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DEVELOPING PROBLEM-BASED LEARNING MODULES FOR FLAT-SIDED GEOMETRY TO FACILITATE STUDENTS' MATHEMATICAL CONNECTION SKILLS

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ABSTRACT This development study aims to produce a problem-based learning module on flat-sided geometry designed to enhance students' mathematical connection skills in Phase D. The teaching module consists of three main sections: the core, general information, and appendices. Given the limitations in students' mathematical connection skills, it is essential for teachers to use effective learning models. Problem-based learning focuses on real-world problems as the central point of instruction, helping students connect lessons to practical, everyday situations. This study followed the 4D development model, which includes the stages of define, design, develop, and disseminate. Product validation was conducted by three validators, who provided feedback for improvements. The readability of the student worksheets was tested through one-on-one trials with three students. Additionally, small-group trials involving 15 Phase D students from MTsN 4 Kampar were conducted to assess the module's practicality. The validation results showed an average score of 3.58, indicating the module is highly valid. The practicality test resulted in an average score of 87.5%, classifying the module as very practical. These findings demonstrate that the developed module can effectively improve students' mathematical connection skills. Furthermore, teachers can use this product as a teaching tool for the flat-sided geometry material in the mathematics learning process.

Keywords: mathematical connection skills, problem-based learning, modules, flat-sided geometry.

ABSTRAK Penelitian pengembangan ini bertujuan untuk menghasilkan modul pembelajaran berbasis masalah pada materi bangun ruang sisi datar yang dirancang untuk meningkatkan keterampilan koneksi matematis siswa di Phase D. Modul pembelajaran ini terdiri dari tiga bagian utama: inti, informasi umum, dan lampiran. Mengingat keterbatasan keterampilan koneksi matematis siswa, sangat penting bagi guru untuk menggunakan model pembelajaran yang efektif. Pembelajaran berbasis masalah berfokus pada masalah dunia nyata sebagai pusat pembelajaran, membantu siswa menghubungkan pelajaran dengan situasi praktis sehari-hari. Penelitian ini menggunakan model pengembangan 4D, yang mencakup tahap pendefinisian, perancangan, pengembangan, dan penyebarluasan. Validasi produk dilakukan oleh tiga validator yang memberikan masukan untuk perbaikan. Keterbacaan lembar kerja siswa diuji melalui uji coba satu-satu dengan tiga siswa. Selain itu, uji coba kelompok kecil melibatkan 15 siswa Phase D dari MTsN 4 Kampar untuk menilai kepraktisan modul. Hasil validasi menunjukkan skor rata-rata 3,58, yang mengindikasikan bahwa modul ini sangat valid. Uji kepraktisan menghasilkan skor rata-rata 87,45%, yang dikategorikan sebagai sangat praktis. Temuan ini menunjukkan bahwa modul yang dikembangkan dapat secara efektif meningkatkan keterampilan koneksi matematis siswa. Selain itu, guru dapat menggunakan produk ini sebagai alat pengajaran untuk materi bangun ruang sisi datar dalam proses pembelajaran matematika.

Keywords: kemampuan koneksi matematis, PBL, modul belajar, bangun ruang sisi datar.

INTRODUCTION

The Merdeka Curriculum aims to provide quality education that meets the needs of students and their learning environment while giving teachers the flexibility to implement teaching. This curriculum encourages innovation from educators, students, and schools to create sustainable learning (Lutfiana, 2022). Mathematics is one of the subjects integrated into the Merdeka Curriculum. According to the Ministry of Education and Culture (Karyanto & Mampouw, 2018), the goal of mathematics education is for students to master mathematical concepts, explain the relationships between those concepts, and use concepts and algorithms to solve contextual problems in a flexible, accurate, efficient, and appropriate manner. One of the indicators of mathematical connection skills is the ability of students to explain how mathematical concepts are related. Mathematical connection skills are essential because they allow students to recognize relationships between concepts within procedures, understand the connections between mathematical topics, and apply mathematical concepts to other fields or in everyday life. According to Maisyarah and Surya (2017), students with strong mathematical connection skills will be able to retain lesson concepts for a longer time and use them as a foundation for understanding new concepts. Students with strong connections can quickly grasp new information and retain it over time. This aligns with Siagian's (2016) view that students will benefit more from learning mathematics if they possess mathematical connection skills, as these skills help strengthen and improve their understanding of mathematical concepts.

