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PROBLEM SOLVING BASED LEARNING MODEL ALTERNATIVE MODEL OF DEVELOPING HIGH ORDER THINKING

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ABSTRACT

The result of preliminary study on junior high school students in Ambon city shows that students' thinking ability is relatively low. From 160 students from 4 junior high schools in Ambon city that became sample, it was found that 90,63% had high thinking ability in low and very low category, and only about 1,25% of students who had good ability. Primarily, this is due to the weaknesses of learning that involve less of problem solving processes, including high order thinking processes.

This research is aimed to develop a new learning model called problem solving based learning model. There are six major components, they are: (1) syntax, (2) social system, (3) principles of reaction, (4) support system, (5) instructional effect and nurturant effect, and (6) evaluation system. This model consists of 7 (seven) phases, they are: (1) the introduction, (2) material discussion, (3) problem solving, (4) presentation, (5) extension of problem solving, (6) presentation, and (7) closing. Problem presentation and problem solving process in this model is started from simple to complex one. In this model, learning activities are directed at problem solving which is believed will be able to stimulate students' thinking and develop highorder thinking skills.

INTRODUCTION

High order thinking skills is one of the important skills that should be

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developed through formal education. Education as the medium for intelligence and culture should not only be directed to develop the basic skills that are described in the school curriculum. The mastery of concepts and skills is an important aspect of education, however those ability is not enough to equip students to survive in life. School education should also be directed to build broader skills, such as critical thinking skills and creative thinking skills, autonomous learning skills, inovation skills, the mastery of informatics technology, etc.

In the Regulation of the Minister of Education and Culture No. 20 Year 2016, it emphasized the importance of thinking and acting skills that must be mastered by graduates of SD/MI, SMP/MTs, and SMA/SMK/MA. The mentioned skills include thinking and acting creatively, productively, critically, independently, collaboratively, and communicatively. The context of high order thinking is also described in the National Examination Grid and the National Standardized Examination in 2016 and 2017. In the mentioned grid, skills that should be mastered by students are categorized into three categories or three levels of cognition, namely (1) knowledge and understanding, including the ability of mentioning, identifying, showing, explaining, defining, categorizing, classifying, deciphering, etc; (2) applications, including the ability of distinguishing, applying, exemplifying, associating, interpreting, comparing, etc.; and (3) verification, including the ability of analyzing, responding to/commenting on, predicting, problems solving, concluding, reflecting, synthesizing, evaluating, creating.

The major problem in Maluku province education generally and the city of Ambon particularly is that the students' critical thinking ability is very low. From the preliminary study obtained from 160 students from 4 junior high schools in Ambon city, it is known that there were about 90,63% of students with high order thinking skills that are categorized into low or very low category, and there are only about 1.25% who had capability in good category. More detailed ability to master the concept and thinking ability of junior high school students are presented in table 1 below:

Table 1. Mastery of Concept and Higher Order Thinking Skill of Junior High School Students.

Score	Mastery of Concept		HOTS		Category
	f	%	f	%	
$85 \leq x$	5	3,125	0	0	Very good
$70 \leq x < 85$	15	9,373	2	1,25	Good
$55 \leq x < 70$	30	18,75	13	8,125	Moderate
$40 \leq x < 55$	63	39,375	32	20	Low
$x < 40$	47	29,375	113	70,625	Very Low
Total	160	100	160	100	

The low of students' high order thinking skills is caused by several factors, they are:

1. Cannot mastering the concept well. Table 1 shows that the concept mastery level from 68,75% of students categorized into low or very low categories.
2. The ability to apply mathematical concepts and principles in problem solving is relatively low.
3. The ability to build relationships between concepts or relationships between mathematical principles in problem solving is relatively low.

These factors are mainly happened due to the weaknesses of learning. Mathematics learning is more directed to conceptualization and less emphasis on problem solving. From preliminary observations toward junior high schools in Ambon city , it was found that some teachers have involved the problem solving process in learning, unfortunately the problem solving involved is considered in simple or intermediate level, the higher problem solving or complex is less of attention.

Therefore, it is necessary to develop a new learning model that is more oriented on problem solving. Problem solving activities from simple to complex should be a routine activity in learning. This problem solving activity will stimulate students' way of thinking to develop high order thinking skills. This research is done with the aim to produce a new learning model called problem solving based learning model.

This research is a developmental research. By doing this research, it is expected can produce (1) Problem Solving Based Learning Model, (2) learning tools, and (3) textbook. The development is done by referring to the development model developed by Plomp (1997:5), consisting of 5 (five) phases, they are: (1) preliminary investigation, (2) design, (3) realization/construction, (4) test, evaluation, and revision, and (5) implementation. This paper is further directed to introduce the model of Problem Solving Based Learning as one of the models that can be applied in learning mathematics.

Problem Solving Based Learning Model

According to Joyce and Weil (2009) there are five components of the learning model: (1) syntax, (2) social system, (3) principles of reaction, (4) support system, and (5) instructional effect and nurturant effect. While Arends (1997) confirms that there are four components, they are: (1) goal, (2) syntax, (3) learning environment, and (4) management system. The goal component of learning, according to Arends,is related to the instructional effect and nurturant effect component of Joyce and Weil; component of learning environment, according to Arends,is related to the social system component and the principles of reaction by Joyce and Weil (Ratumanan, 2016).

Model component according to Joyce and Weil (2009) and Arends (1997) furthermore become references in the development of problem solving based learning model. Referring to the mentioned concept, problem solving based learning model that is developed consists of 5 (five) important components, namely (1) syntax, (2) social system, (3) principles of reaction, (4) support system, and (5) instructional effect and nurturant effect component.

