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Developing problem-based learning worksheet of relations and functions topic to support students' conceptual understanding

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Abstract

This research is qualitative research with design research methods and a development research type aiming to produce valid and practical worksheets on relational and functional materials based on problem-based learning (PBL) to support students' conceptual understanding. The learning process is carried out in the classroom with learning activities, accompanied by a student's worksheet, which consists of 2 questions. The subjects of this study were students of class VIII 10 of SMP Negeri 8 Palembang, with 6 students as the focus of the research. There are 2 stages in this research, namely: (1) preliminary stage and (2) prototyping stage (formative evaluation), which is divided into 5 stages, namely (1) self-evaluation, (2) expert review, (3) one to one, (4) small group and (5) field test. This research was conducted based on the learning system in schools with data collection techniques, namely walkthroughs, tests, interviews, and questionnaires, to be collected and analyzed qualitatively to see the validity and practicality of the worksheet. The results of this study will show that the worksheet that has been made is valid, as seen from the results of the expert review and practical validation sheets obtained from the questionnaire results, with an average of 84.03%, which is included in the valid and practical categories. The developed worksheet also supports understanding PBL-based concepts (Problem-Based Learning) in solving problems given in relation and function material, which can be seen from the overall student test results.

Keywords: relations and functions; development research; worksheet; PBL; conceptual understanding

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I. Introduction

Mathematics is also the main subject found in elementary school to college, so with mathematics, students can change their mindset to be creative and innovative in solving problems related to everyday life and have an important role in various aspects of life (Sari et al., 2020). So that students can solve problems related to mathematics in everyday life by learning mathematics (Nuryadi et al., 2018). Based on Permendikbud Number 24 of 2016, in learning the 2013 curriculum, there are competencies that students at the secondary education level must master. Namely, students must understand, apply and analyze factually, conceptually, and procedurally to solve mathematical problems.

Meanwhile, According to the National Council of Mathematics Teachers (Handayani, 2021) (NCTM, 2000), the objectives of learning mathematics contained in the aspects of mathematical thinking skills are (1) conceptual understanding, (2) problem-solving, (3) reasoning, (4) proof and (5) connection, and representation. Based on the description, students must have several abilities to achieve the objectives of learning mathematics, one of which is understanding concepts.

One of the mathematics materials that require understanding concepts is the relation and function material for class VIII SMP. Relation and function material is also important for students to continue with the material of straight-line equations, functions, or functional relationships between mathematical elements and linear equations. Students can easily understand and solve a problem, so this relation and function material becomes a prerequisite to this stage next (Akbar et al., 2020). The material of relations and functions is also the basic material used to enter the next material, for example, the limit of functions, derivatives, and others (Pratiwi et al., 2021). Concept understanding is a process of understanding the relationship between concepts through factual knowledge or examples (Finamore et al., 2021).

The ability to understand concepts is very important for students. Students can use the ability to understand mathematical concepts to look for new ideas in the form of mathematical concepts from information collected as new statements from several other statements that have been known by understanding the problems that exist in problem-solving (Asmana et al., 2018). According to (Kilpatrick, 2013) states that understanding concepts are mathematical ideas, so it refers to an integrated understanding. Good concepts will help one understand statements as facts behind mathematical ideas. Students who have good concept understanding skills will easily re-explain concepts,

However, in reality, students still have low concept understanding skills, causing difficulties in understanding mathematical concepts in problems (Sari et al., 2020; Novitasari, 2016). In line with research (Korstjens & Moser, 2018) that students still cannot meet the indicators of concept understanding ability, namely re-explaining concepts, stating concepts with various representations, and applying concepts, so there are still many students who do not understand the material being studied. This is in line with the results of research conducted by Pratama (2020), which states that the level of understanding of students' concepts is still low because students have not been able to explain the requirements of a function and have not been precise in re-explaining the concept of relationship and function and not yet appropriate in applying the concept of relationship and function.

This is because students still have difficulty connecting mathematical concepts with other concepts and are still not used to solving mathematical problems with real-world concepts or non-routine problems (Handayani & Wandini, 2020). In line with what was stated by (Korstjens and Moser, 2018 Fransiska et al., 2022), teaching materials are less interesting and still contain questions that cause students not to understand the concepts in the material being taught. The model applied in learning also does not follow the material being taught (Widiastuti & Kurniasih, 2021).