However, even though students can understand mathematical concepts, many struggle to connect these concepts with other aspects of mathematics or real-life situations. Indicators of mathematical connection skills include linking mathematical topics, connecting within a single topic, linking mathematics with other sciences, and applying mathematical concepts to everyday life (Nur et al., 2022).

Research shows that students' mathematical connection skills remain relatively low, particularly in applying mathematical concepts to real-life problems. Ritonga's (2020) study found that out of 25 students who took a mathematical connection ability test, only two met the minimum requirements, with an average score of 42.67. Additionally, only 8% of students were able to relate mathematical concepts, and none were able to connect mathematics to daily life. Interviews with mathematics teachers at MTsN 4 Kampar revealed that students struggle to relate previously learned material to current lessons and face difficulties solving contextual problems because the format of the problems differs from the examples provided by the teacher. This demonstrates a lack of mathematical connection skills, particularly because students are not used to problem-based learning and struggle to apply mathematical concepts to everyday situations.

To address this issue, learning designs that integrate the connections between mathematical topics and contextual problems are needed to facilitate mathematical connection skills. According to Nugroho et al. (2020), a relevant learning model that trains students to solve mathematical problems is needed to improve mathematical connection skills. Problem-Based Learning (PBL) is one learning model that can help students develop their mathematical connection skills. Rusma, as cited in Aisyah et al. (2022), stated that the PBL syntax can enhance students' ability to connect mathematical concepts. Similar findings were reported by Rohaly & Abadi (2019), who showed that problem-based learning can improve students' achievements and their mathematical connection skills. The PBL model aims to encourage students to think critically about contextual problems. According to Rustina & Anisa (2018), the PBL model stimulates students' thinking more than traditional teaching methods. These perspectives confirm that Problem-Based Learning (PBL) is a learning model that places classroom lessons in real-world contexts to foster critical thinking and understanding among students.

The PBL model can be packaged into learning modules that show how teachers prepare before implementing the lesson. Learning modules are instructional designs or tools that are tailored to meet curriculum requirements. A learning module typically includes the author's identity, initial competencies, the Pancasila student profile, facilities and infrastructure, target students, the learning model, and product specifications. The core components of a learning module include learning objectives, types of assessments, meaningful understanding, trigger questions, learning activities, and reflections. Additionally, the module is equipped with attachments such as glossaries, bibliographies, student worksheets, assessments, and reading materials for both teachers and students.

Previous research by Dwi Agitsna et al. (2019) and Astuti et al. (2017) developed problem-based learning worksheets, but they did not focus on the skills being facilitated. This study aims to develop learning modules aligned with the latest format of the Merdeka Curriculum for flat-sided geometry material, with a specific focus on developing modules that facilitate students' mathematical connection skills. In addition, this study includes a cognitive diagnostic assessment to help teachers identify students' initial abilities related to the material being studied and use this as a reference when designing future lessons.

METHODS

This study is development research (R&D) that employs a four-stage, four-dimensional development model: defining, designing, developing, and disseminating. In the defining stage, five main tasks were completed. First, interviews were conducted with mathematics teachers at MTsN 4 Kampar for an initial analysis. Additionally, at SMPIT Al-Fityah in Pekanbaru, a literature review and observation of students' analytical activities were carried out to identify variations in students' thinking abilities, which informed the creation of the teaching modules. The findings revealed that some students still struggled to connect concepts, making it difficult for them to solve problems. During this stage, task analysis, concept analysis, and the formulation of learning objectives were also conducted. Learning objectives were derived from an analysis of the learning outcomes, aligned with the independent curriculum.

