Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.8, No.19, 2017

Development of Mathematics Module Based on Metacognitive Strategy in Improving Students' Mathematical Problem Solving Ability at High School

Yakin Niat Telaumbanua[1*] Bornok Sinaga[2] Mukhtar[3] Edy Surya[4]
State University of Medan (UNIMED), Jl. Willem Iskandar Psr. V, Medan 20221, Indonesia

Abstract

This research is based on problems that occur in SMA Negeri 3 Gunungsitoli, that is mathematical problem solving ability of student is still low. Based on the results of observations by researchers, it is because the teaching materials used by students less attention to students, not equipped with tests of mathematical problem solving ability or still contains routine questions. This encourages researchers to develop teaching materials in the form of mathematics modules based on metacognitive strategies equipped with tests to measure mathematical problem solving ability of students. The development of this math module uses the Dick & Carey development model. The criteria of validity and effectiveness are used by the researcher to determine a good mathematics module. Module validation by three experts and two practitioners earned an average total validity score of 4.58 with valid criteria. Mathematics module based on metacognitive strategy in improving students' mathematical problem solving ability of SMA Negeri 3 Gunungsitoli developed is effective. In trial I obtained the results of the test of mathematical problem solving ability with an average value of 2.99 and on trial II obtained the test results of mathematical problem solving ability with an average value of 3.18. Based on the result of mathematical problem solving test in trial I and trial II it was found that there was an improvement of students' mathematical problem solving ability.

Keywords: development, mathematics modules, metacognitive strategy, mathematical problem solving ability

1. Introduction

In formal education, mathematics is one of the areas studied by students. Mathematics is a language that represents a series of meaningful statements that we want to convey. Basically mathematics is required by all scientific disciplines to increase the predictability and control of the science. Besides being a language, mathematics also serves as a tool of thought in drawing a conclusion by using a particular mindset. There are several responses to mathematics according to Suriasumantri (2012) that is, mathematics according to Wittgenstein is "nothing but a method of logical thinking", and according to Bertrand Russell, "mathematics is a period of logic maturity, whereas logic is a childhood of mathematics". From these descriptions, it is clear that mathematics is very important to learn, cultivate and mastered in the field of education as in school. So the mathematics lessons in school are expected to be learned correctly and appropriately in the learning process so that the benefits of mathematics can really be used and applied in the student's life.

In the process of learning mathematics there are several components of learning that affect the achievement of learning objectives. One component of learning is learning materials. According to Suparman (2014) that there are six basic components in the learning activities are: learners, graduates as competent as expected, instructional process or learning, teachers, curriculum and learning materials. Learning materials are components that are closely related to the content of each subject and must be relevant to the learning objectives, student characteristics, and learning strategies. Furthermore, Suparman said that the form of learning materials varies, one of them is learning materials used in independent learning approach or often referred to as modules. The module helps students learn independently because the module contains the complete learning content and the module has its own self-explanatory power and the module is also developed according to the characteristics of the students. It can attract students 'attention and increase students' interest in learning math. Modules are learning materials arranged systematically according to a particular curriculum, packed in the smallest learning unit and enables students to study independently within a certain time (Purwanto *et al.* 2007).

Meyer said in Lasmiyati (2014) that "a module is relatively short self-contained independent unit of instructional designed to achieve a limited set of specific and well-defined educational objectives. It usually has a tangible format as a set or kit of coordinated and highly produced materials involving a variety of media . A module may or may not be designed for individual self paced learning and may employ a variety of teaching techniques". The

meaning of the module is a learning material of instructional that is relatively short and specific content that is arranged to achieve the learning objectives. The module usually has a well-coordinated series of activities related to material , media and evaluation.

From the above statements, it is concluded that the mathematics module is a self-learning material of students in mathematics learning systematically designed based on a particular curriculum, compiled relatively briefly and specifically in the form of the smallest learning unit, and is designed with an interesting that contains a series of coordinated activities with good relating to the material, media and evaluation so that students are more focused, systematic and can easily learn it to achieve the expected competencies according to the learning objectives.

