

Development of Teaching Materials Based on Guided Discovery Learning Methods to Increase Mathematical Problem Solving Ability

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Abstract—The aims of this study is to develop teaching materials based on guided discovery learning that fulfill the quality criteria of validity, practicality, and effectiveness. This research was a research and development study using the Dick and Garrey development model with consisting of ten steps: (1) identify instructional goal, (2) conduct instructional analysis, (3) identify entry behaviors, (4) write performance objectives, (5) develop instruction strategy, (6) develop and select instructional materials, (7) develop criterion referenced test, (8) develop and conduct formative evaluation, (9) revise instruction, and (10) develop and conduct summative evaluation. The data analysis technique used in this study is a descriptive quantitative and qualitative analysis. The results of this study show that all of the products are valid, practical, and effective. The product fulfills the validity criterion by experts appraisal which is in $4 \leq Va < 5$. The product fulfills the practicality criterion based on instructional material implementation and teacher and student assessment to instructional material, that is in a very good category. The product fulfills the effectiveness criterion based on complete of classical reaches $\geq 85\%$, the ability of teacher to manage learning that is in a good category, and the learning time is not much different from the usual learning time.

Keywords—teaching material; problem-solving; guided discovery

I. INTRODUCTION

Mathematics is one of the subjects taught at every level of education both elementary, junior high, high school and college. Mathematics is one of the sciences that underlies the development of science and technology progress so that mathematics is seen as a structured and integrated science, knowledge of patterns and relationships and the knowledge of ways of thinking to understand the world around.

[1] Abdurrahman stated that mathematics needs to be taught early on to students because mathematics is: (1) a means of clear thinking; (2) the means to solve problems in daily life; (3) the means of recognizing patterns of relationships and generalizing experiences; (4) means of

developing creativity; and (5) means of increasing awareness of cultural developments.

The ability to solve problems is one of the abilities that must be achieved by students in learning mathematics at any school level [2]. Furthermore, [3] NCTM states that "problem solving is an integral part of mathematics learning", which means problem solving is an important part of mathematics learning. The findings show that problem solving ability is a very important ability in learning mathematics, as well as the role of the heart for a human body.

Important mathematical problem solving abilities are mastered by students because in everyday life we are always faced with a problem, both easy and difficult problems, and we are required to be able to solve it [4]. In addition, the facts show that in the 21st century someone who is able to solve problems in his life will live more productively. Furthermore [5] Holmes stated that "people who are skilled at solving problems will be able to race against their needs, become more productive workers, and understand global issues". The expression illustrates that mathematical problem solving skills are needed as a provision for productive life in this day and age.

Seeing the importance of mathematical problem solving skills, then this ability should be a focus in learning mathematics at school. This is in accordance with the recommendations of [3] NCTM that "problem solving must be the focus of school mathematics" or problem solving must be the main focus of learning mathematics in schools. But in fact, the learning of mathematics carried out in schools has not focused on developing mathematical problem solving skills, but only the process of transferring knowledge to students. So that this causes the students' problem solving abilities are still relatively low.

The low mathematical problem solving ability can be seen from the results of observations that have been made at Palapa Binjai High School. The results of the tests given at the time

of observation showed that most students had difficulty in solving problems related to problem solving steps.

The low mathematical problem solving ability of students is a natural thing, when viewed from the mathematics learning process that occurs in the field. Where learning so far still applies conventional learning where learning is still centered on the teacher (teacher centered). This is in accordance with the findings of [6] Khomsiatun and Retnawati that the low mathematical problem solving abilities of students is due to the delivery of material in learning generally predominantly teacher-centered. Furthermore in his findings [7] Suhartini, Syahputra and Surya, stated that the low mathematical problem solving abilities of students was caused by students not accustomed to solving non-routine problems or problems that needed problem solving abilities. In line with that, the findings [8] Rahmiati, Musdi and Fauzi also stated that the low mathematical problem solving abilities of students was caused by students not accustomed to solving math problems specifically designed by teachers to measure mathematical problem solving abilities.