In the design stage, several activities were undertaken, including the selection of format and media, the design of the teaching module, and the development of validity and practicality assessment sheets. The format of the teaching module was chosen with consideration for the requirements of the independent curriculum. The teaching module consists of three main sections: general information, core content, and appendices. The appendices contain reading materials for teachers and students, assessments, enrichment and remediation materials, a glossary, and a bibliography. The initial design of the teaching module was then created, along with the validity and practicality assessment sheets.

During the development stage, the initial design of the teaching module was validated by three validators. Two of the validators hold master's degrees and are lecturers in mathematics education. After validation, the module was revised based on the suggestions and comments provided by the validators, ensuring that it met the valid criteria. The following formula was used to calculate the validity score:

$$\overline{M_V} = \frac{\sum_{i=1}^{n} \overline{V_i}}{n}$$

Description:
$\overline{M_V}$ = average total validity
$\bar{V}_i$ = average validation of the i-th validator
n = number of validators

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The criteria for analyzing the average validity score are shown in Table 1 below:

Table 1. Device Validity Test Categories

Interval	Category
$3{,}25 \leq \overline{M_V} \leq 4$	Very Valid
$2{,}50 \leq \overline{M_V} < 3{,}25$	Valid
$1{,}75 \leq \overline{M_V} < 2{,}50$	Less Valid
$1{,}00 \leq \overline{M_V} < 1{,}75$	Invalid

(Source: Arikunto in Habibah et al., 2017)

After meeting the validity criteria, a small group trial was conducted with 15 Phase D students to assess the practicality of the teaching module. Additionally, a one-on-one test was carried out with three students to evaluate the readability of the student worksheets. The difficulties encountered by the students during this test were used as a reference for revision. Practicality was analyzed using the following formula:

$$P = \frac{T_{Se}}{T_{Sh}} \times 100\%$$

Description:
P = Practicality Percentage
T_{Se} = Total score obtained
T_{Sh} = Total maximum score expected

The criteria for the level of practicality are shown in Table 2:

Table 2. Teaching Module Practicality Test Categories

Interval	Level of Practicality
85% ≤ P ≤ 100%	Very Practical
70% ≤ P < 85%	Practical
50% ≤ P < 70%	Less Practical
25% ≤ P < 50%	Impractical

In the dissemination stage, the teaching module was packaged and distributed to schools for potential use in the learning process.

FINDING AND DISCUSSION

At the defining stage, a comprehensive analysis was conducted, including end-to-end analysis, student analysis, task analysis, concept analysis, and the formulation of learning objectives. Although the independent curriculum sets specific goals, mathematics instruction still relies on traditional learning tools that do not align with the curriculum's aims. Teachers continue to use conventional methods, often without incorporating relevant learning models. This disconnect means that the objectives of mathematics learning will not be fully achieved if educators continue to rely on such tools. Observations at SMPIT Al-Fityah Pekanbaru and interviews with a mathematics teacher at MTsN 4 Kampar revealed that students' mathematical connection skills remained relatively low. Students struggled to apply different mathematical concepts to the material being studied, relying instead on memorizing formulas and methods for solving specific problems. Consequently, when faced with contextual problems requiring the integration of multiple mathematical concepts, students became confused and unable to solve these problems effectively. This finding emphasizes the need for teaching modules that align with the independent curriculum to help students understand contextual problems, the relationships between mathematical concepts, and their applications in real-world situations.

