



# Developing Guided Discovery-Based Learning Device for Improving Middle School Students' Mathematics Problem-Solving Ability

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## Abstract

According to the 2011 PISA Mathematics Survey, Indonesia ranked 72nd out of 78 countries. This is a very worrying position for the development and quality of Indonesian education in the eyes of the world. This study aims to create a learning device based on guided discovery to enhance students' valid, practical, and effective problem-solving skills. The developed instructional devices are presented as lesson plans and worksheets for high school math students. This development study uses the Plomp model in three phases: pre-production, prototyping, and evaluation. The research subjects are 7th-grade students of SMPN 2 Northern Rao. Experts conduct verification in mathematics education, educational technology, and the Indonesian Language. The practicality of the teaching aid is evident in the results of practicality surveys in teaching practice and questions from students and teachers. Efficiency can be seen in student learning outcomes. The Data Analysis Result Guided Discovery Learning Device is effective because it meets valid criteria in terms of content and design, is practical in terms of implementation, simplicity, and turnaround time, and can improve learning outcomes. In essence, this research can provide an overview for enhancing the quality of education. In addition, it can be used as an indicator to improve students' problem-solving skills by making math learning more accessible and efficient.

*Keywords:* guided discovery-based learning device; mathematics problem solving

## I. Introduction

The importance of problem-solving ability was also expressed by the Ministry Of Education (MOE) Singapore, "Mathematics education in schools is to develop mathematical thinking and problem-solving skills and apply these skills to formulate and solve mathematics problems is the subject of mathematics learning and involves the proficiency and application of mathematics concepts and skills in a wide variety of situations, including problems not routine, open, and real-life

problems" (MOE, 2007). Mathematics lessons in the United States since the 1980s (Ruseffendi, 2006) also emphasize that the development of problem-solving abilities is central to learning school mathematics. In general, mathematics ability can be seen from the results of the 2019 Programme of International Student Assessment (PISA) survey, which shows that Indonesia can still not show brilliant achievements in reading, science, and mathematics. The results of the PISA survey in mathematics show that Indonesia

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occupies the 72nd position out of 78 countries (R&D of the Ministry of Education and Culture, 2011). This is a very worrying position for the development and quality of Indonesian education in the eyes of the world. The poor performance of Indonesian students in this program is closely related to their school performance. Learning in school did not train students to address the questions included in the PISA Question Criteria. These PISA questions unlock many math skills, including problem-solving. Since Indonesian students did not do well in PISA, it can be concluded that the quality of Indonesian education still needs to improve regarding the student's abilities.

Students expect mathematics learning to facilitate students in finding concepts from the material in a guided manner. Teachers can develop a learning activity to encourage students to use their mindset. For this reason, the things that can be done to support student learning activities using their perspective are contained in the Lesson Plan and can be used as a learning media using teaching materials such as Student Worksheets. Students' worksheet aims to assist students in understanding the material and assist teachers in activating students learning activities so that students are more motivated to try to find problems in students' worksheet and discuss them with their friends. So, researchers designed a mathematics learning tool based on guided discovery methods supported by students' worksheets so that the resulting learning can facilitate students in finding concepts and be able to improve problem-solving skills.

Based on an interview conducted with a teacher at SMP N 2 North Rao on November 23, 2020, conducted as an initial observation of the study, it was found that students would need clarification if the exercises given differed from the examples of the questions studied. If the questions were in the form of story questions or problems, most students could not solve them. This is also supported by the initial problem-solving ability test results, where no one can answer the questions correctly, so the scores

obtained are below the KKM. This is because students need help to write down what information they want, make mathematics models, and solve the problems given. The students' worksheet has yet to fully become a means for students to develop students mathematics problem-solving skills and solve the mathematics problems of learners. Student worksheets used in schools do not contain questions or statements that require students to solve problems, which prevents students from developing math problem-solving skills. Student worksheets contain only material that may not suit your needs, sample questions, placeholders, and exercises in multiple-choice format. Students' worksheets start directly with math concepts, sample questions, and practice questions. This contradicts the characteristics of 7th-grade middle school students who like colors to stimulate their interest in learning.

Based on the observations obtained in the field, mathematics learning tools consisting of lesson plans and students' worksheets could be more optimal. This can be seen from the learning of mathematics has yet to use learning strategies that follow the needs of students. Based on the problem students face, namely the lack of mastery of concepts, one of the strategies teachers can use is learning that can make students discover the concepts themselves. The learning steps made by the teacher still use routine activities; students are given concepts, sample questions, and exercises in the package book. If this is done continuously, the learners feel saturated and less motivated during learning. The goal of learning mathematics has not been achieved because the learning tools have not stimulated students to find concepts and use their thoughts. A study by Putri et al. (2016) found that textbooks and worksheets used by students are still widely used but still need to aim to improve problem-solving skills. Suhendra (2016) found that school student worksheets need to be revised to improve math problem-solving skills. Similarly, Husna et al. (2013) found that mathematics study at MTs Banda Aceh needed to develop problem-solving skills fully.

