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Needs Analysis of Assessment Instruments to Measure Mathematical Communication Skills of Phase D Students in Measurement Content

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ABSTRAK

Asesmen dalam pembelajaran matematika harus dapat mengukur kemampuan matematis yang diharapkan dimiliki peserta didik, salah satunya yaitu kemampuan komunikasi matematis. Namun bentuk penilaian yang ada saat ini cenderung berfokus pada penilaian kompetensi kognitif peserta didik dan mengabaikan dimensi penting lain dari pembelajaran. Tujuan penelitian ini adalah untuk menganalisis kebutuhan dalam mengembangkan instrumen asesmen untuk mengukur kemampuan komunikasi matematis peserta didik fase D pada konten pengukuran. Penelitian ini merupakan penelitian pengembangan awal dengan metode mengadopsi langkah define pada model pengembangan 4D. Subjek penelitian ini adalah 20 orang guru matematika dan 15 orang peserta didik SMP di Pekanbaru. Instrumen penelitian yang digunakan adalah penyebaran angket kepada guru dan pemberian soal pada peserta didik. Hasil yang diperoleh pada penelitian ini menunjukkan bahwa diperlukan adanya pengembangan instrumen asesmen yang dapat mengukur kemampuan komunikasi matematis peserta didik fase D pada konten pengukuran.

Kata Kunci: Analisis Kebutuhan; Asesmen; Kemampuan Komunikasi Matematis.

ABSTRACT

Assessment in mathematics learning should be able to measure the mathematical abilities that students are expected to possess, one of which is mathematical communication skills. Nevertheless, the prevailing forms of assessment tend to focus primarily on evaluating students' cognitive competencies, while overlooking other important dimensions of learning. The purpose of this study is to analyze the needs in developing assessment instruments to measure students' mathematical communication skills of Phase D in the context of measurement. This research is kind of preliminary development research and the method adopts the define stage of the 4D development model. The research subjects consisted of 20 mathematics teachers and 15 junior high school students in Pekanbaru. The research instruments used were teacher questionnaires and test items to students. The results of this study indicate the necessity of developing assessment instruments that are able to measure the mathematical communication skills of Phase D students in measurement content.

Keywords: Needs Analysis; Assessment; Mathematical Communication Skill.

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1. INTRODUCTION

Assessment is the process of collecting and processing information to determine learning needs and developmental achievements or student learning outcomes (Permendikbud No. 21 of 2022; Nurwahidah, 2023). Assessment is a vital component of the learning process as it provides data regarding the attainment of student competencies (Oktaviana, Effendi, & Rosyadi, 2023; Lele, Marsigit, & Retnawati, 2024). In the context of mathematics education, students are required not only to perform calculations but also to master several mathematical skills.

However, assessment practices commonly employed by mathematics teachers in schools often focus solely on measuring cognitive aspects, thus failing to fully represent students' mathematical abilities comprehensively (NCTM, 2000; Rohmah et al., 2022; Adeleke, Balogun, & Ayanwale, 2025). Summative assessments tend to emphasize cognitive-procedural aspects (calculations/final results) in the form of multiple-choice or simple essay questions. Consequently, the potential of assessment to describe more complex competencies, such as mathematical communication skills, has not been optimally utilized (Barana, Boetti, & Marchisio, 2022; Ata Baran & Kabael, 2023; Budiono, 2023; Nirmala, 2024).

According to the NCTM (2000), there are several abilities that students must possess in mathematics learning, one of which is mathematical communication. Mathematical communication is an essential standard process because it enables students to express, explain, and justify their thinking (Thanheiser & Melhuish, 2023; Ikhsan & Afriansyah, 2023; Normalasari, Sutiarso, & Rahayu, 2025). Beyond its benefits for students, mathematical communication is also needed by teachers to observe the extent to which students can interpret and express their understanding after learning a new concept, as well as to identify conceptual misconceptions (Ishmah, Emi & Tri, 2018; Biber, 2023; Arwadi, 2023; Anim & Sapta, 2025). Indicators of mathematical communication skills, according to Heris, Euis, and Utari (2021), include: (1) *written text*, which involves making mathematical statements using one's own language; (2) *drawing*, which involves reflecting real objects, images, and diagrams into mathematical ideas; and (3) *mathematical expressions*, which involve expressing mathematical concepts by stating everyday events in mathematical language or symbols.

