

THE DEVELOPMENT OF PROBLEM-BASED LEARNING WORKSHEETS TO FACILITATE MATHEMATICAL PROBLEM-SOLVING SKILLS IN RELATION AND FUNCTION TOPICS

Risma Yanti¹, *Nahor Murani Hutapea², Rini Dian Anggraini³

^{1,2,3} Universitas Riau, Indonesia

nahorm.hutapea@lecturer.unri.ac.id

ABSTRACT This research aims to develop student worksheets for eighth-grade mathematics, focusing on the topics of Relations and Functions, using a Problem-Based Learning approach. The development process followed the 4D model, which includes the stages of defining, designing, developing, and disseminating. The research instruments used were validation sheets and student questionnaires. After the preparation stage, the worksheets were evaluated by three validators and revised based on the feedback received. Data analysis showed an average validation score of 89.12%, indicating a very high level of validity. Subsequently, the validated worksheets were tested on a small group of students, resulting in a practicality score of 80.28%, which is classified as very practical. This research successfully produced valid and practical worksheets for eighth-grade mathematics, particularly in the topics of relations and functions.

Keywords: mathematical problem-solving skills, problem-based learning, students worksheets, function.

ABSTRAK Pembelajaran Berbasis Masalah. Proses pengembangan mengikuti model 4D yang meliputi tahap mendefinisikan, merancang, mengembangkan, dan menyebarkan. Instrumen penelitian berupa lembar validasi dan kuesioner yang diberikan kepada siswa. Setelah tahap persiapan, lembar kerja dievaluasi oleh tiga validator, kemudian direvisi berdasarkan umpan balik yang diperoleh. Hasil analisis data menunjukkan rata-rata nilai validasi sebesar 89,12%, yang mengindikasikan tingkat validitas yang sangat tinggi. Selanjutnya, lembar kerja yang telah divalidasi diuji coba pada kelompok kecil siswa dan menghasilkan nilai praktikalitas sebesar 80,28%, yang termasuk dalam kategori sangat praktis. Penelitian ini berhasil menghasilkan lembar kerja yang valid dan praktis untuk pembelajaran matematika kelas delapan, khususnya pada materi relasi dan fungsi.

Keywords: kemampuan pemecahan masalah matematis, PBL, lembar kerja peserta didik, relasi dan fungsi.

INTRODUCTION

Mathematics, as a fundamental branch of science, has experienced significant development and plays an important role in education (Sundayana, 2016). The success of mathematics in supporting the advancement of scientific knowledge makes it essential to be learned by all levels of society, especially students as the future generation of the nation. The process of learning mathematics requires active involvement from both teachers and students, and the achievement of mathematics learning goals can be effectively accomplished if it involves active participation from all students.

According to the Ministry of Education and Culture Regulation No. 21 of 2016 concerning the Content Standards for Primary and Secondary Education, one of the main objectives of mathematics education is to enhance students' mathematical problem-solving skills. According to Hafriani (2021), mathematical problem-solving skills are essential competencies that students need to master while studying mathematics. This ability is crucial as it enables students to understand and solve problems encountered in mathematical contexts.

Hendriana and Soemarmo recognize problem-solving skills as one of the most crucial components of mathematics education (Agustami, Aprida, & Pramita, 2021). This perspective highlights that the ability to solve problems is fundamental to the discipline of mathematics. Suherman (in Fitria, 2018) further emphasized that the importance of students' problem-solving abilities lies in the development of key aspects of mathematics, including the application of rules to non-routine problems, identifying patterns, and developing skills through problem-solving activities.

Mathematical problem-solving skills are a critical aspect of mathematics learning (Mariani & Susanti, 2019). Pattimura, Hutapea, & Maimunah (2020) also emphasized the importance of these skills not only in solving mathematical problems but also in addressing problems in various fields of knowledge and everyday life. These skills align with the development of mathematics education, which focuses on meeting contemporary challenges. Mastery of problem-solving abilities is considered essential, as it enables students to overcome various challenges in everyday life and find solutions to the problems they face.