To overcome students' low mathematical problem solving abilities, it is necessary to change methods in mathematics learning. [9] Heningsen and Mary stated that "mathematical activities are activities that seek and explore patterns to understand the structure of mathematics and the underlying relationships; use available and effective resources to formulate and solve problems; making mathematical ideas, thinking and reasoning in a flexible way: guessing, generalizing, giving reasons, and communicating mathematical ideas; and decide the reasonableness of mathematical results ". Therefore, learning must provide opportunities for students to develop mathematical problem solving abilities based on observation, making guesses, investigating, generalizing, giving reasons, and communicating.

One alternative solution that can be used is through guided discovery learning. [10] Yuliani and Saragih stated that "Guided discovery models are a learning model that presents a problem or question that makes students think, observe, make conjectures, explain, and analyze knowledge with guidance and instructions from teachers" where the meaning is a learning model that presents an issue or question that makes students can think, observe, make guesses, explain and analyze to find information with guidance from the teacher. In other words, through guided discovery learning, the teacher acts as a facilitator who guides students through questions that direct students to relate their knowledge to the knowledge they are learning. Through guided discovery learning it is expected that students will learn actively through the process of discovery as an experience where the teacher participates in providing guidance to students during the discovery process, if needed.

Guided discovery learning is considered to be more inherent to students because they will learn based on their own experience (learning by doing), so that through guided discovery learning students are expected to be able to find the concept of their own knowledge through the problems they

have solved and can apply the concept which has been found in solving a problem.

Besides the need for the selection of appropriate learning methods and strategies, there is also a need to develop teaching materials that are also suitable for the learning methods and strategies used. Teaching materials are a number of tools, media, instructions and guidelines that will be used in learning activities. Correspondingly, [11] Nwike and Catherine stated that "teaching material is a teaching aid used in the classroom to achieve the expected learning goals.

Based on the description above, the preparation of teaching materials based on guided discovery learning is believed to be able to help overcome problems regarding the problem solving abilities experienced by students. This is in accordance with the results of the study [6] Khomsiatun and Retnawati who concluded that students' mathematical problem solving abilities had increased after being taught using guided discovery-based learning tools. In line with that [12] Susanti, Musdi and Syarifuddin from the results of their research show that the application of guided discovery-based learning tools can improve the problem-solving ability to achieve the specified classical completeness which is 78.13%, which can be concluded that learning devices are developed effectively to improve solving mathematical problems of students.

II. THEORETICAL FRAMEWORK

A. *Development of Teaching Materials*

In KBBI, materials are tools or equipment, while learning is the process or way of making people learn. Whereas according to [13] Linnusky and Wijaya, teaching material is something or some preparation prepared by the teacher both individually and in groups so that the implementation and evaluation of learning can be carried out systematically to obtain the desired results. Teaching materials serve to give direction to the implementation of learning so that it becomes directed and efficient. Therefore, teaching materials must be designed so that they can lead to the learning objectives to be achieved.

The purpose of the development of teaching materials is to: (a) provide teaching materials that are in accordance with the demands of the curriculum by considering the needs of students, namely learning tools that are in accordance with the characteristics and settings or social environment of students; (b) help students in obtaining alternative learning tools in addition to textbooks which are sometimes difficult to obtain; and (c) facilitate teachers in carrying out learning [14].

In addition, with the availability of varied teaching materials, students get the benefit of learning activities becoming more interesting. Learners get more opportunities to learn independently, reduce dependence on teacher attendance, and get ease in learning every competency that must be mastered. In this study, the teaching materials in question are: Student Books (SB), and Student Worksheet (SW) which will be developed based on guided discovery learning.