The importance of mathematical communication skills is not yet aligned with the facts in the field. According to research by Desta and Ramlah (2021), students' mathematical communication skills fall into the low category, particularly in the drawing and writing indicators. Students are unable to understand the given problems, preventing them from solving them according to procedures. Other research by Ai & Afriansyah (2021) shows that 62.75% of students struggle to explain problem ideas orally or in writing, and 62.5% of students are not yet able to create mathematical models from a mathematical problem.

Students' difficulties in using mathematical symbols and models, as well as creating drawings from given contextual problems, have an impact on the low achievement of the National Assessment (AKM). The 2025 AKM data shows that students, particularly in Pekanbaru City, experienced a decline in the geometry aspect by -1.2007 (Susanta et al., 2025). This decline occurred primarily in the understanding of spatial concepts, shapes, and measurement. Students face challenges when linking mathematical concepts to contextual situations in mathematical problems that demand visual representation, mathematical modeling, and problem-solving interpretation.

This occurs because, during learning, students only listen to and watch the teacher present a mathematical problem and solve it themselves, followed by practice questions (Murni, Risma & Nelly, 2021; Kartina & Afriansyah, 2024; Saragih, Siregar, & Mu'awiyah, 2025). Thus, the knowledge students acquire is through a process of "telling" rather than mathematical exploration, which leaves their mathematical communication skills unsharpened (Ansari in Hodiyanto, 2017; Rahmawati, Cholily, & Zukhrufurrohmah, 2023).

Various previous studies have discussed students' mathematical communication skills, whether through analysis of ability levels, the influence of specific learning models, or the development of learning tools that support mathematical communication (Indriani & Noordyana, 2022; Linda & Afriansyah, 2022; Arnisya & Sundayana, 2025; Pramuditya, Hanan, & Laelasari, 2025). However, most of these studies emphasize the results of measuring mathematical communication skills rather than the needs analysis of assessment instruments specifically designed to measure these skills. Furthermore, research focusing on the development or analysis of instruments is often general and has not been specifically directed toward *measurement* content and the characteristics of *Phase D* in the *Merdeka* Curriculum.

Therefore, there is an urgent need to conduct a needs analysis of assessment instruments capable of measuring students' mathematical communication skills accurately, contextually, and in alignment with the Phase D learning outcomes. This needs analysis is a crucial initial step before the development of valid and relevant assessment instruments can be carried out. Consequently, this research focuses on the needs analysis of assessment instruments to measure the mathematical communication skills of Phase D students in measurement content, aiming to provide an empirical and theoretical foundation for the development of more meaningful assessments in mathematics learning.

2. METHOD

The research method adopted for this study follows the *Define* phase of the 4D development model. The participants included 20 junior high school mathematics teachers in

Pekanbaru and 15 students from SMPN 44 Pekanbaru. The data analysis process for this research is illustrated in Figure 1.