Every three years, the Organization for Economic Cooperation and Development (OECD) conducts the Programme for International Student Assessment (PISA), an international assessment program that measures students' proficiency in reading, mathematics, and science. PISA covers four categories in mathematics, namely quantity, space and shape, uncertainty and data, as well as change and relationships. Indonesia's low ranking in the 2018 PISA study indicates that students' mathematical problem-solving skills still fall short of expectations. Out of 77 participating countries, Indonesia ranked 72 (Maharani & Aini, 2021).

Research conducted at SMP Negeri 31 Pekanbaru (Nufus, Wira, & Kurniati, 2019) revealed that the average score of students' mathematical problem-solving skills was only 39.5, indicating a low level of proficiency. When 28 junior high school students were given a test on problem-solving indicators, Prastiwi and Nurita (2018) found that more than half of the students struggled with understanding problems, formulating a solution plan, executing the plan, and reviewing the results. These difficulties likely arose because students were accustomed to being given and guided through problems, rather than finding and solving them independently.

Research at SMP IT As-Sajadah Pekanbaru also revealed that students' mathematical problem-solving skills were low. Only 46% of the students were able to correctly identify the known and asked elements of a problem, and only 10% were able to formulate the problem correctly. An even lower result was found in the indicator of applying problem-solving strategies, with only 6% of students answering the questions correctly, and none of the students were able to draw a final conclusion from the problem-solving process. These low problem-solving skills are suspected to be due to the lack of variety in the mathematics teaching methods used by teachers.

Problem-Based Learning (PBL) is one of the three teaching models used in the 2013 Curriculum, as regulated by the Ministry of Education and Culture Regulation No. 103 of 2014. Through several stages, this approach is implemented to motivate students to actively engage in problem-solving, improve problem-solving skills, and foster positive attitudes toward mathematics learning (Maryati, 2018). Arends asserts that Problem-Based Learning enables students to tackle real-life problems, build knowledge, develop critical thinking, foster independence, and build self-confidence (in Sumartini, 2016).

The Problem-Based Learning model, according to Wondo (2017), encourages students to interact and share knowledge, potentially enhancing their problem-solving abilities. In this context, Wondo also emphasized that PBL can improve the quality and activity of students through meaningful learning, where they are actively involved in discussions to identify, understand, and solve problems using various knowledge resources. Nurfitriyanti's (2016) research confirmed that the application of Problem-Based Learning effectively has a positive impact on students' mathematical problem-solving skills.

However, one of the ongoing challenges in the learning process is the lack of variety in the media used by teachers, which has the potential to hinder students' problem-solving abilities. To address this issue, innovation is needed in the form of student worksheets. Worksheets are learning materials that include questions and guidance to increase students' engagement and participation during the teaching and learning process (Ali, Nurhanurawi, & Noer, 2022). Therefore, teachers need to design mathematics lessons that are engaging and meaningful to address the low level of students' mathematical problem-solving skills.

Furthermore, mastery of the concepts of relations and functions is considered crucial in mathematics education at the junior high school level (Anggreni, Busrah & Gusniwati, 2022). Research shows that students often struggle to understand math problems due to a lack of accuracy in reading and translating the questions. Agustin & Ruli (2023) also found that junior high school students experience difficulties in using the concepts of relations and functions because of their challenges in translating problems, making it difficult for them to apply the appropriate formulas.

Based on these findings, the researcher is interested in developing student worksheets by applying the Problem-Based Learning model. These worksheets are designed as learning resources that not only provide material but also offer guidance and motivation to students. The goal is to encourage active learning and facilitate the development of students' mathematical problem-solving skills.

METHODS

This research falls under the category of development research (Research and Development), focusing on the development of student worksheets. The R&D method was employed to produce a specific educational product. In this study, the researcher utilized the 4-D development model proposed by Thiagarajan. The 4-D model was chosen because it is suitable, easy to implement, and has a well-structured development process that is clear at every stage. The 4-D model includes four stages: define, design, develop, and disseminate.