Based on the problems above, teaching material supporting learning is required. Teaching materials are one of the learning tools teachers use to convey messages and teaching materials to students efficiently and effectively. So, teaching materials can help students learn actively and be a bridge for students to think and understand concepts (Setiyani et al., 2020). Therefore, selecting the right teaching materials to achieve learning objectives is necessary. One of them is the student's worksheet. According to the understanding indicators, the worksheet is a collection of several activities students must complete to achieve the ability. The worksheet is also used for learning activities following Basic

Competencies (KD), attracting student learning interest and motivating students to learn (Syabani et al., 2018). The worksheet must also be prepared based on the right learning model so that the results will impact student development in learning activities.

Researchers will combine it with a problem-based learning model or problem-based learning (PBL) that is appropriate to increase creativity, mindset, and student activities by using problems in everyday life in learning activities. PBL is designed so that students can understand mathematical concepts to solve problems in relation to and function material. This learning model influences students' abilities, especially the ability to understand concepts in solving a problem (Akbar et al., 2020).

Problem-based learning (PBL) is a learning approach containing contextual problems so students can see problems in everyday life or the real world. Applying problems in the real world in the Problem-Based Learning (PBL) model can provide positive learning conditions or opportunities. This learning model is also an innovative learning model developed from the curriculum for problem-based learning (Nurdyansyah & Fahyuni, 2016). So, problem-based learning in the learning process to solve problems or challenges in everyday life uses a systematic method so that students can solve the problems they face by learning to understand the problem and collect information (Yuniati et al., 2020).

Thus, the problem-based learning (PBL) learning model is expected to improve students' understanding of mathematical concepts related to functional material. Based on research (Kilpatrick, 2010), the results of student's ability to understand mathematical concepts are higher, so the Problem-Based Learning (PBL) model greatly influences students' ability to understand mathematical concepts. Meanwhile, research (Azzahra, 2019) states that Problem-Based Learning (PBL)-based worksheets are valid and practical and can improve students' conceptual understanding.

Research Method

The research used is qualitative, using a research design method and a development study type. According to Tessmer (1993), in carrying out qualitative research using design research methods with the type of development study, researchers are required to conduct 2 stages of research, namely the preliminary stage and the prototyping stage (formative evaluation), which is divided into 5 stages: self-evaluation, expert review, one-to-one, small group, and field test.

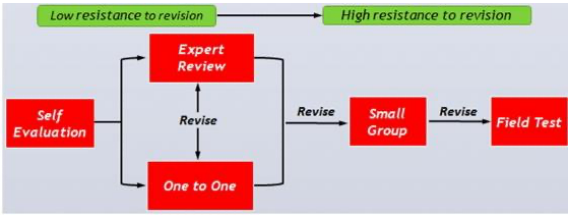

Figure 1. Formative evaluation design flow

In Figure 1, stage Introduction consists of 3 stages: preparation, analysis, and design. At the preparatory stage, preliminary observations will be made to select schools, research subjects to study, curriculum analysis, and worksheet analysis. In the selection of subjects based on certain criteria, namely students with the achievement of the standard of completeness of mathematics scores, which the school will determine, then at the analysis stage, student analysis, curriculum analysis and material analysis will be carried out following the curriculum of SMP Negeri 8 Palembang and at the stage of problem design in Based Learning.

Problem-based learning (PBL) is based on the worksheet to support students' conceptual understanding skills on relation and function material, and the Learning Implementation Plan (RPP) on relation and function material in Class VIII is based on problem-based learning (PBL). The researcher will make instrument validation sheets, tests, interview guidelines, and a questionnaire at this stage. In contrast, at the prototyping stage (Formative evaluation) and the self-evaluation stage, the researcher will review and evaluate the worksheet that has been made independently.

The results of this review and evaluation are in the form of the first prototyping of the worksheet. At the Expert Review stage, the validator will validate the results of the first prototyping compiled and evaluated by the researcher.

At the one-to-one stage, the worksheet in the first prototyping compiled and evaluated by the next researcher will be tested one-to-one to see the practicality of the questions in terms of clarity, ease of use, and student interest in the worksheet. Moreover, a questionnaire is used at the Prototyping stage (Formative Evaluation); at the self-evaluation stage, the researcher will review and evaluate the worksheet that has been made independently. The results of this review and evaluation are in the form of the first prototyping worksheet; at the Expert Review stage, the validator will validate the results of the first prototyping compiled and evaluated by the researcher.