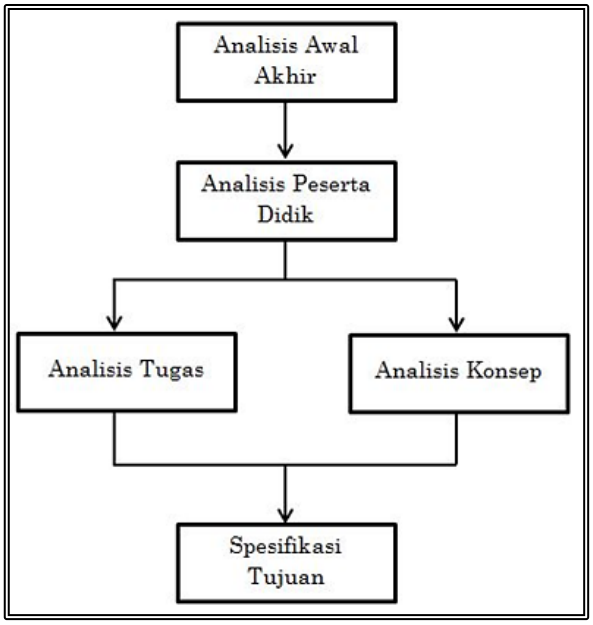

Figure 1. The Flow of the Define Phase

The *Front-End Analysis* was conducted by distributing questionnaires via Google Forms to 20 junior high school mathematics teachers in Pekanbaru to obtain data regarding existing challenges in the field. The teacher questionnaire grid included: (1) the development process of summative assessment instruments; (2) the types of summative assessments utilized; (3) students' mathematical communication skills (MCS); (4) the use of word problems; and (5) the relationship between assessment and MCS. The questionnaire was structured using a Likert scale with scores ranging from 1 (Strongly Disagree), 2 (Disagree), 3 (Agree), to 4 (Strongly Agree).

Data obtained from the questionnaires were analyzed using descriptive statistics to illustrate the necessity for assessment instruments that measure the mathematical communication skills of Phase D students. Scores from each respondent were aggregated to obtain a total score, followed by calculating the average value for each indicator of the assessment instrument needs.

The subsequent analytical process involved *Learner Analysis*, which was conducted by administering assessment questions on measurement content to 15 students at SMPN 44 Pekanbaru. this analysis aimed to examine student characteristics based on their diverse levels of knowledge, skills, and cognitive development processes.

Furthermore, *Concept Analysis* and *Task Analysis* were performed to identify the core concepts that would serve as the primary focus of this research and to determine competency achievement indicators for structuring the assessment. The final step in the *Define* phase was

the *Formulation of Learning Objectives* (Specification of Objectives), which was conducted to establish final conclusions based on the results of the preceding analytical stages.

3. RESULT AND DISCUSSION

a. Front-End Analysis

The front-end analysis was conducted by distributing questionnaires to 20 junior high school mathematics teachers in Pekanbaru. The questionnaire contained questions related to summative assessment instruments and the mathematical communication skills of Phase D students. The distribution was carried out via Google Forms to facilitate data collection. The results are presented in Table 1.

Table 1. Results of the Junior High School Mathematics Teacher Questionnaire

Analyzed Aspect	Conclusion of Responses	Follow-up Action
Summative assessment instrument development process	Teachers utilize existing problems from textbooks for summative assessments	Teachers pay insufficient attention to the instrument development process; thus, independent development of summative assessment tasks is required
Types of summative assessments utilized	The assessment tasks used are in the form of essay questions	The question format utilized is appropriate for measuring student skills
Students' Mathematical Communication Skills (MCS)	Students still struggle to communicate mathematical thinking processes in writing, illustrating/drawing, and using mathematical symbols	There is a need for assessment tasks that specifically measure students' mathematical communication skills (MCS)
Use of contextual problems	Teachers perceive contextual problems as difficult for students to understand, leading to infrequent use	There is a need to develop contextualized summative assessment tasks
Relationship between assessment and MCS	Teachers pay insufficient attention to integrating mathematical communication indicators into assessment tasks	There is a need to develop assessment tasks integrated with MCS indicators

Based on the questionnaire results, it was found that teachers have not independently developed assessment tasks, instead relying on problems available in student handbooks. Consequently, there are no assessment tasks integrated with indicators capable of measuring students' mathematical abilities, specifically mathematical communication skills. Assessments are typically structured only to measure students' cognitive competence.

