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DEVELOPMENT OF PROBLEM-BASED LEARNING MATHEMATICS MODULES TO ENHANCE STUDENTS' MATHEMATICAL PROBLEM-SOLVING SKILLS

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ABSTRACT This research aims to develop a mathematics module based on Problem-Based Learning (PBL) for straight-line equation material, designed to enhance students' mathematical problem-solving skills at SMP Negeri 1 Pasir Penyu. The study employed a Research and Development approach, utilizing a 4-D development model that includes the stages of Define, Design, Develop, and Disseminate. The subjects were eighth-grade students at SMP Negeri 1 Pasir Penyu. Data collection instruments included validation sheets to evaluate the module's validity and student response questionnaires to assess its practicality. The module was tested in two phases: a small group trial and a large group trial. Results from the small group trial indicated that the module achieved an average score of 3.66, categorizing it as highly practical. Similarly, the large group trial yielded an average score of 3.57, also placing the module in the very practical category.

Keywords: mathematical problem-solving skills, problem-based learning, mathematics modules, development.

ABSTRAK Penelitian ini bertujuan untuk mengembangkan modul matematika berbasis Problem-Based Learning (PBL) pada materi persamaan garis lurus, yang dirancang untuk meningkatkan keterampilan pemecahan masalah matematika siswa di SMP Negeri 1 Pasir Penyu. Penelitian ini menggunakan pendekatan Research and Development, dengan model pengembangan 4-D yang mencakup tahapan Define, Design, Develop, dan Disseminate. Subjek penelitian ini adalah siswa kelas VIII di SMP Negeri 1 Pasir Penyu. Instrumen pengumpulan data meliputi lembar validasi untuk menilai validitas modul dan kuesioner tanggapan siswa untuk menilai tingkat kepraktisan modul. Modul ini diuji dalam dua tahap: uji coba kelompok kecil dan uji coba kelompok besar. Hasil uji coba kelompok kecil menunjukkan bahwa modul matematika tersebut memperoleh skor rata-rata 3,66, yang termasuk dalam kategori sangat praktis. Demikian pula, hasil uji coba kelompok besar menunjukkan skor rata-rata 3,57, yang juga masuk dalam kategori sangat praktis.

Keywords: kemampuan pemecahan masalah matematis, PBL, modul pembelajaran.

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INTRODUCTION

Mathematical learning in schools aims to cultivate students' ability to think logically, critically, and analytically, while fostering a careful, thorough, and responsible attitude. Students are also expected to be responsive, persistent in solving problems, curious, have a strong sense of self-confidence, and possess a continuous passion for learning, especially in mathematics. Additionally, students should be able to clearly convey mathematical ideas in both group interactions and daily activities (Permendikbud Number 21 of 2016).

Education prepares students to face the demands of the 21st-century skills, including Creativity, Collaboration, Critical Thinking, and Communication. Mathematics learning plays a crucial role in achieving these skills, aligning with its goal to develop students' problem-solving, communication, reasoning, connection, and representation skills (NCTM, 2000).

However, students' mathematical problem-solving skills remain relatively low. This is evident from the Programme for International Student Assessment (PISA) results, where Indonesia ranked 72nd out of 78 participating countries in 2018 (OECD, 2019). The low problem-solving skills are further highlighted by the Trend International Mathematics and Science Study (TIMSS) results, where Indonesia ranked 44th out of 49 countries in 2015, with an average score of 397, below the international average of 500.

Rohani (2015) in his survey on "Current situation on mathematics and science education in Bandung," sponsored by JICA, found that solving mathematical problems is considered essential by both teachers and students across all educational levels, from elementary to high school. However, it remains one of the most challenging aspects of mathematics for both students and teachers.

Using modules as teaching materials offers an effective solution to overcome learning obstacles, particularly in enhancing students' mathematical problem-solving skills (Amalia et al., 2019). Modules provide several advantages, including offering feedback, clearly detailing learning objectives, improving student motivation through engaging design, flexibility in learning pace and style, reducing competition and promoting cooperation among students, and providing opportunities for self-assessment and remediation (Ramadhany et al., 2020).