Based on the observations made on mathematics teaching materials in the form of mathematics books and supporting books used by teachers at SMA Negeri 3 Gunungsitoli is known that there are still shortcomings. Books used by teachers and students also lack the involvement and training of students' thinking processes. Students are less interested in reading and studying the math book used. The book used also does not contain elements that are characteristic of an area where the student is located. In the process of learning the teacher also does not provide modules to students as learning materials that can be used and studied easily by students independently. Books used by teachers only present the material and provide non-routine questions and less stimulate the thinking process of students in solving problems.

The objectives of mathematics subjects according to Mendiknas (2006) are: to understand the concepts of mathematics, to explain the interconnectedness of concepts and apply the concept or algorithms, flexibly, accurately, efficiently, and appropriately in problem solving and problem solving including the ability to understand problems, design mathematical models, complete the model and interpret the solutions obtained. NCTM (2000) to declare that there are 5 processes standard that are important in the study of mathematics, namely: problem solving, reasoning, communication , connections and representation. According to NCTM (2000) problem solving means involved in tasks that the solution is not known in advance. In order to find solutions, students must use the knowledge they have, and through this process, they will often develop new understandings in mathematics.

According to Das, R. & Das, G. (2013) "Problem solving significantly plays a important role in mathematics teaching and learning. Trough problem solving students can enhance reviews their thinking skills, apply procedures, deepen reviews their conceptual understanding ". Meaning problem solving plays an important role in learning mathematics. With problem solving, students can improve their thinking skills, apply procedures, deepen their conceptual understanding. Liljedahl, et al. (2016) says mathematical problem solving has long been viewed as an important aspect of mathematics, mathematics teaching, and mathematics learning. The more people who want to help solve the problems of others, the more the person's chance to use high-level thinking when thinking in solving scientific problems (Gallagher *et al.* 2012).

The most common problem solving is defined as an experiment to achieve some results, in the absence of known methods to achieve them (Schoenfeld 2013). According to Ahghar (2012) that one of the characteristics of independent learners is having the ability to use problem solving skills. According to Szabo & Andrews (2017) that the problem-solving task is expected to uncover the mathematical competence needed to solve it rather than recall the previously solved problem. Because mathematical problem solving is very important in mathematics learning, then the ability to solve mathematical problems must be owned by a student.

Problems in mathematics are challenging and non-resolvable issues in a routine way. According to Marsigit (2012) problem solving can encourage students to think logically, consistently, systematically and develop documentation systems/records, and can develop skills and skills to solve problems. The problem-solving process begins after the problem solver generates enough information about the problem space to gain an understanding of the problem (Dixon & Brown 2012). Successful problem solving is not possible without first doing the problem representation appropriately (Sajadi *et al.* 2013).

According to Polya (1973) there are four stages in problem solving:First, we have to understand the problem; we have to see clearly what is required. Second, we have to see how the various items are connected, how the unknown is linked to the data, in order to obtain the idea of the solution, to make a plan. Third, we carry out our plan. Fourth, we look back at the completed solution, we review and discuss it.

Based on the tests given to the students on the preliminary observation tested to 33 (thirty three) students of class X (ten) in SMA Negeri 3 Gunungsitoli, about the mathematical problem solving test, the result of mathematical problem solving still low. This is because the process of learning mathematics is less interesting for students so that the motivation of students in learning mathematics is still lacking and also due to students are not familiar

with the problems that involve mathematical problem solving ability. This has an impact on student learning outcomes in lower mathematics lessons, especially on mathematical problem solving ability.

Teachers should be able to design a mathematical learning process that can mathematical problem solving ability. As a solution to the problem, the researcher develops a mathematics module based on effective metacognitive strategies to improve students' mathematical problem solving ability, modules involving students' 'thinking processes, modules that draw students' attention to learn, and modules containing elements that become characteristic of the students' area is located. Because one of the learning process that is believed to improve students' mathematical problem solving ability is a learning based on metacognitive strategy. This metacognitive strategy-based learning is still not implemented in SMA Negeri 3 Gunungsitoli. Metacognitive is to give consideration to what is thought, whether it is appropriate or not.