B. Guided Discovery Learning

Discovery learning or learning with discovery is one of the lessons that teachers can choose to create effective learning. [15] Bruner (Dahar) says that learning discovery is in accordance with the search for knowledge actively by humans and by itself gives the best results. Trying yourself to find solutions to problems and the knowledge that accompanies them, produces knowledge that is truly meaningful. Therefore the discovery method is a method that can be used in learning where students are actively involved and experience or do themselves in building their knowledge so that students will have the ability to solve better problems regarding what they get rather than just receiving it directly without involvement students in learning.

Learning with the method of discovery will certainly require considerable time considering the limited learning time in class. Therefore we need guidance or direction from the teacher so that students can easily draw conclusions in accordance with the specified time. Based on this, the method of discovery chosen is a guided discovery method. Learning with guided discovery is a learning where students find their own concepts that are learned by the direction and guidance of the teacher to achieve the goals that have been set by the previous teacher.

[16] NRC (Sunismi and Nu'man) states that guided discovery is a series of learning activities that emphasizes the process of thinking critically and analytically to find and find answers to problems that are questioned with the guidance of the teacher. [17] Wahyu and Sutiarmo stated that the guided discovery method is a teaching method that regulates teaching in such a way that students gain knowledge that they have not yet known, it is not through notification but is found by students themselves.

Thus the guided discovery method is a learning method where students are faced with a situation or problem through questions that have been prepared by the teacher, then students will collect data that supports to make guesses, so that a correct conclusion is obtained. A series of activities are carried out by the students themselves to find new information with help or direction and teacher guidance with questions that can stimulate students' mathematical thinking skills so that they find a concept of the material being studied.

[18] Howee (Hermawan, Eriyan and Sondang) outlines some of the main characteristics of guided discovery learning (guided discovery), namely: (1) performance goals (performance objectives); (2) statement of target results or statement of learning objectives to be achieved in learning; (3) materials used (material); (4) a list of tools and materials needed during learning activities that will support the achievement of learning objectives; and (5) learning activities which consist of steps: (a) motivation; (b) data collection activities (data collecting); (c) data processing activities (data processing); (d) closure activities; and (d) appraisal activities.

C. Mathematical Problem-Solving Ability

Problem solving skills are competencies in the mathematics curriculum that students must possess. In solving problems students are enabled to gain experience using the knowledge and skills they have to solve problems that are non-routine. Through problem solving activities, important aspects in mathematics learning such as the application of rules to non-routine problems, pattern discovery, generalization, mathematical communication and others can be well developed (Erman Suherman) [19].

[20] Lester states that "problem solving should mean that problem solving should be a learning goal and approach to learning mathematics. As an approach, problem solving is used to find and understand material or mathematical concepts. Whereas as a goal it is expected that students can identify the known elements, which are asked as well as the adequacy of the elements needed, formulate problems from everyday situations in mathematics applying strategies to solve various problems within or outside mathematics, explain or interpret results according to origin problems, arrange mathematical models and solve them for problems and use mathematics meaningfully. As an implication, the ability to solve problems should be owned by a child who studies mathematics.

Furthermore, [21] Gagne (Makaraka) suggests that high-level intellectual skills can be developed through problem solving, because in problem solving is a high-level learning type of the eight types that Gagne presents, namely; signal learning, stimulus response learning, chaining, verbal assumptions, discrimination learning, concept learning, rule learning and problem solving.

From some views on problem solving, a conclusion can be drawn that problem solving as the core and main objectives in the mathematics curriculum means that learning mathematics prioritizes the process of students solving problems rather than results, so that problem solving abilities are used as basic abilities that participants must have. students in learning mathematics.

For a long time [22] Polya (Hudojo) detailed the steps in solving problems as follows: (1) activities to understand problems; (2) activities for planning or designing problem solving strategies; (3) activities to carry out calculations; and (4) activities to re-examine the truth of the results or solutions. In line with that, [19] Erman Suherman stated that the steps in solving problems are (1) Understanding the problem, students can identify the elements that are known, are questions, and are adequately the elements required. (2) Planning problems, students can formulate a mathematical problem or develop mathematical models, or can implement strategies to solve various problems. (3) Resolve the problem; students are expected to perform well to complete the planning. (4) Checking back and get the conclusions.