Furthermore, the results indicate that the assessment tasks used by teachers are still dominated by non-contextual problems, showing that the current assessments are unable to

illustrate students' ability to communicate mathematical ideas in real-life situations. According to Nor et al. (2022), problems or tasks provided should be linked to students' daily lives, as this natural context encourages students to think and acquire knowledge naturally. Based on these findings, the researcher concludes that it is necessary to develop assessment instruments capable of measuring students' mathematical communication skills through contextual problems relevant to everyday life.

b. Learner analysis

Learner analysis involves examining student characteristics—such as academic ability, cognitive development, and topic-related skills—to ensure they align with the product being developed. In this study, learner analysis focused on mathematical communication skills using tests and unstructured interviews.

The test consisted of problems on the topic of surface area and volume of polyhedra, modified from National Examination (UN) questions to integrate mathematical communication indicators: (1) explaining mathematical ideas through drawings; (2) expressing mathematical problems in the form of mathematical models; and (3) writing conclusions based on student understanding. The test was administered to 15 students at SMPN 44 Pekanbaru.

Sebuah aula berbentuk balok dengan ukuran panjang, lebar dan tinggi berturut-turut adalah 6 meter, 10 meter dan 5 meter. Dinding bagian dalam akan dicat dengan biaya Rp 40.000 per meter persegi. Buatkan:

a. Ilustrasi gambar aula dengan ukuran tersebut
b. Tuliskan rumus matematika yang digunakan
c. Tentukan total biaya pengecatan aula tersebut.

Figure 2. Mathematical Communication Skill Test Question

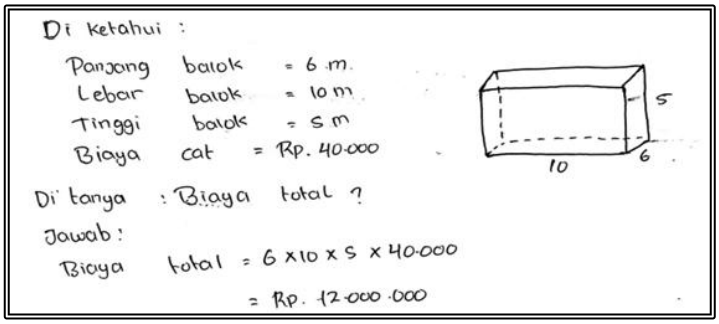

Figure 3. Student Response – 01

Based on the student's response in Figure 3, the student was able to illustrate the mathematical situation using a drawing. However, the student was unable to translate the problem into mathematical sentences using proper symbols and failed to provide a conclusion. Further interviews revealed that the student was confused about which symbols corresponded to the information given. The student struggled to formulate the mathematical model and could

not reach the correct solution or conclusion. This occurs because the assessment tasks they usually encounter do not require them to create illustrations, write formulas, or detail the steps taken to solve a problem. The low level of students' MCS serves as the rationale for developing assessment tasks that can facilitate and measure these skills.

c. Concept Analysis

In the concept analysis phase, the researcher identified and organized the concepts required to develop assessment tasks integrated with MCS indicators, based on the learning outcomes (*Capaian Pembelajaran* / CP) of the *Merdeka* Curriculum. According to BSKAP Decree No. 032/H/KR/2024, the CP for the Measurement element is presented in Table 2.

Table 2. Learning Outcomes for Measurement Content

Element	Learning Outcome
Measurement	At the end of Phase D, students can explain how to determine the surface area and volume of geometric solids (prisms, cylinders, spheres, pyramids, and cones).

Source: BSKAP No. 032/H/KR/2024

In this study, the geometric solids discussed further are prisms and pyramids. Based on the CP, the primary focus is not only on calculating final results but also on understanding, communicating, and explaining the mathematical thinking processes used to determine surface area and volume. The mathematical concepts students must master include the definition of solids, nets of solids, surface area, volume, and visual representation (drawing solids).

d. Task Analysis

Task analysis was conducted to determine the competencies students must master. The results serve as a reference for formulating learning objectives integrated with MCS indicators. The concept map for task analysis is presented in Figure 4.