At the one-to-one stage, the worksheet in the first prototyping compiled and evaluated by the next researcher will be tested one-to-one to see the practicality of the questions in terms of clarity, ease of use, and student interest in the worksheet. Moreover, a questionnaire is used in the Prototyping stage (Formative Evaluation); at the self-evaluation stage, the researcher will review and evaluate the worksheet that has been made independently. The results of this review and evaluation are in the form of the first prototyping worksheet; at the Expert Review stage, the validator will validate the results of the first prototyping compiled and evaluated by the researcher.

At the Expert Review stage, the validator will validate the results of the first prototyping that the researcher has compiled and evaluated.

This study's data collection and analysis techniques include walkthroughs, interviews, tests, and questionnaires. A walkthrough was conducted to collect suggestions and comments from expert reviews to see the validity of the worksheet based on construct, content and language. The expert review in this study consisted of two lecturers of Mathematics Education at Sriwijaya University and a mathematics teacher at SMPN 8 Palembang. The test is carried out at the field test stage, which aims to obtain data on the ability of students to understand concepts in solving problems in the developed worksheet.

This interview was conducted at the one-to-one and small group stages, aiming to explore comments and suggestions from students to find out the practicality of the worksheet. The comments and suggestions obtained are used to revise the worksheet. The questionnaire used is closed and given to determine student responses to the developed worksheet and determine the practicality of the developed worksheet. The questionnaire will be used at the one-to-one and small-group stages. The formula calculates data analysis of worksheet validity:

$$Percentage\ level\ of\ validity: = \frac{The\ number\ of\ scores\ obtained}{maximum\ scores}\ x\ 100\%$$

The validity of the instrument used a score of 1-4 according to the percentage interval of the result score and the interpretation criteria that have been previously determined.

Table 1. Percentage validity criteria

Criteria	Category
85.01%-100.00%	Very Valid
75.01%-85.00%	Valid
60.1%-75.00%	Quite Valid
50.01%-60.00%	Less Valid
<50.00%	Very Invalid

Analysis of test data using the formula:

$$T = \frac{The\ number\ of\ scores\ obtained}{scores} \times 100$$

(Utami et al., 2021)

The final grade category of students based on Table 2

Table 2. Value category

Value Interval	Category
81-100	Very good
61-80	Well
41-60	Enough

21-40	Not enough
0-20	Very less

(Utami et al., 2021)

II. Results and Discussion

The Preliminary stage consists of 3 stages: the preparation stage, the researcher makes initial observations to select schools and research subjects to be studied; the 2013 curriculum analysis and worksheet analysis. The selection of subjects is based on certain criteria, namely, students who have achieved the standard of completeness in mathematics scores that the school will determine. Next will be an analysis of students from subject teachers, then analyzed the curriculum that will be used and analyzed the material that is following the curriculum, and in the last stage at the Preliminary stage, namely designing problems in the worksheet based on Problem-Based Learning (PBL) to support students' conceptual understanding skills in relation and function material and compiling The Learning Implementation Plan (RPP) on relation and function materials in class VIII is based on Problem-Based Learning (PBL). Researchers are also at this stage making instrument validation sheets, tests, interview guidelines, and questionnaires.

The developed worksheet is problem-based on the main language of relations and functions adapted to the PBL model's stages: student orientation to problems, organizing students to learn, guiding individuals/groups, developing and presenting work, and analyzing and evaluating problem-solving processes. The presentation in the developed worksheet contains 5 stages of PBL. Every activity in the worksheet begins with a problem related to everyday/real life. Furthermore, the worksheet activities direct students, individually and in groups, to solve problems that the teacher guides.

Expert Review

At this stage, the results of the first prototype were validated by 3 experts in terms of content, construct, and language. The suitability of the material used with the applicable curriculum and conformity with KI and KD in the 2013 curriculum concept can be seen in the content. In terms of language, judging from the suitability of the language used with EYD, the sentences used are easy, do not cause multiple interpretations and do not offend someone. The validation results at the Expert Review from 3 experts were 83.3% in the valid category from Expert 1, 80% in the valid category from Expert 2, and 85% in the valid category from Expert 3.

Table 3. Validity of worksheet from expert review

Validity Category	Percentage (%)
Contents	80
Construct	76
Language	85

The worksheet was categorized as valid for 80% of the contents, 76% of the construct, and 85% of the language.

One-to-One

At this stage, in line with expert review validation, this one-on-one trial was carried out by students consisting of 4 students. The trial was conducted to see the clarity of the content, construction, and language used in the worksheet and the difficulties students had in solving problems with the worksheet. Students' comments and suggestions, as well as difficulties in understanding the use of words when students complete the worksheet, are then used to improve the developed worksheet. The results of the validation at the one-to-one stage can be seen in Table 6. Then the worksheet was revised so that prototype 2 was formed that met the valid criteria.