According to Aljaberi & Gheith (2015) metacognitive is "Thinking about thingking". Metacognitive also deals with the competence of learning and thinking as well as problem solving. According to Anggo (2011) that the Polya problem solving based on the *knowledge of cognition* and *regulation of cognition.* Both elements are a component of metacognitive. According to Cohors-Fresenborg & Kaune in Anggo (2011) that metacognitive activity consists of: (1) planning, (2) monitoring and (3) reflection. Thus metacognitive gives consideration in using the knowledge possessed in regulating cognitive processes.

Metacognitive is an important feature of problem solving (Chimuma & Johnson 2016; Wismath & Orr 2015). Metacognition is the knowledge of one's ability to control his thought processes in solving problems (Bajar-Sales *et al*. 2015; Mamona-Downs & Downs 2013). Metacognition includes the skills of learners to understand cognitive processes (Ahghar 2012). Thus metacognitive gives consideration in using the knowledge possessed in regulating cognitive processes.

Based on research conducted by Hassan & Ahmed (2015) it is said that metacognitive strategies have a high influence in improving students' academic achievement. This is also supported by another study which says that with metacognitive strategies students can succeed in problem solving (Sengul & Katranci 2015; Suriyon *et al*. 2013).

Based on these problems then the formulation of the problem in this research are: 1) How is the level of the validity of mathematics module based on metacognitive strategy in improving students' mathematical problem solving ability at SMA Negeri 3 Gunungsitoli? 2) How is the effectiveness of mathematics module based on metacognitive strategy in improving students' mathematical problem solving ability at SMA Negeri 3 Gunungsitoli? 3) How to improve students' mathematical problem solving ability in the application of mathematics module based on metacognitive strategy?

Some research questions are asked related to the effectiveness of learning related to the use of mathematics module based on metacognitive strategy that is:

a. How is the level of students ' learning mastery of students' mathematical problem solving ability?
b. How is the level of students' active activity during the learning process using mathematics modules based on metacognitive strategy?
c. How is the level of teacher ability to manage learning?
d. How does the student's response to the processes and components of the use of mathematics modules based on metacognitive strategy?

2. Research Methods

The development of the module used in this study is to use the Dick & Carey model development procedure for several reasons: the Dick & Carey model has been widely used to develop effective tools, every step of the Dick & Carey model is feedback or revised, Dick & Carey's model is very concise, compact and clear and interconnected with each other and in accordance with the applicable curriculum. The module development procedure with Dick & Carey's development model can be described as follows Dick *et al.* (2005):