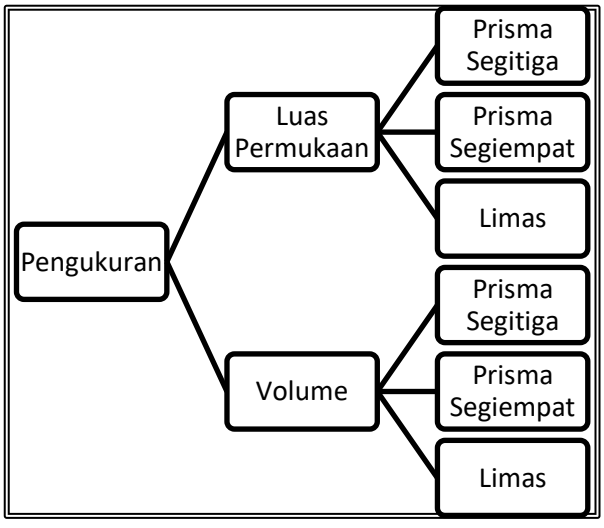

Figure 4. Concept Map of Task Analysis for the Measurement Element

The integration of the *writing* indicator is achieved by measuring students' ability to write logical and systematic solution steps using appropriate mathematical symbols. The *drawing* indicator is integrated by measuring students' ability to draw geometric solids and their nets. The *mathematical expression* indicator is integrated by measuring students' ability to write formulas or models that match the problem context.

e. Specification of Objectives

Learning objectives were formulated based on the task and concept analyses, as shown in Table 3.

Table 3. Specification of Learning Objectives

Learning Objective	Topic	Objective Achievement Indicators
1.1. Determine the surface area of polyhedra (prisms and pyramids) and apply them to solve related problems.	Surface Area of Prisms	1.1.1. Draw a prism.
		1.1.2. Determine the formula for the surface area of a prism.
		1.1.3. Solve problems related to the surface area of a prism.
	Surface Area of Pyramids	1.1.4. Draw a pyramid.
		1.1.5. Determine the formula for the surface area of a pyramid.
		1.1.6. Solve problems related to the surface area of a pyramid.
1.2. Determine the volume of polyhedra (prisms and pyramids) and apply them to solve related problems.	Volume of Prisms	1.2.1. Determine the formula for the volume of a prism.
		1.2.2. Solve problems related to the volume of a prism.
	Volume of Pyramids	1.2.3. Determine the formula for the volume of a pyramid.
		1.2.4. Solve problems related to the volume of a pyramid.

Based on these objectives, assessment tasks for the *writing* indicator will be essay questions asking students to explain the process of determining surface area based on nets. The *drawing* indicator will require students to draw solids and their components, labeled for calculation. This is in line with Dewi & Nuraeni research, Gunawan et al., (2024) research, Zohriah, Ahyan, & Endriana (2024) research, and Mufidah et al. (2025) research that *mathematical expression* indicator will involve contextual problems requiring students to write equations for surface area or volume. Thus, the assessment will not only evaluate correctness but also measure thinking processes and mathematical communication skills.

4. CONCLUSION

Based on the results of the initial analysis, it is concluded that the assessments conducted by teachers are still limited to the use of problems sourced directly from textbooks without independent development. The assessment instruments utilized generally focus on cognitive aspects and have not yet been able to measure the mathematical skills that students are expected to possess following the learning process, particularly mathematical communication skills. Furthermore, the use of non-contextual assessment tasks results in assessments that are unable to represent students' ability to communicate mathematical ideas.

Analysis of student performance indicates that students still face difficulties in translating problems into mathematical models, using mathematical symbols or notation accurately, and writing conclusions based on their thinking processes. This is due to students' limited experience in engaging with tasks that require drawing, formulating mathematical models, and writing systematic solution steps. Therefore, based on the analysis conducted, there is a clear necessity for the development of assessment tasks that do not only evaluate the final result but also facilitate and measure students' mathematical communication skills.

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