From the description above, the steps in mathematical problem solving abilities in this study refer to the steps of Polya's problem solving abilities, namely: (1) Understanding the problem, (2) Planning the Settlement, (3) Resolving the problem, and (4) Doing examination.

III. RESEARCH QUESTION

- How is the validity of guided discovery-based learning devices developed to improve students' mathematical problem solving abilities?
- How is the practicality of guided discovery-based learning devices developed to improve students' mathematical problem solving abilities?
- How is the effectiveness of guided discovery learning-based learning devices developed to improve students' mathematical problem solving abilities?

IV. RESEARCH METHOD

This type of research is development research using the Dick & Carey Model which consists of 10 steps, namely: (1) Identify Instructional Goals; (2) Conduct Instructional Analysis; (3) Analyze Learn and Contexts; (4) Write Performance Objectives; (5) Develop Assessment Instruments; (6) Develop Instructional Strategy; (7) Develop and Select Instructional Materials; (8) Design and Conduct Formative Evaluation of Instruction; (9) Revise Instruction; and (10) Design and Conduct Summative Evaluation [23]. The teaching materials are evaluated by referring to formative evaluations which consist of expert reviews and field evaluations. Validation of teaching materials was carried out by three mathematics lecturers and 2 mathematics teachers. After the teaching material is validated, a field trial is conducted. Field trials were conducted to see the practicality and effectiveness of guided discovery-based learning materials. Field trials will be carried out on 26 students of class X IPA SMA Palapa Binjai. The research data were collected through validation sheets, teaching material implementation sheets, teacher response questionnaire sheets and student responses, student activity observation sheets, observation sheets of teacher abilities and results of tests of mathematical problem solving abilities.

V. DATA ANALYSIS, RESULTS AND DISCUSSION

This research on the development of teaching materials uses a development procedure in accordance with the steps of developing Dick & Carey. The purpose of this development is to produce a product in the form of teaching materials in the material system of three variable linear equations in SMA based on guided discovery learning that is valid, practical, and effective.

A. Identify Instructional Goals

Based on the results of observations in class X and interviews with teachers at Palapa Binjai High School, the fact is that students' problem solving abilities are still relatively low. One of the low abilities of students is because the learning activities that have occurred so far are only in the process of transferring knowledge by the teacher. So that in learning activities, students are not given the opportunity to actively construct their own knowledge. In addition, customer books and activity sheets used as long as by students are not those that can facilitate them to hone and improve their mathematical problem solving abilities. Therefore, in this study will be

prepared a teaching material combined with learning methods that can help students to be active in learning, so that it can help improve mathematical problem solving skills.

B. Conduct Instructional Analysis

At this stage an analysis of the 2013 curriculum for three-variable linear equation system material at the high school level was carried out. This analysis is carried out to determine Core Competencies, Basic Competencies, and Indicators to be achieved after using the devices to be developed. At this stage, an analysis of the prerequisite material needed by students will be carried out to be able to participate in learning using the learning tools to be developed.

C. Analyze Learners and Contexts

At this stage the characteristics of the Palapa Binjai High School students will be analyzed, especially the characteristics of the X class students of the 2018/2019 academic year that will be the subject of the trial in this study. The characteristics of students are analyzed in terms of academic ability (prerequisite knowledge), cognitive development (mathematical problem solving) and the activeness of students based on learning models that are often used.

D. Write Performance Objectives

The formulation of learning objectives will be used as a reference in designing teaching materials to be developed. Learning objectives are adjusted to the basic competencies and the purpose of developing teaching materials. Learning objectives in this study can be seen in TABLE 1.