The participants in this study were 18 eighth-grade students from SMP IT As-Sajadah. The instruments used were expert validation questionnaires and student response questionnaires to assess the validity and practicality of the developed student worksheets. Data analysis for validity was conducted based on the expert validation questionnaires, while practicality was evaluated using the student response questionnaires.

The product is considered suitable for testing if it meets the validity criteria with a minimum average score of 70%. The product is categorized as valid if it falls into the valid or highly valid category. Similarly, the product is considered practical for use if it meets the practicality criteria with a minimum average score of 70%. The product is categorized as practical if it falls into the practical or highly practical category.

Table 1. Validation and Practicality Criteria for Student Worksheets

Achievement Level (A)	Validation Criteria	Practicality Criteria
$A \geq 80$	Very Valid	Very Practical
$70 \leq A < 80$	Valid	Practical
$50 \leq A < 70$	Less Valid	Less Practical
$A \leq 50$	Not Valid	Not Practical

FINDING AND DISCUSSION

The result of this development research produced a product in the form of student worksheets aimed at supporting the mathematical problem-solving skills of eighth-grade students at SMP/MTs in learning about relations and functions.

In the define stage, the activities conducted included evaluating and analyzing the needs required for the development process. This stage involved an initial and final analysis, an analysis of student characteristics, a concept analysis, and the specification of learning objectives. From interviews with a mathematics teacher at SMP IT As-Sajadah, it was found that the teaching method used at the school was predominantly lecture-based, where the teacher explained the material on the blackboard, gave example problems, and concluded with problem-solving exercises. The teacher relied solely on the textbook as a learning resource.

An analysis of student characteristics showed that the subjects of this study were eighth-grade students aged between 13 and 15. According to Jean Piaget's cognitive development theory, students of this age are typically in the formal operational stage, where they are capable of formulating hypotheses about a problem, thinking abstractly, and using logical reasoning. These abilities enable students to think more complexly and solve problems in a more abstract manner.

A concept analysis was conducted to identify and detail the learning material in line with the 2013 curriculum for eighth-grade students. The material was divided into five sessions, covering topics such as: representing relations in arrow diagrams, Cartesian diagrams, and sets of ordered pairs; determining the domain, codomain, and range of functions; solving relations through diagram representations; and understanding one-to-one correspondence relations.

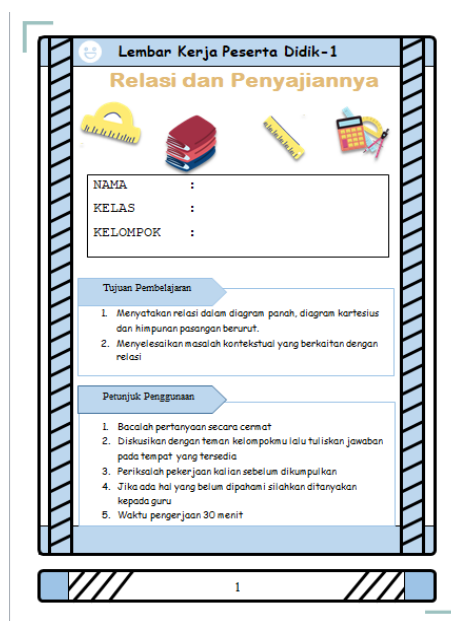


Figure 1. Student Worksheet Front Page

In the design stage, the researcher developed the format for the student worksheets, which included a front page and main content. The front page contained the title, learning material, learning objectives, student identity, and worksheet instructions. The design of the front page can be seen in Figure 1.

The content of the student worksheets was designed using the Problem-Based Learning (PBL) model, which consists of five main steps. In the student orientation phase, the worksheet presents problems relevant to the topic of relations and functions. The design of the worksheet content for the orientation phase can be seen in Figure 2.