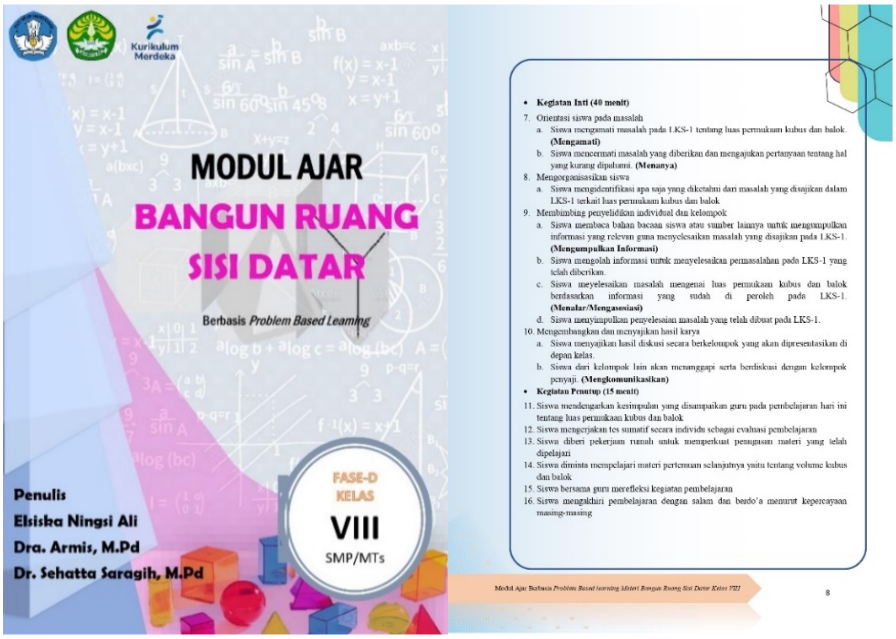

Figure 1. Design of teaching modules

Research by Rohmah et al. (2018) showed that the mathematical connection skills of eighth-grade students at Darul Falah Junior High School improved when the Problem-Based Learning (PBL) model was applied. The administration of mathematical connection ability tests demonstrated an increase in students' understanding and their ability to link mathematical concepts. This finding is consistent with the research by Septian and Komala (2019), which found that students' average ability to connect mathematical concepts increased with the implementation of the PBL model. Based on the students' characteristics, the teaching modules developed also include relevant learning models. Students aged 14 to 16 typically possess the cognitive ability to think mathematically, logically, and

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abstractly. This aligns with Piaget's theory, which suggests that students at the junior high school level are capable of creative thinking, abstract reasoning, and imagining the outcomes of specific actions. Based on these learning outcomes, task and concept analyses were conducted, leading to the formulation of 12 learning objectives across six meetings.

At the design stage, the initial design or prototype of the PBL-based teaching module was created using printed media and Microsoft Office Word 2019 on A4-sized paper. The module's format was developed in accordance with the independent curriculum and includes general information, core components, and attachments. The design of the teaching module is shown in the figure 1.

In the development stage, validation was conducted by three experts to assess the product's validity. The results of the teaching module validation analysis are presented in Table 3.

Table 3. Teaching Module Validation Results

Aspect of Assessment	Module					Average Score	Category
	1	2	3	4	5		
Content Validity							
Appropriateness of teaching module format	4,00	4,00	4,00	4,00	4,00	4,00	4,00
Formulation of learning objectives	3,44	3,22	3,00	3,22	3,22	3,56	3,28
Modules content/ material	3,17	3,00	3,17	3,25	3,17	3,17	3,15
Average	**3,54**	**3,41**	**3,39**	**3,49**	**3,46**	**3,57**	**3,48**
Construct Validity							
Learning model and approach	3,33	3,33	3,22	3,22	3,33	3,22	3,28
Learning steps	3,73	3,73	3,73	3,80	3,73	3,87	3,89
Average	**3,58**	**3,58**	**3,57**	**3,61**	**3,58**	**3,57**	**3,58**
Face validity							
Module Display	4,00	4,00	4,00	4,00	4,00	4,00	4,00
Average	4,00	4,00	4,00	4,00	4,00	4,00	4,00
Assessment on diagnostic assessment	3,67	3,67	4,00	3,83	3,83	3,83	3,81
Assessment on formative assessment	3,33	3,33	3,22	3,44	3,22	3,33	3,31
Assessment on summative assessment	3,33	3,22	3,56	3,78	3,44	3,33	3,44

Aspect of Assessment	Module					Average Score	Category
	1	2	3	4	5		
Average	3,44	3,41	3,59	3,69	3,50	3,50	3,52
Average validity	**3,64**	**3,60**	**3,64**	**3,70**	**3,64**	**3,66**	**3,65**

Based on the validation results, the overall average validity score was 3.65, which falls into the "Very Valid" category. However, some aspects showed lower validity, particularly the module content/material, which received a score of 3.15, and the learning models and approaches, which scored 3.28. As a result, the validators provided several suggestions for improvement.