To optimize mathematical modules, an appropriate learning model is essential to facilitate students' problem-solving skills. Sumartini (2016) asserts that problem-based learning is designed to develop students' thinking, problem-solving, and intellectual skills. Problem-Based Learning (PBL) is one such model that engages students in direct problem-solving during the learning process, enhancing their understanding of the material (Anggraini, 2018).

Research by Elita et al. (2019) showed that students in an experimental class using a problem-based learning model scored higher (average 72.58) than those in a control

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class (average 65.00), indicating the positive impact of PBL on students' problem-solving skills. Similarly, studies by Ningsih et al. (2023) and Agustin et al. (2024) found that PBL improves both the learning process and students' problem-solving abilities. Ulva et al. (2020) also observed better improvement in students' problem-solving skills with the application of the PBL model.

Based on this background, this study developed a mathematical module based on the Problem-Based Learning model, specifically focusing on the straight line equation material, to enhance the problem-solving skills of grade VIII junior high school students.

METHODS

This research employs the Research & Development (R&D) method using the 4-D model, which is based on the development theory by Thiagarajan (as cited in Sugiyono, 2017). The 4-D model consists of four stages: Define, Design, Develop, and Disseminate. The Define stage involves several key activities, including early-to-end analysis, student analysis, concept analysis, task analysis, and the formulation of learning objectives. The aim is to identify the core problems faced by students, understand their learning characteristics, identify learning materials based on basic competencies, and formulate specific learning goals.

In the Design stage, test standards are prepared, media and format selections are made, and the initial design of the mathematical modules is carried out. The outcome of this phase is the first draft of the mathematical modules, which are developed based on feedback from the supervising lecturer. The Develop stage involves testing the validity and practicality of the modules. The validity of the modules is assessed by three validators, while practicality is tested through small group trials involving six students and large group trials involving 26 students from the 8th grade at SMP Negeri 1 Pasir Penyu. In the final Disseminate stage, the mathematical modules are packaged as a book for broader distribution.

Qualitative data for this study were gathered from expert lecturers, mathematics teachers, and student feedback on the mathematical modules. Additionally, quantitative data were collected from the validation sheet scores provided by the validators and the response scores from students using the modules. Data analysis focused on assessing both validity and practicality. Validity analysis was performed to determine the extent to which the mathematical modules were valid, using a specific formula adapted from Sudijono (2011) that calculates the final average validation score based on the assessments from the expert validators.

$$\overline{X}_V = \frac{\sum_{i=1}^{n} \overline{V}_i}{n}$$

(adapted from Sudijono, 2011)

Where:

$\overline{X}_V$ represents the final average validation score

$\overline{V}_i$ represents the validation assessment from each expert

n is the number of expert validators involved

The results obtained can be seen in the following Table 1.

Table 1. Validation Assessment Criteria

Interval	Category
$3{,}25 < \overline{X}_V \leq 4{,}00$	Very Valid
$2{,}50 < \overline{X}_V \leq 3{,}25$	Valid
$1{,}75 < \overline{X}_V \leq 2{,}50$	Less Valid
$1{,}00 < \overline{X}_V \leq 1{,}75$	Not Valid

Source: Arikunto (2012)

A mathematics module is considered suitable for testing at least the validity level reaches the valid category. Practicality analysis using the following formula.

$$\bar{X}_P = \frac{\sum_{i=1}^{n} \bar{P}_i}{n}$$

Where:

$\bar{X}_P$ is the final average score of practicality

$\bar{P}_i$ is the practicality assessment score from the *i* th student.

n is the number of students who completed the questionnaire

Then a conclusion is drawn based on the practicality criteria in the following Table 2.

Table 2. Practicality Assessment Criteria

Interval	Category
$3{,}25 < \overline{X}_P \leq 4{,}00$	Very Practical
$2{,}50 < \overline{X}_P \leq 3{,}25$	Practical
$1{,}75 < \overline{X}_P \leq 2{,}50$	Less Practical
$1{,}00 < \overline{X}_P \leq 1{,}75$	Not Practical

Source: Arikunto (2012)

The development mathematics module is said to be practical if the average final practicality meets the practical criteria at the minimum.