The lack of problem-solving skills is because teachers must engage students in solving problems that challenge their thinking processes. Students need to become more familiar with problem-solving; students more often memorize formulas, copy formulas according to tasks, and answer routine questions. Therefore, for non-standard or other problem-solving questions, students need help to apply and use the concepts they already have to solve non-standard real-life problems. As stated in Permendikbud Nomor 58 Tahun 2014, students should have the ability to solve problems when learning mathematics.

Suryosubroto (2002), the guided discovery method is defined as a teaching procedure that attaches importance to individual teaching; this discovery method is a component of educational practice that includes teaching methods that advance active learning, process-oriented, self-directing, and self-seeking. Teachers act as facilitators who help students to use the ideas, concepts, and skills they have learned to discover new knowledge. So, learning with the guided discovery method is an effort to find concepts, procedures, or principles under the teacher's guidance. Alkrismanto (2003), The role of the teacher in the guided discovery method is to state the problem, then guide the learner to find a solution to the problem with the commandments or worksheets. Based on this comment, teachers use student worksheets when setting student assignments. Students follow instructions and find solutions under the teacher's guidance. What level of thinking should be used in the content of student worksheets or student responses, which are essentially discoveries, depends on the general conditions of the class or the level of cognitive ability of the students to be working.

To improve students' problem-solving abilities and overcome the above problems, teachers must make learning more innovative by developing mathematics learning tools based on guided discovery methods. This opinion is emphasized by the results of Fitri's research (2016), which proves that learning using guided discovery-based learning tools developed in this

study can improve students' problem-solving abilities. Based on the existing problems, this is a challenge for teachers, parents, and students. Improving student learning outcomes requires the improvement of devices in the learning process. For this reason, a study aimed to develop a mathematics learning tool based on guided discovery methods. The developed tools are expected to facilitate students in improving problem-solving skills from student learning outcomes. The teaching system using mathematics learning tools based on guided discovery methods is expected to be more efficient, relevant, and effective.

Research that is relevant to research on the development of mathematics learning tools based on guided discoveries is the research of Chaidir (2008), Armiami (2011), Yerizon et al. (2018), Yuliana et al. (2017) on the development of guided discovery-based learning tools to improve problem-solving skills. Based on several national and international studies relevant to this research, both research on mathematics learning. In general, the research uses a guided discovery model but there are several using different models; Dewi (2016) uses the development of problem-based learning tools to improve problem-solving ability. At the same time, there is also something relevant to the ability used, namely the ability to solve mathematics problems. In general, guided discovery model-based learning tools can improve mathematics problem-solving skills in junior high school grade VII. The relevant research is only used as a basis for developing and enhancing the research to be carried out. Researchers hope this mathematics learning tool will later produce a valid, practical, and effective mathematics learning tool.

This study aimed to produce valid, practical, and effective guided discovery-based mathematics learning tools to improve the mathematics problem-solving skills of students in junior high school.

## **II. Research Method**

Sugiyono, (2011), this research is development research used to produce specific products and test their validity, practicality, and effectiveness. Development research is a systematic study to design and develop a product, such as programs, models, teaching materials, teaching and learning strategies, materials, and so on. The resulting product is the development of guided discovery-based learning tools to improve the problem-solving ability of grade VII junior high school students. The primary purpose of development research in education is not to formulate or test theories but to develop effective products for use in schools in the learning process.

The development model used is the Plomp development model developed by Tjeerd Plomp. The Plomp model consists of three phases, namely the preliminary research phase, the development or prototyping phase, and the assessment phase. The instruments used and the data collection objectives, namely: (a) interview, the purpose uncover the obstacles encountered by the teacher, the learning models, methods and resources used, the learning resources expected, and the teacher's responses to the development of guided discovery-based learning. (b) Observation is the purpose of observing the teacher's role as a facilitator who teaches students. (c) Questionnaire to express students' perceptions of mathematics and the specification of learning resources that students expect. (d) Primarily test the purpose of identifying the initial conditions of students' mathematical problem-solving abilities.