Figure 2. Worksheet Content in the Student Orientation Phase to the Problem

In the develop stage, the designed student worksheets were validated by three validators. The validation results for the worksheets on relations and functions for eighth-grade students at SMP/ MTs are shown in Table 3 below.

Table 2. Validation Results of the Student Worksheets

Aspect Evaluated	Validator			Average Score	Category
	1	2	3		
Student Worksheet Front Page Appearance	100.00	100.00	95.00	98.33	Very Valid
Student Worksheet Content	90.83	85.83	97.50	91.39	Very Valid
Student Worksheet Suitability with PBL Model	100.00	100.00	100.00	100.00	Very Valid
Student Worksheet Suitability with Problem-Solving Indicators	75.00	91.67	75.00	80.56	Very Valid

Aspect Evaluated	Validator			Average Score	Category
	1	2	3		
Compliance with Didactic Requirements	81.25	93.75	78.75	84.58	Very Valid
Compliance with Construction Requirements	85.00	90.00	90.00	88.33	Very Valid
Compliance with Technical Requirements	80.63	75.00	86.25	80.63	Very Valid
Average Score	87.53	90.89	88.93	89.12	Very Valid

The validation results for the five sessions of the student worksheets, as shown in the table above, indicate that the average validation score reached 89.12%, signifying a very high level of validity. Based on this score, the worksheets are considered ready for trial testing after making revisions based on the validators' suggestions.

The next stage involved a small group trial with 18 eighth-grade students at SMP IT As-Sajadah. The goal of the trial was to assess the practicality of the developed worksheets. Each student was asked to fill out a response questionnaire to evaluate the practicality of the worksheets. The results of the student response questionnaire for the small group trial can be seen in Table 3.

Table 3. Student Response Questionnaire Results for the Small Group Trial

Aspect Evaluated	Student worksheet					Average Score	Category
	1	2	3	4	5		
Worksheet Appearance Attracts Student Interest	80.90	82.29	81.60	82.99	82.29	82.01	Very Practical
Student Interest in Learning with the Worksheet	82.41	82.87	82.87	82.41	82.87	82.69	Very Practical
The Worksheet is Practical	81.02	80.09	79.63	79.63	79.63	80.00	Practical
The Worksheet Increases Student Learning Activity	79.17	78.47	77.08	77.78	78.47	78.19	Practical
The Worksheet Stimulates Student Thinking	79.63	79.17	80.09	79.63	80.09	79.72	Practical
Using the Worksheet Saves Time	80.09	78.24	79.17	78.24	79.63	79.07	Practical
Average Score	80.54	80.19	80.07	80.11	80.50	80.28	Very Practical

Based on the student response questionnaires, the mathematics worksheets designed to support the students' mathematical problem-solving skills received an average score of 80.28%, placing them in the very practical category.

In the disseminate stage, the developed student worksheets were packaged in book format and provided to SMP IT As-Sajadah for use in their teaching practices. The cover design of the product can be seen in Figure 3.



Figure 3. Student Worksheet Cover

This study began with the define stage, which focused on identifying the initial problem: the lack of teacher-made worksheets in the teaching process due to time constraints. After progressing through the design, development, validation, and trial stages, the developed student worksheets proved to be valid and very practical for teaching the topic of relations and functions to eighth-grade students.

CONCLUSIONS AND RECOMMENDATIONS

Based on the research results, the student worksheets developed show a very high level of validity, with an average score of 89.12%. Evaluations of aspects such as appearance, content, alignment with the Problem-Based Learning model, as well as didactic, construction, and technical criteria, all fall into the highly valid category. The highest scores were achieved in appearance (98.33%) and alignment with the Problem-Based Learning model (100.00%).

The worksheets also meet didactic, construction, and technical standards, with scores of 84.58%, 88.33%, and 80.63%, respectively, confirming that the product is effectively designed and adheres to educational standards. In addition to being valid, the worksheets are practical and support students' mathematical problem-solving skills.

As a recommendation, further research should include field testing to assess the effectiveness of these worksheets in broader learning contexts.

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