Small Group

At this stage, the revision results from the expert review and the difficulties experienced by students during one-to-one were revised to produce a second prototype that met the valid criteria. The results of the second prototype were tested in small groups of 16 students, with 4 students in each group.

The validity and practicality assessment results obtained from 31 respondents, with a

percentage value of 84.03%, show that the Problem-Based Learning (PBL) Relation and Function worksheet is valid and practical regarding content, context, and language. Then, students complete test questions to support their conceptual understanding skills in solving problems of material relations and functions. The following are the answers to the test questions from students, as shown in Figure 3, as follows:

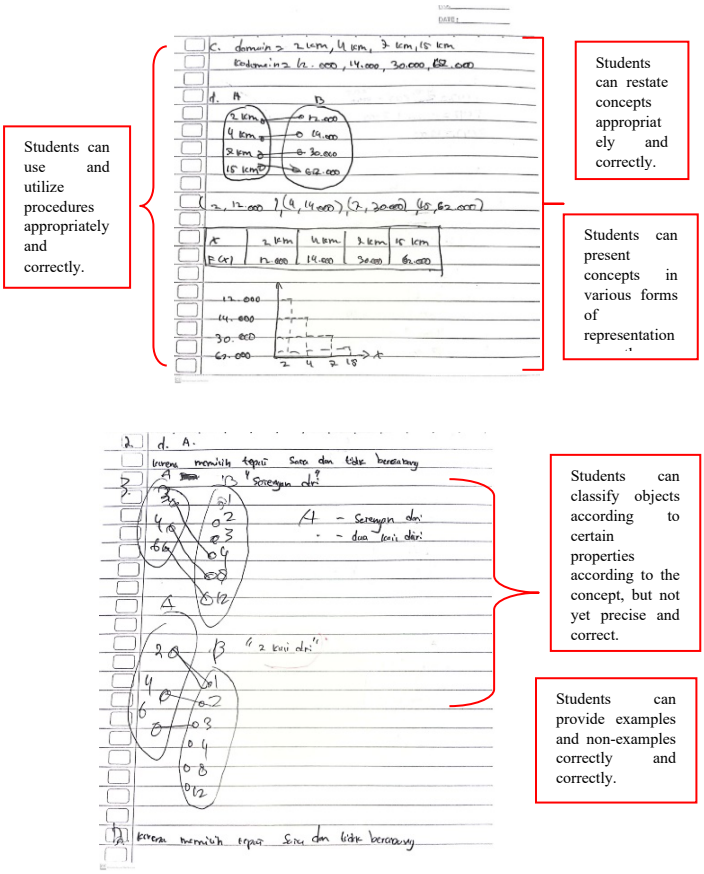

Figure 2. Student's answers 1

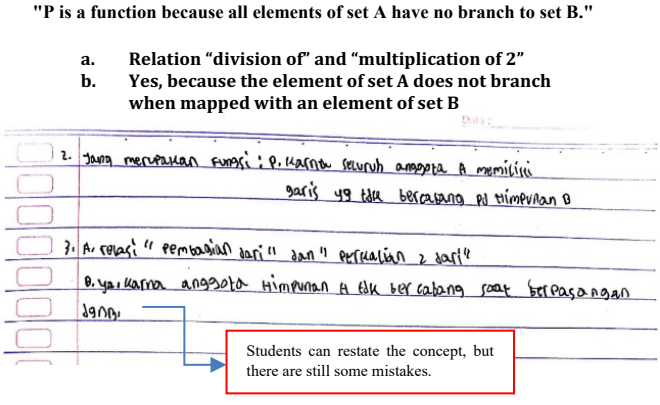

Figure 3. Student's answers 2

Based on the results of the student's answers, it can be seen that they had difficulties understanding the concept of relations and functions. The student had difficulty describing examples on arrow diagrams and has not been able to re-explain the concept of the example. Her answers also show that many errors still arise from each indicator of concept understanding. Some other results of student's answers showed many indicators of concept understanding given on the relation and function test questions; it appears that some students were able to restate concepts, classify objects, provide examples, use and utilize procedures, develop requirements according to concepts, state concepts with various representations and able to apply concepts in everyday life by solving the test questions. However, some of them have some incorrect answers.

The overall ability to understand students' concepts is in the good grade category. Based on the results of practicality data analysis, the quality of the developed worksheet is feasible to use. This is also in line with Sari's research (2017), which states that the effectiveness data obtained are categorized as practical, which means that the use of problem-based worksheets that have been developed is effective in supporting students' conceptual understanding.