The preliminary research phase is a preparatory phase consisting of needs analysis, curriculum analysis, and concept analysis. At the development or prototyping stage, i.e., (a) Prototype I., (b) Prototype II: human evaluation (individual evaluation). (c) Prototype III: Small Group Assessment and (d) Prototype IV: Testing Guided Navigation-Based Math Learning Tools for Large Classrooms. The goal is to determine the feasibility and practicality of a training device configured for implementation in the field. In the assessment phase, the assessment carried out are

(a) practicality tests, (b) effectiveness tests, (c) product trials, and (d) student trial subjects. The instruments used in the preliminary stage are observation sheets, interview sheets, interview guidelines, and questionnaires. The instruments at the prototype development stage are self-evaluation sheets, lesson plans, and students' worksheet validation sheets. Practical instruments are interview guidelines, learning observation sheets, educator interview sheets, teacher response questionnaires, and student response questionnaires. The instrument for testing the effectiveness of learning tools is a problem-solving ability test containing the test objectives, a grid of questions, and creating a scoring rubric. Next - Steps of exam questions for SMPN 2 Year VII students in Northern Rao.

Data analysis is performed in two ways: (1) accuracy and (2) data analysis. When analyzing efficacy data, follow these steps: Determining the validation values included in the validation sheet, the average number of points the validator assigns to each element and the learning device's validation decision. The learning device verifier consists of three experts in mathematics education, a linguist and an educational technology expert. The tool verifier consists of three math education experts and one language expert. Actual data analysis is performed in stages of teacher and student questionnaire analysis, interview data analysis, and observation sheet analysis for lesson plan implementation. At the same time, efficacy data analysis was conducted in the small group and field trial phases.

## **III. Results and Discussion**

### **A. Results**

#### **1. The result of the preliminary research phase**

The first step in developing learning tools is applying the first step, namely collecting information from one of the math teachers, interviewing the students, observing and distributing questionnaires to the students, and testing the initial conditions of the participants' math problems. Will. strong ability. Middle School No. 2 in North Rao had 3 students

#### **2. The result of the Development or**

### prototyping phase

The development phase is designed to develop discovery pedagogies suitable for middle school students. The design results are then evaluated to determine the errors found by the learning device. Some things need fixing in learning tools, like typos. The RPP considers two aspects: accuracy of typos and punctuation. This worksheet evaluates five aspects: typos, correct use of punctuation, right text size, incorrect placement of images, and the presence of blank space to address issues contained in the worksheet. Then fix the error. The revised tool was endorsed by 5 math-savvy experts: 3 materials experts, 1 language expert, and 1 media expert. The RPP review findings are component aspects and indicators of competency attainment, learning objectives, learning materials, understanding approaches, models, methods, learning stages, learning resources and teaching aids, assessments, language and writing, and instructional benefits plans.

#### 1) The Validity of Learning Devices

The learning device is valid if the average assessment results are more than 2,8 to 4.

Table 1.

Learning device validation results

Learning Devices	Average assessment results	Criterion
Lesson Plan	3.47	Very Valid
Students Worksheet	3.49	Very Valid

### 3. The result of the assessment phase

At this stage, practicality and effectiveness tests were conducted to determine the practicality and effectiveness of teaching aids. The usability test determined the teaching aid's usability level obtained from the usability questionnaire. In this study, questionnaires were distributed to teachers and students. Meanwhile, an effect test was conducted to determine the effect of teaching aid use on students' learning outcomes. In this study, the effectiveness of manipulatives was derived from student learning tests. An educational device is considered

practical if the practical value is between 75% and 100%. The practicality and efficiency of test results can be found in Tables 2 and 3.

#### 2) Practice Learning Devices

Table 2.

Learning device practicality results

Respondent	results (%)	Criterion
Teacher	87,92	Very Practical
Student	85,88	Very Practical
Average	86,90	Very Practical

#### 3) Student learning test results

Table 3.

Learning device efficiency results

Post-test	Passing grade		Total
	Passed	Not passed	
Number of students	25	7	32
percentage	78,125%	21,875%	100%

Data analysis shows 75.00% of students above the specified KKM value, which is  $\geq 75$ . In Table 3, the overall practical value of teacher and student discovery learning-based learning was 86.90%, which was on the most pragmatic criterion. Therefore, the study of mathematics was classified as something that could be used as a source of practical and independent learning. Table 4 shows the test scores for 32 students or 78,125% of students who did not complete assignments and 21,875% of students who did not. Because the students did not pay attention during the discussion and did not practice seriously, the students could not answer the test questions well. According to these test results, more than 75% of students coped with it. Therefore, it can be concluded that discovery-based learning is effective.

## B. Discussion

### a) The Validity of Learning Devices

#### (1) Validity of lesson plan

Expert or expert assessment asks experts to provide assessment and input on learning tools designed by validating learning tools based on guided discovery methods. The experts involved in this validation process are mathematics education experts, Indonesian experts, and



learning design experts. Validation of learning tools based on guided discovery methods includes two things: the validity of the content and the validity of the construct. Content validation means the suitability between the resulting product and the subject syllabus to determine whether the learning tools developed are in accordance with the competency standards and basic competencies. The validity of the construct means the conformity between the resulting product and the established element of development; in this case, it is guided discovery method-based learning. After being examined by mathematics, if there is an error, a revision of the mathematics learning device is carried out according to input from the validator and then validated again; validation results are valid, feasible to use, and ready to be used for the next stage. Based on the validation carried out on the learning tools, it can be concluded that the lesson plan used is valid according to table 1.

