractive images based on research indicating that visual elements in problems draw more attention from students (Sylviani et al., 2019). Additionally, the problems are designed to relate to students' daily life issues, which can help enhance their mathematical literacy skills (Masjaya & Wardono, 2018).

The development stage is the third stage of this research, carried out by developing and conducting expert validation on the test instruments to be tested. The development of the test instruments was based on comments or suggestions from validators. Additionally, expert validation was conducted to assess the validity of the test instruments. This study used validity categories based on research by Rizqiyani et al. (2022), which classify $P \leq 20$ (very invalid), $21 < P \leq 40$ (invalid), $41 < P \leq 60$ (fair), $61 < P \leq 80$ (valid), $81 < P \leq 100$ (very valid). Based on this classification, the mathematical literacy test instruments were found to be very valid, scoring 88% for the material domain, 88% for the construction domain, and 83% for the language domain. This indicates that the test instruments can be used as they have been proven to be very valid.

The implementation stage, which is the fourth stage of this research, involved conducting trials with 32 eighth-grade students at a public school in Serang Regency. This trial included the mathematical literacy test and a questionnaire on student responses after completing the test instruments. The results of this trial will be used for improvements in the evaluation stage.

The final stage of this research is the evaluation stage, which showed that all the problems were valid and very valid with a reliability test score of 0.79, indicating that the problems have consistency and reliability in measuring mathematical literacy skills. All six problems had good distinguishing power and were acceptable with moderate to easy difficulty levels. Additionally, the average practicality score was 87%, with 79% for the material domain, 93% for the construction domain, and 90% for the language domain. Thus, it can be concluded that the mathematical literacy instruments are practical and efficient to use. This aligns with the student response questionnaire criteria for the practicality of the test instruments according to Purwanto, which states that if the percentage is > 80%, the instrument is classified as very practical and can be applied in mathematics learning.

4. CONCLUSION

Based on the results of research and development of mathematical literacy instruments on circle material for junior high school students, it can be concluded that the developed instrument is valid and practical, making it applicable in the mathematics learning process. The validity of this instrument is based on validity tests, reliability tests, and distinguishing power, which resulted in valid, reliable, and acceptable questions.Additionally, the results of the student response questionnaire showed an instrument practicality level of 87%, which falls into the very practical category. The details include 79% for the material domain, 93% for the construction domain, and 90% for the language domain. Based on these results and conclusions, the researcher suggests that future researchers develop more varied mathematical literacy questions to support students' mathematical literacy skills.

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