One suggestion was to add questions related to how students felt during the learning process. Before the revision, the student reflection section only covered general aspects. After the revision, the student reflection section was updated to include questions about their learning experience, providing space for students to express how they felt throughout the learning process.

Additionally, the validators recommended that indicators of mathematical connection skills be included in every step of the module activities. Before the revision, the activity steps in the module did not fully incorporate these mathematical connection skills. After the improvements, two indicators of mathematical connection skills were added: the ability to connect ideas within mathematics and the application of mathematical concepts to everyday life. These changes were intended to help students better understand the relationship between the mathematical concepts they learned and their real-world applications.

Following these revisions, the teaching module was deemed ready for testing. After the validation process was completed, a one-on-one test was conducted to assess readability, followed by a small-group test to evaluate the practicality of the module. During the one-on-one test, minor issues such as typographical errors and images lacking descriptions were identified. Revisions were made based on the findings from the one-on-one test. After the revisions were finalized, a small-group test was conducted with 15 Phase D students. The results of the student response questionnaires on the practicality of the teaching module indicated that the module could be used effectively. The data collected from these questionnaires were analyzed to assess the practicality of the module, and the detailed results of this analysis are presented in Table 4 below.

Table 5. Teaching Module Practicality Results

Aspect of Assessment	Module (%)						Average	Category
	1	2	3	4	5	6		
Module Display	87.3	86.0	84.7	88.7	89.0	88.3	87.3	Very Practical

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Aspect of Assessment	Module (%)						Average	Category
	1	2	3	4	5	6		
Content/Material of Module	81.7	83.0	85.0	85.3	80.7	85.0	83.4	Practical
Ease of Use of Worksheets	91.1	92.8	92.8	90.0	91.1	91.7	91.6	Very Practical
Practicality Percentage	86.7	87.3	87.5	88.0	86.9	88.3	87.5	Very Practical

Based on the results of the practicality questionnaire analysis, the module meets the criteria for practicality. This indicates that the worksheets within the developed teaching module are suitable for further testing to determine the product's level of effectiveness.

In the dissemination stage, the teaching module was distributed in printed form to schools, where it can be used in the learning process to help Phase D students enhance their mathematical connection skills, particularly in relation to flat-sided space geometry. However, this study only measured the practicality of the teaching module. The instructional materials used were not yet fully designed specifically for this module, which limits the scope of the research and prevents conclusions regarding its broader effectiveness. Future research could focus on larger-scale evaluations of this teaching module.

Relevant to this study, Agitsna et al. (2019) developed worksheets using a problem-based learning model on the topic of flat-sided geometry. Their research produced valid and practical learning worksheets, similar to this study. However, the limitation of their research was that it did not focus on a specific skill to be facilitated. In contrast, this development research focuses primarily on improving Phase D students' mathematical connection skills. Furthermore, the development research by Styasih et al. (2021) focused on STEM-based worksheets with a problem-based learning model that were applied to linear programming material. This evolution from basic worksheets to a comprehensive teaching module aligns with the independent curriculum's problem-based learning approach, providing a more structured and effective way to help students develop their mathematical connection skills, especially in the context of flat-sided space geometry.

CONCLUSIONS AND RECOMMENDATIONS

This development research produced teaching modules based on problem-based learning for flat-sided space geometry to help Phase D students improve their mathematical connection skills. The developed product is divided into three main parts: Part I includes general information about the teaching modules, Part II consists of the core components, and Part III contains attachments such as assessments, student worksheets, enrichment and remedial materials, teacher and student reading materials, a glossary, and a bibliography. The teaching module proved to be reliable, practical, and effective in enhancing students' mathematical connection skills. One key advantage of the developed product is the inclusion of updated contextual-based questions, which facilitate the measurement of indicators related to mathematical connection skills.

However, the trial of the product had limitations, primarily due to its small-scale implementation. As such, further studies should test the module on a larger scale to better evaluate its overall effectiveness. Future research should also incorporate teaching materials that are specifically aligned with the module's content, ensuring that students have the resources needed to solve problems and further develop their mathematical connection skills.

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