Discussion

Using research methodologies, worksheet material on relations and functions was created based on Problem-Based Learning (PBL). Tessmer (1993) developed worksheets that promote students' legitimate and useful concept-understanding abilities by focusing on material linkages and functions through Problem-Based Learning (PBL). Two problems comprise this Problem-Based Learning (PBL) worksheet on relations and function topics.

Worksheet Problem 2 dealt with taxi fares, while Problem 1 dealt with family relationships. The assessment results by three validators yielded an average of 80.33%, indicating that the worksheet prepared was valid. According to the study by White (2022), a

worksheet was deemed valid if the validation results showed a percentage value between 75.01% and 8500%. Aside from that, the worksheet's validity may be assessed based on its language, construction, and content. It has two faults that the validator has approved, and it is acceptable to use with minor modifications. The activity's content aligned with the PBL stages and the fundamental competencies in relational and functional material.

In terms of content, the activity was consistent with the PBL stages and basic competencies in relational and functional material. In terms of construction, the worksheet created corresponded to the ability level of class VIII students and was an indicator of students' idea-understanding abilities. Meanwhile, in terms of language, the worksheet was designed to use language that is grammatically correct, simple to grasp, and does not insult anyone.

Based on the findings of the one-on-one trial questionnaire data, it was discovered that there are three problems in the worksheet, with an average value of 75.833%, indicating that the worksheet has a practical category. Aside from that, the practicality of the worksheet was also obvious from the outcomes. In addition, after developing a valid and practical PBL-based worksheet, students in this study were requested to work on exam questions. The test questions comprise three questions designed to help class VIII students understand concepts in relation to and function content. Based on the analytical results of the answers to the test questions provided by students during the field test, it was discovered that various signs of concept understanding capacity occurred on average in the student's responses. The ability of students to understand concepts was then assessed based on the outcomes of the test questions, with the research subjects grouped into three categories: high, medium, and low.

First, in the high group, two students had an average score of 96.4, indicating excellent idea-grasping abilities. Indicators of students' ability to understand mathematical concepts appeared in seven concept understanding indicators evaluated by researchers, indicating that students have advanced abilities. Among them are students who are already capable of repeating a draft, grouping objects based on their properties, providing examples and non-examples, displaying concepts from various mathematical models/forms, developing according to a concept's requirements, utilizing and using appropriate procedures, and applying these concepts to problems.

Second, in the medium group, two students responded with an average score of 73.2, indicating that they have high idea grasping abilities. Only 4-5 indicators of students' ability to understand mathematical concepts were found among the 7 indicators of concept understanding examined by researchers, indicating that students had moderate abilities. Students work on and answer all the questions, but the responses remain incorrect and contain errors.

Third, two students answered in the low category, with an average 55.3 score, indicating adequate concept grasping abilities. Only 3-4 indicators of students' ability to understand mathematical concepts were found among the 7 indicators of concept understanding examined by researchers, indicating that students had limited capacities. Students work on and answer all the questions, but the responses remain incorrect and contain errors.

According to Kuzu (2022), a low ability to understand a draft occurs when participants cannot explain or paraphrase the concepts they receive and convey them in mathematical representations, resulting in a lack of conceptual understanding. Students can still not demonstrate their knowledge of relations and function concepts in test questions by restating the concept of function in tariff-related questions. Taxi as in Write down the known function's a and b values. This also follows the conclusion of Fielding and Makar (2022), who indicated that comprehension ability of mathematical concepts was still classed as low because most students could not complete the test.

III. Conclusion

Based on the research that has been done, it is concluded that this research produces the relations and functions of worksheets based on Problem-Based Learning (PBL) to support the ability to understand concepts of class VIII students that are valid and practical. Student Worksheets based on Problem-Based Learning (PBL) were developed based on the 1993 Tessmer development procedure, namely the preliminary and prototyping stages (formative evaluation) divided into 5 stages: self-evaluation, expert review, one-to-one, small group and test. Field. Try in small groups. The results of the expert validation sheet show that the problem-based learning (PBL) worksheet that was developed is valid. The developed worksheet is also practical, as seen from the results of the questionnaire analysis, with an average value of 84. This indicates that the Problem-Based Learning (PBL)-based worksheets developed are very practical and can be used in learning. This worksheet can also support students' conceptual understanding skills, which can be seen from the results of student tests and interviews with an average score of 74.96 in the good grade category.

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