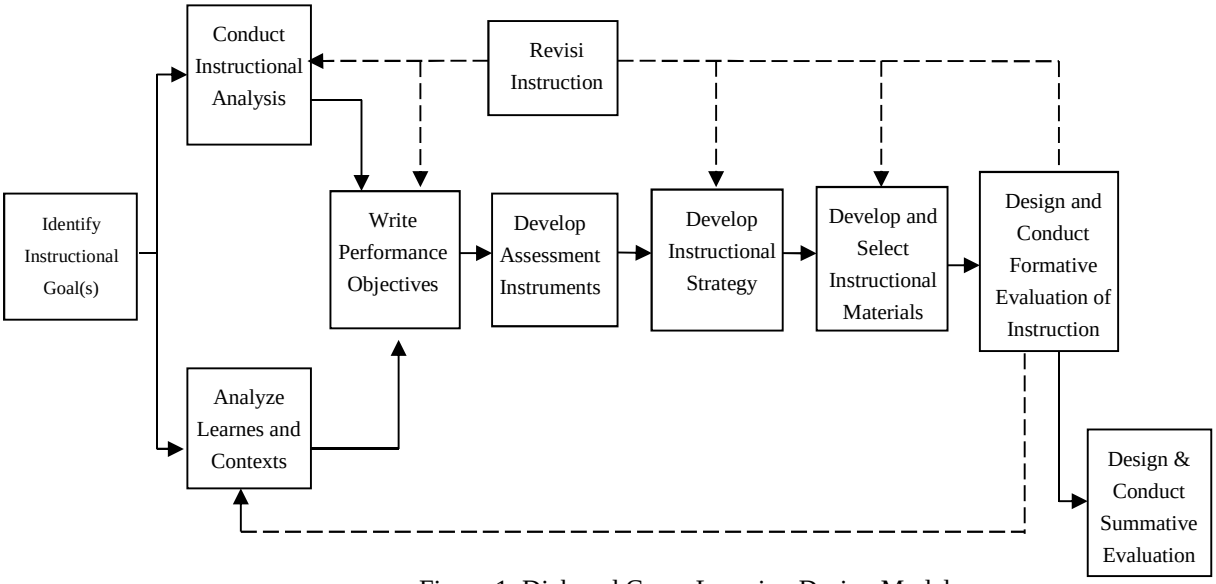

Figure 1. Dick and Carey Learning Design Model

The development of a mathematics module based on metacognitive strategies was developed in accordance with the Dick & Carey development model procedure consisting of ten steps. Each step is always connected to the revision. After the module has been developed, it is validated by the experts and applied in the learning process in the first class, then the module effectiveness analysis is based on the indicator that becomes the module effectiveness criteria called trial I. Based on the experiment result I, analyzed the part of the module that needs to be revised or repaired again. The revised module is applied in the learning process in the second class, after which a module effectiveness analysis is performed based on the indicator that becomes the module effectiveness criteria called trial II. A good module to use in mathematics learning is a good quality math module. The high quality module criteria used in this study is valid and effective.

The validity instrument module uses the module validation sheet. The module validation sheet is used to measure the validity of the module. The validity of the module is useful to know whether the module is adequate to achieve the learning objectives. Module validity can be measured through expert analysis. The criteria states that a metacognitive strategy-based module has a good degree of validity, if at least the validity level achieved is a valid level. If the level of validity achievement below is valid, then it needs to be revised based on input (correction) of the experts. Furthermore, validation activities are performed again. And so on until the ideal module obtained from the size of validity.

The effectiveness of the module is used to find out whether the developed module can be used as expected to improve the students' mathematical problem solving ability. The module effectiveness instrument consists of: test to know the level of student's mathematical problem solving ability, observation sheet of active student activity level, teacher's ability observation sheet to manage the learning and questionnaire of student response to process and component of module usage. The criteria for determining the effectiveness of the mathematics module based on metacognitive strategy is operational in the field (in the implementation of classroom learning) the four indicators of effectiveness aspects are met: 1) students' learning mastery of students' mathematical problem solving ability, ie at least 85% of students who follow learning can achieve more value than or equal to 2.67 or at least B^-, 2) Achievement percentage of ideal time of assigned student activity, 4) Achievement of teachers' ability to manage learning at least well, 5) At least 80% of the subjects studied (for each trial) provide positive response to the activities and learning components.

3. Research Results

This research resulted some conclusions from research conducted based on problem formulation, that is module validity, module effectiveness, improvement of students' mathematical problem solving ability.

3.1. Module validity

Module validity can be measured through expert analysis. Based on the results of expert analysis of mathematics module based on metacognitive strategy obtained the average value of total validity is as shown in the following table.

Table 1. Results Validity Module

Object / Aspect Assessed	Average Every Aspect	Average Value of Total Validity	Validation Level
Mathematics Module Based on Metacognitive Strategy			
a. Quality of Presentation Method	4.6		
b. Language Usage	4.6	4,58	Valid
c. Presentation / Illustrations	4.6		
d. Quality of Content	4.5		

The following validity criteria:

$1 \leq Va < 2$: invalid

$2 \leq Va < 3$: less valid

$3 \leq Va < 4$: is quite valid

$4 \leq Va < 5$: valid

$Va = 5$: very valid

Based on table-1, obtained the average value of total validity of the mathematics module based on metacognitive strategies are at intervals: $4 \leq Va < 5$. Based on the criteria of validity it can be said that the mathematics module based on metacognitive strategies developed valid.

3.2. Effectiveness Module

The criteria for determining the effectiveness of mathematics modules based on metacognitive strategy in the field operation (in the implementation of classroom learning) consist of four indicators of effectiveness aspect. Based on the results of research on trial I, the results obtained from the four indicators are as follows:

1. Learning mastery to students' mathematical problem solving ability is classically, ie 87.5% of students who take the learning reaches a value of 2.67 or B -.
2. Achievement percentage ideal time student activity is not in accordance with established
3. Achievement of the ability of teachers to manage learning is good
4. 75% of the many subjects studied gave positive response to the activities and learning components.