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FINDING AND DISCUSSION

As outlined in the research methodology, this study applies the 4-D model in product development. Here is a description of the research results from each stage that has been carried out. The defining stage consists of initial and final analysis, learner analysis, task analysis, concept analysis, and formulation of learning objectives. In the initial and final analysis, the researcher observes the learning process and the teaching materials used. The observation results show that the teaching materials used by teachers and students are the 2013 curriculum mathematics textbook for eighth grade junior high school/ Madrasah Tsanawiyah from the government and student worksheets. Although the student worksheets have been introduced, their use has not consistently included indicators of mathematical problem-solving skills, which has resulted in a lack of experience for students in solving mathematical problems. In addition, the teaching materials used have not directly facilitated students in discovering and applying mathematical concepts, which has not encouraged them to learn independently.

In the analysis of students, it appears that the learning process still tends to be teacher-centered. The learning process expected in the 2013 Curriculum is student-centered learning, aimed at creating meaningful learning experiences. According to Piaget (Marinda, 2020), eighth-grade students in junior high school have reached a level of ability to think logically and draw conclusions at that stage of development. Therefore, students can use the mathematics module with the Problem Based Learning model. In the task analysis, the researcher identifies the tasks performed by the students to learn the material provided. The tasks were analyzed based on Core Competencies and Basic Competencies, by formulating Competency Achievement Indicators. In the concept analysis, the researcher identified and systematically organized concepts relevant to the material of linear equations. The result of this analysis is a concept map about the material of linear equations. In formulating the learning objectives, the researcher defined the learning goals based on the previously established GPA. The learning objectives serve as a reference in the development of mathematics modules to foster the desired changes in learning behavior among students.

The design stage consists of developing test standards, selecting media, choosing formats, and creating an initial module design. In the development of test standards, the researcher designs a validation sheet for the mathematics module and a questionnaire for student responses. There are several types of learning media, including print, audio, voice slides, video, interactive multimedia, e-learning, and digital/electronic media. In this study, the chosen medium for developing the mathematics module is print media. In the selection of the format, the researcher designed the mathematics module according to the steps of the PBL model. The structure of the mathematics module writing is based on the Ministry of Education and Culture Regulation Number 8 of 2016, which consists of the cover of the

mathematics module, the introduction section, the content section, and the conclusion section. The cover of the mathematics module contains the Tut Wuri Handayani logo, the Universitas Riau logo, the 2013 Curriculum logo, the title of the mathematics module, the name of the researcher and the supervising lecturer, the school level and semester, as well as supporting images.

The introduction section includes a description of the module, instructions for using the module, Core Competencies, Basic Competencies, and a concept map. The content section presents information about Competency Achievement Indicators, learning objectives, and a description of the material. The material description includes student activities that refer to the steps of the PBL model for the topic of linear equations, namely orienting students to the problem, organizing students for learning, conducting individual or group investigations, developing and presenting results, as well as analyzing and evaluating the problem-solving process. The material description also contains example questions, summaries, and practice questions. The closing section contains formative tests, self-assessment for students as feedback, and a bibliography which is a list of references used in compiling the mathematics module. After the selection stage for the format of the mathematics module, the next step is to draft the initial design of the mathematics module. At this stage, the product is designed according to the needs and input from the supervising lecturer.

The Development stage, the mathematics module that has been created based on the initial design using the PBL model, was then validated by three validators. The results of the validation of the mathematics module can be seen in Table 3 below.