TABLE 1. LEARNING OBJECTIVES

Sub Topic	Learning Objectives	Meeting
Discover the concept of the system of three-variabel linear equation	1. Students can conceptualize a system of three-variable linear equations. 2. Students can find the requirements for the system of three-variabel linear equation .	1
Completion of the system of three-variabel linear equation	3. Learners can solve the contextual problem of the system of three-variabel linear equation with the method of elimination and substitution. 4. Learners can solve the contextual problem of the system of three-variabel linear equation with the method of elimination and substitution.	2 and 3

E. Develop Assessment Instruments

At this stage, an evaluation instrument was developed to measure whether the teaching material developed could help students carry out learning objectives. Evaluation instruments or assessment instruments developed are used to measure whether the teaching materials developed have met valid, practical, and effective criteria. The validity data of teaching materials were collected using a validation sheet of teaching materials to be carried out by 5 validators (3 lecturers and 2 teachers). Data on practicality of teaching materials was collected using the learning material implementation sheet, teacher response questionnaire and student response questionnaire. While the data on the effectiveness of teaching materials will be collected using observation sheets of teacher's abilities and student activities as well as the results of tests of students' mathematical problem solving abilities.

F. Develop Instructional Strategy

At this stage a teaching strategy will be developed. Instructional strategic arrangement includes five main components, namely preliminary activities, final activities, closing activities, processing time and class atmosphere. Instructional strategies will be arranged in the form of learning implementation plans (LIP) using guided discovery learning methods. The LIP in this research consists of 3 sets for 3 meetings with the duration of each meeting is 2 x 45 minutes. The draft LIP prepared based on guided discovery learning activities can be seen in TABLE II.

TABLE II. GUIDED DISCOVERY LEARNING ACTIVITIES

No	Stage of Learning Activities	Time
1	Introduction Activities Condition the readiness of students, conduct apperception activities, motivate students, and convey learning objectives.	10 menute
2	Core Activities a. <i>Data Collecting</i> (giving problems and guiding students to collect data from the process of solving a given problem). b. <i>Data Processing</i> (Guiding students to process and analyze data that has been collected to make temporary guesses). c. <i>Closure</i> (students communicate the findings of the group and with the help of the teacher draw conclusions about the material that has been studied). d. <i>Appraisal</i> (Giving questions or training to students)	30 menute 15 menute 15 menute 10 menute
3	Closing Activities Help make conclusions, give awards, and inform the material to be studied next)	10 menute
Total Time		90 Menute

G. Develop and Select Instructional Materials

To support the learning strategy that has been designed, it is also developed learning materials in the form of student books (SB) and student activity sheets used by students as a reference in the learning process. This learning material is prepared based on consideration of the needs of students in instructional activities, instructional analysis that has been carried out, characteristics of students, and goals of learning activities. The learning material developed was adapted from the learning materials used in the school. Where researchers apply guided discovery learning methods that can facilitate students in learning activities that direct students to be more active in learning activities, especially in problem solving activities.

Student books (SB) are prepared with the aim that students have guidelines in understanding the subject matter according to the set learning objectives. In this book contains questions and exercises that are presented in the form of problems that aim to train students' abilities in solving a problem related to the material system of three-variable linear equations. The expectation of the SB design is that it can foster the interest of students to study both during lessons and outside of school hours, so as to improve students' ability to solve problems.

The cover section is designed in a way that reflects the contents of the book, or in other words is a general snapshot of what is contained within the SB. The design is expected to give students an idea of what will be learned. The design of the SB cover can be seen in Figure 1.



Fig.1. . Display of Student Book Cover

The contents of the students' books are in the form of learning materials adapted to the core competencies and basic competencies of the 2013 curriculum. In addition to containing material on the system of three-variable linear equations, the book is accompanied by instructions that students can make when learning is adapted to guided discovery learning. The content of SB material can be seen in Figure 2.