(2) Validity of students' worksheet

The aspects assessed when validating the student's worksheet are content, Language, and display. The instrument used is a student's worksheet validation sheet, which is made following these aspects. Similar to the lesson plan, the validity of the student's worksheet is determined by 5 validators, namely 3 mathematics lecturers, 1 Indonesian lecturer, and 1 Educational Technology lecturer. Five verifiers checked the learner worksheets and found that the developed learner worksheets were very valid. Before scanning, the workbook had several errors, including typos, punctuation usage, and handwriting size. After revising, take a math test. The results of checking the lesson plans and student worksheets are shown in Table 1.

*b) Practice Learning Devices*

The practicality of learning devices refers to the convenience obtained when using learning devices. Based on the general Indonesian dictionary (Depdiknas, 2002), practical means easy, happy to use, and suitable because the implementation is easy. Practicality is related to the use of learning tools by students and teachers.

Devices can be practical if teachers and learners can use such devices to carry out learning logically and continuously without much problem. To measure the level of practicality related to the development of instruments in the form of learning materials, Plomp & Nieveen (1999) argues that measuring its practicality is carried out by looking at whether teachers and other experts consider the material easy and can be used by teachers and students. Sukardi (2008), Especially for the development of mathematics learning tools developed in development research, the mathematics learning device is said to be practical if experts and practitioners state that theoretically that mathematics learning devices can be applied in the field and the degree of reliability of the mathematics learning device is included in the good category. Based on the teacher's response questionnaire results, the average results of the practicality of student worksheets based on guided discovery range from 87% to 100% with very practical criteria.

In contrast, the results of the student response questionnaire show that the average results of the practicality test on discovery-based student worksheets guided ranged from 85% to 100% with very practical criteria. Thus, teachers and students view student worksheets based on guided discovery as very practical for use in junior high school mathematics learning. This can be seen through the results of the recapitulation obtained in table 2, which shows that based on teacher and student responses, the student worksheets that have been compiled are very practical.

*c) Effectiveness of Learning Devices*

The effectiveness of the developed product can be confirmed by testing students' ability to solve math problems. The student's math problem-solving skills test results are evaluated with the Student's Problem-Solving Skills Assessment Rubric. In addition, the results of the problem-solving ability test, which were compared with the baseline average of students' problem-solving ability, were reviewed and analyzed. Data analysis showed that 75% of

students exceeded the indicated KKM value ( $\geq 75$ ). completeness. Muchayat (2011) also explained that the achievement of the effectiveness of learning tools is shown by students' learning outcomes with the problem-solving ability to achieve minimal completion criteria.

This is in line with the opinion Fitri (2016) that the form of an effective guided discovery-based mathematics learning device is a device that, in this case, a lesson plan and student's worksheet, can direct students to various positive activities and minimize negative activities. In addition, learning outcomes after using this learning tool have met the minimum completion criteria.

Based on the scores of the problem-solving ability test shows that the scores obtained by students from the trial class to see the effectiveness of the learning tools developed increased from the initial test of problem-solving ability to the problem-solving ability test. It can be concluded that students' worksheet based on the guided discovery model that has been developed has been effective in improving students' mathematics problem-solving abilities.

#### IV. Conclusion

The development studies conducted by the researchers have allowed the development of mathematics teaching tools in lesson plans and student worksheets based on class VII inductive reasoning on integer data. Researchers go through several phases of development, starting with a preliminary analysis phase, a design phase, and an evaluation phase. At this stage, many steps are taken to create a feasible, practical, and effective product. Judging by empirical data, tools developed to teach mathematics based on guided discovery have proven effective. In this case, the completion rate for students using the guided exploratory learning device is 78.125% of students with a specified KKM score ( $\geq 75$ ) or higher. This can be seen in Tables 1, 2, and 3 above. In essence, this study can provide education providers with an overview for

improving the quality of education. In addition, math learning can be made easier and more efficient, and it can be used as an indicator to improve students' problem-solving skills. Other class teachers can carry out the development of this device without neglecting its feasibility, practicality, and efficiency. Teachers can test learning tools with their peers and math education educators. This development is carried out according to the implementation of classroom learning according to the objectives. The development of tools based on Guided discovery aims to help learners. Teachers can use a variety of methods and methods to stimulate student motivation. Start with a game, song, or other fun activity. This development also provides students opportunities to learn independently and express their ideas in a concept or material.

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