Based on the results of research on trial II, the results obtained from the four indicators are as follows:

1. Learning mastery to students' mathematical problem solving ability is classically, ie 95% of students who take the learning reaches a value of 2.67 or B -.
2. Achievement ideal percentage of time the student activity was in accordance with established
3. Achievement of the ability of teachers to manage learning is very good
4. 85% of the many subjects studied gave positive response to the activities and learning components.

From the result of trial II, it is known that the developed mathematics module has fulfilled the four indicators of effectiveness. With the application of mathematics module based on metacognitive strategy, students are mastery is classical to problem solving ability, the ideal time percentage of student activity has been in accordance with established, the ability of teachers to manage the learning is very good and the number of students who give positive response to the activities and learning components have in accordance with the requirements that have been established from the indicators of effectiveness. In addition, the application of mathematics modules based on metacognitive strategies in the learning process can improve problem solving skills and mathematical connections of students. This is in line with research done by Devesh and Nasseri, through their research saying that many students are easier, more useful and more interesting learning math because they use modules and the use of mathematical modules is very effective in learning (Devesh & Nasseri 2014).

Furthermore, the results of this study are also supported by research conducted by Sengul and Katranci. According to Sengul & Yasemin (2015) based on his research saying that there is a correlation between metacognitive with problem solving and students who learn to use their metacognitive skills are more successful in problem solving.

3.3. Mathematical Problem Solving Ability

The level of mathematical problem solving ability was measured based on test results tested on the students in trial I and trial II. In the test I obtained the results of the test of mathematical problem solving ability with average value of 2.99. While in the trial II obtained the test results of mathematical problem solving ability with average value of 3.18. Based on the results of trial I and trial II, it is known that there is an increase in students' mathematical problem solving ability by using mathematics module based on metacognitive strategy.

4. Conclusion

Based on the results of the research that has been obtained, it is concluded that:

- The mathematics module based on the metacognitive strategy developed is valid in improving students' mathematical problem solving ability with the validity level at the interval: $4 \leq Va < 5$ with valid criteria
- The mathematics module based on metacognitive strategy developed is effective in improving students' mathematical problem solving ability with the fulfillment of the five effectiveness indicators in trial II that is:
  a. Students' learning mastery is classically that get a minimum value of B- to the mathematical problem solving ability reach 95%,
  b. Achievement of the percentage of ideal time of student activity has been in accordance with the set,
  c. Achieving the ability of teachers to manage learning is very good,
  d. 85% of the many subjects studied gave a positive response to the the activities and learning components.
- The improvement of students' mathematical problem solving ability in the application of mathematics module based on metacognitive strategy is 0.19 with the average score of mathematical problem solving test results in test I obtained is 2.99. While in trial II obtained the average value of the test results of mathematical problem solving ability is 3.18.

5. Suggestion

From the research conducted, there are some research findings both that support the learning and constraints faced during the research. The things that support the learning process are: (1) students are interested in using and reading the module, (2) in the presence of active student modules in the learning process such as reading and understanding modules, ask and discuss with group friends and solve problems that exist in modules, (3) students' problem solving ability increased by using mathematics modules based on metacognitive strategies. While the obstacles encountered during the study are: (1) learning with metacognitive strategies is new followed by students so that there are still students who do not follow the stages of metacognitive strategies, (2) the problem solving tests are rarely tested to the students so that there are students who find difficulty in doing the questions given by the teacher, (3) in the learning process there are still students who do not participate in the discussion in the group.

Based on the findings of the research, the researcher gives some suggestions, either to the reader, to the teacher or to the next researcher, that is:

1. The resulting modules need to be developed and used in other materials and other similar fields using metacognitive strategies
2. Teachers should always remind students of metacognitive strategy stages through metacognitive questions, so that students follow the metacognitive strategy stages during problem solving in the learning process
3. The test of mathematical problem solving ability should be frequently tested to the students so that the students become accustomed to solve the problems of mathematical problem solving and students are always reminded to solve the existing problems according to indicators of problem solving consisting of understanding, planning, resolving and checking back

4. Teachers should continue to motivate students to be active in learning and group discussions, explaining the importance of the material is learned and its relation to daily life by loading elements that are characteristic of the student's area or environment in the learning module.

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