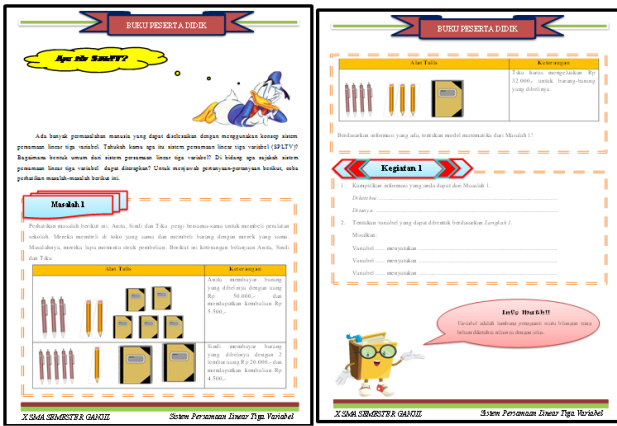


Fig 2. . Display of Student Book Content

The student worksheet (SW) is a form of solution to invite students to be more active in the learning process. This SW was designed with reference to the SB. The SW are also displayed with the aim that students can try them out of school hours or as training material in solving mathematical problems. Student worksheet is designed to give students space to practice in exploring and communicating their ideas in solving problems. Display of SW contents can be seen in Figure 3.

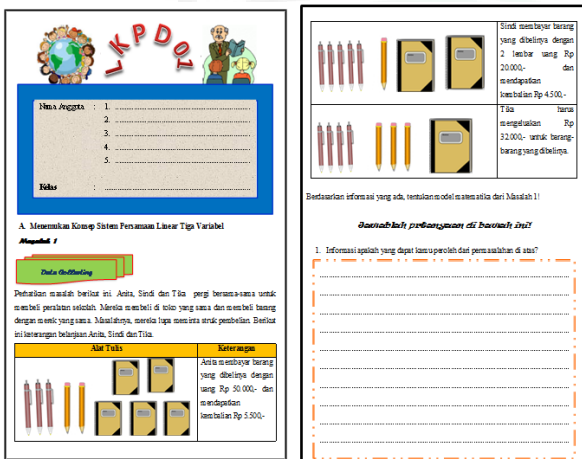


Fig. 3. Display Student Worksheet

H. Design and Conduct Formative Evaluation of Instruction

In the initial stages of formative evaluation expert validation will be carried out which aims to see the contents of the product developed before conducting the trial. This validation aims to improve teaching materials to be feasible to be tested. Validation activities will be done by giving the text of the teaching material (SB and SW) along with the validation sheet to five expert validators. The results of expert validation are in the form of values of validation, correction, criticism, and suggestions used to revise and refine the teaching materials developed.

Based on the results of the validation conducted on the SB and SW, the average data from the five validators is obtained as shown in TABLE III.

TABLE III. DATA ANALYSIS ON VALIDITY OF TEACHING MATERIAL

No	Object Assessed	Average Value of Total Validity	Criterion Validity
1	Student Book (BS)	4,38	Valid
2	Student Worksheet (SW)	4,13	

Information

- $1 \leq Va < 2$: Invalid
- $2 \leq Va < 3$: Less Valid
- $3 \leq Va < 4$: Quite Valid
- $4 \leq Va < 5$: Valid
- $Va = 5$: Very Valid

Based on TABLE III., the average total of each teaching material is at an interval of $4 \leq Va < 5$. Based on validity criteria, it can be said that the teaching materials developed meet the "Valid" criteria. In addition, the teaching materials developed can be used with small revisions according to the suggestions for revisions provided by experts.

The next step in formative evaluation is to conduct field trials conducted at Palapa Binjai High School. This trial involved students of class X, totaling 26 students and 1 subject teacher. In addition, in the learning process, students will be grouped into 4-5 students. Where the selection of group members is carried out heterogeneously both in gender and academic ability in mathematics This trial was conducted to assess the practicality and effectiveness of teaching materials that have been developed.