Table 3. Results of the Mathematics Module Validation

Evaluated Aspects	Average Score of the Three Validators			Average	Category
	1	2	3		
Appearance	3,71	3,71	3,86	3,76	Very Valid
Language	3,33	3,67	3,67	3,56	Very Valid
Content Suitability	3,22	3,67	3,89	3,59	Very Valid
Presentation	3,86	3,57	4,00	3,81	Very Valid
Average	3,53	3,65	3,85	3,68	Very Valid

Based on the assessment from the three validators, it was found that the average validation score is 3.68, categorized as very valid. This result is in line with the research conducted by Khayati et al. (2016). In addition to providing assessments, validators also offer comments and suggestions as a way to refine the module before it is tested with students. Some comments and suggestions from the validators regarding the mathematics module include: 1) improving the captions for the images in Learning Activity 1; 2) revising the wording of the practice questions in Learning Activity 1; 3) revising the wording of the example questions in Learning

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Activity 3 to make them easier to understand; and 4) adding educational images in the empty spaces.

The mathematics module that has been validated and revised according to the comments and suggestions from the validators will next undergo small group trials and large group trials. A small group trial was conducted involving 6 students from class VIII.1 of SMP Negeri 1 Pasir Penyu, consisting of students with heterogeneous abilities. The trial aimed to assess the practicality of the mathematics module and to observe the responses of the small group of students towards the mathematics module before it is used with a larger group. During the trial, students were instructed on how to use the mathematics module and were asked to complete the tasks included in the module. After working on the mathematics module, students were asked to fill out a response questionnaire containing their feedback on the module. The results of this trial are presented in the following Table 4.

Table 4. Results of the Questionnaire for Small Group Student Participants

Evaluated Aspects	Average Score of Small Group						Average	Category
	1	2	3	4	5	6		
Display	4,00	4,00	4,00	4,00	4,00	4,00	4,00	Very Practical
Content	3,33	3,67	3,17	3,17	3,33	3,33	3,33	Very Practical
Language	4,00	4,00	4,00	3,00	4,00	3,00	3,67	Very Practical
Average	3,77	3,89	3,72	3,39	3,77	3,44	3,66	Very Practical

Based on the results of the small group trial, it shows that the mathematics module meets the criteria of being very practical, with an average score of 3.66.

The next step is a large group trial to assess the practicality of using the math module on a broader scale. A large group trial was conducted involving 26 students from class VIII.2 of SMP Negeri 1 Pasir Penyu. During this trial, the activities and responses of the students were observed while they worked on the math module. Initially, the students were still confused about working on the math module, but after they began to understand how to tackle it, they appeared interested and enthusiastic about engaging in the activities within the math module. They actively asked questions when they encountered confusion, and there was active communication among the students. Overall, the large group trial process went smoothly. The results of this trial are presented in the following Table 5.

Table 5. Results of the Questionnaire for Large Group Student Participants

Evaluated Aspects	Average	Category
Display	3,61	Very Practical
Content	3,37	Very Practical

Evaluated Aspects	Average	Category
Language	3,73	Very Practical
Average	3,57	Very Practical

Based on the results of the large group trial, the average score obtained is 3.57, categorized as very practical. This result is in line with the research conducted by Khayati et al. (2016). The Disseminate stage involves packaging the validated and practical mathematics module in the form of a book, which is then distributed by providing the book to the school, namely SMP Negeri 1 Pasir Penyu, so that it can be understood and utilized by the school.

CONCLUSIONS AND RECOMMENDATIONS

Based on the final assessment of validity and practicality, it has been established that the mathematics module grounded in problem-based learning for the topic of linear equations is highly effective in facilitating the development of mathematical problem-solving skills among eighth-grade junior high school students. The thorough evaluation of this module demonstrates its ability to serve as a practical tool that not only enhances students' understanding of linear equations but also strengthens their overall problem-solving abilities in mathematics. This module stands out as a valuable resource that can be integrated into the classroom setting to provide students with engaging and challenging opportunities to apply their mathematical knowledge in solving real-world problems.

Given the positive outcomes associated with this module, it is recommended that future research continues to explore the development of mathematics modules that address a broader range of learning objectives. Specifically, future studies could focus on creating modules that target the enhancement of student engagement, motivation, and the overall effectiveness of the learning experience. Additionally, it would be beneficial to investigate the application of different instructional strategies within mathematics modules, such as collaborative learning or technology-enhanced learning, to further support and expand students' mathematical problem-solving skills.

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