Data on practicality of instructional materials developed are seen from the results of the observation of the instructional materials that were obtained during the teaching and learning activities. In addition, practicality data is also seen from the response of teachers and students to the use of teaching materials after the learning activities have ended. The data on practicality of teaching materials developed can be seen in TABLE IV.

TABLE IV. DATA ANALYSIS ON PRACTICALITY OF TEACHING MATERIALS

No	Practical Aspects	Value	Category	Criterion
1	Implementation of Teaching Materials	4,33	Well Done	Practical
2	Student Response to Teaching Materials	89,31%	Very Positive	Practical
3	Teacher Response to Teaching Materials	3,13	Very Good	Practical

Based on the data in Table 4, it can be concluded that the teaching materials in the form of SB and SW have met the practicality criteria. Thus the teaching materials developed can be said to provide convenience for teachers and students in their use.

Data on the effectiveness of the teaching materials developed were obtained from the results of classical achievement tests of mathematical problem solving abilities

$\geq 85\%$, student activities were not different from ordinary learning, and the teacher's ability to manage learning was at least in the range of $3 \leq \text{NKG} < 4$. for effectiveness there will be 2 trials. This is because the first trial of classical achievement is still $\leq 85\%$ and the teacher's ability to manage learning is still not good. The data on the effectiveness of teaching materials developed in the first and second trials can be seen in TABLE V.

TABLE V. DATA ANALYSIS ON EFFECTIVENESS OF TEACHING MATERIALS

No	Effective Aspects	Trial-I	Trial-II	Criterion
1	Classical Completeness	76,92%	96,15%	Effective
2	Activity of Students	91,85%	98,15%	Effective
3	The Teacher's Ability to Manage Learning	2,96	3,67	Effective

Based on the data in Table 5, it can be seen that in the first trial, the effectiveness criteria have not been fulfilled. Therefore, the results of trial I will be used as a reference for revision of teaching materials for improvement. After the repairs were carried out, a second trial was conducted. From Table 5 it can also be seen that the effectiveness criteria have been fulfilled. So that it can be concluded that teaching materials developed effectively are used to improve students' mathematical problem solving abilities.

I. Revise Instruction

At this stage a revision of the instructional materials developed was carried out. This revision was carried out to correct the errors in teaching materials at the time of the trial which caused failure in fulfilling one of the criteria for the effectiveness of teaching materials. The results of the improvement at this stage are the final product (Final Draft) of the teaching materials developed.

J. Design and Conduct Summative Evaluation

The summative evaluation phase is not carried out, because summative evaluation is not a part of the design or development process and this evaluation is not carried out by the learning designer. In this stage implementation is carried out on a wider scale in schools and requires very thorough preparation and requires a very long time. After implementation is carried out extensively, a summative evaluation has only been carried out in order to see whether new products are developed more effectively than pre-existing products, then can be determined whether or not new products replace the existing products.

VI. CONCLUSION

Based on the results of the research and development carried out, conclusions were obtained: (1) mathematics teaching materials using guided discovery learning in the material system of linear variables three variables consisting of SB and SW included in valid criteria; (2) products in the

form of mathematical materials using guided discovery learning in material systems of linear equations three variables that have undergone developmental tests are included in practical criteria. This is based on the results of the teacher's assessment of teaching materials that have been tested to meet practical criteria. While the results of student assessment of teaching materials indicate that the teaching materials developed have met practical criteria. The practicality of the device is also supported by the implementation of learning that has been carried out very well; (3) mathematics learning products with guided discovery learning in the material system of linear equations developed three variables consisting of SB and SW have met the effective criteria. This is based on the results of classical achievement reaching 96.15%, the ability of teachers to manage learning is good with an average value of 3,67 and learning time is not much different from the usual learning time.

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