1. Syntax

Syntax refers to the overall plot and sequence of teaching and learning activities. The syntax determines the types of teacher and students actions that is needed, the sequence and the tasks for the students (Arends, 1997). Syntax is described in the sequence of activities called phases, each model of learning has a different plot of phase (Joyce and Weil, 2009). The initial syntax of the problem solving based learning model is presented in Table 2 below.

Table 2. Initial Syntax of Problem Solving Based Learning Model.

Phase	Description
Introduction	Pre learning activities is delivered in the form of delivering goals, apperception, motivating, and organizing students to learn. Students are grouped in small groups of 3-5 people.
Material Discussion	In this phase the learning materials are studied or discussed. Teachers can present the subject material briefly, or can also be constructed by students referring to the teaching materials prepared by the teacher.
Problem Solving	Relevant problems are presented to be solved by each group. Problems are given ata simple and moderate level. While the group works, the teacher goes around controlling and providing support to the group.
Presentation and discussion	Randomly, the teacher point out a certain group to present or write their work on the board. The result of small group work is discussed in large group.
Extension of problem solving	The teacher gives more complex problem, studentss work on it in small group. The teacher goes around controlling and giving help.
Presentation and discussion	The teacher point out a group randomly to write down the work on the board. The result of group work is discussed in large group. In this phase, the teacher also gives confirmation
Closing	The teacher direct students to make summary, provide tasks and give test (if from the beginning has been planned).

2. Social System

According to Joyce& Weil (2009) the social system shows the role and relationship of students and the types of norms recommended. The role of teacher leadership is greatly different from one model to another.

In the problem solving based learning model, problem solving activities are done in small groups of 3-5 people. In each group, students work together, interact, support each other, and share in solving the group's problem. In the context of group work, teachers need to play a role to facilitate and motivate students, hence, they all can be involved in the problem solving process. The mental involvement actively in problem solving activities in spite of strengthening students' understanding of learning materials (concepts, principles, and procedures/skills), it will also stimulate the development of students' higher order thinking skills.

The principles contained in this problem solving based learning model are (1) cooperation, (2) responsibility for ownself and group, and (3) focus on

learning activities, including problem solving activities. These principles become the basis for group work and will ensure the success of the group in completing the problem solving task.

3. Principles of Reaction

Principles of reaction related to how the teacher put attention and treat students, including how the teacher respond to answer questions, response or what students do. Joyce& Weil (2009) explains that "Principles of reaction tell the teacher how to regard the learner and how to respond to what the learner do. "

In the problem solving based learning model, the teacher act as facilitator, motivator, conductor, moderator, and evaluator. As a facilitator, the teacher provides learning resources that enable students to learn and work on problem solving activities. As a motivator, the teacher motivates students to involve actively in every phases, especially in the problem solving, presentation and discussion phases. As a conductor, the teacher organizes each student to perform their role well and ensures that each student is active and focus in the learning process. As a moderator, the teacher leads, organizes, and directs class discussions so that the expected result can be achieved. As an evaluator, the teacher assesses students' progress and follow up the assessment's result.

Some of the teacher's behaviors (principles of reaction) expected in the problem solving based learning model are described as follows:

1. Give attention on the creation of good cooperative atmosphere among students, hence, they are able to interact and mutually shared in problem solving.
2. Provide and manage relevant learning resources that can support students in problem solving activities, both simple and complex problem.
3. Control the problem solving process and provide limited assistance to groups that found difficulties or face deadlock. The limited assistance intended here is the provision of assistance to each student (individually or in groups) in form of sufficient explanation without providing answers to the problem that is studied, or assistance in the form of focused questions that enable students to be aware on the relationship of concepts that are temporary studied in accordance to the principle of(Ratumanan, 2003).

4. Support System

Support system of a learning model is all the medium, materials and tools needed to apply the mentioned model. According to Joyce & Weil (2009), they confirm that "we use this concept to describe not the model itself so much as the supporting conditions necessary for its existence."

In learning through problem solving based learning model, it requires a number of materials and learning media. For each subject that will be discussed, the teacher needs to prepare teaching materials (in form of student's book, handout, student's worksheet, etc.), evaluation tools, and relevant learning media. By preparing and managing these learning materials and media, beside to increase the active participation of each group member to learn and work, it will also improve the learning outcomes.

Important aspects that the teacher needs to consider in relation to learning materials are (1) the sufficiency and the depth of learning materials (including concepts, principles, and procedures/skills), (2) math problems. Mathematical problems need to be carefully designed by the teacher, from simple problems to the complex one.

Example:

1. In the discussion of the linear equations system of two variables material, for instance. After a brief discussion about methods that can be applied in determining the completion of a linear equations system of two variables, the teacher can give a problem, in example:

   Please determine the completion of $2x + 3y = 7$ and $3x - y = 5$!

   To complete the task, it only takes the mastery of the procedure of elimination or substitution, and the mastery of the algebraic operations concept.

   To stimulate the thinking process of students, in the 3rd phase, the form of task (problems) can be improved, for example:

   a. Please determine the completion of $2x + 3y = 7$ and $3x - y = 5$ by using the method of elimination and substitution!
   b. Compare those two methods. In your opinion, which one is the easiest? Please give an explanation!

   In this problem, it does not only require the routine mastery of the linear equations system of two variables completion procedures. Students are encouraged to do the evaluative and analytical thinking process. Look at the various aspects of both methods and consider which one is the most simple or easy for them.

   In the 5th phase, namely the extension of problem solving, the teacher needs to design the

problem with higher levels of complexity. As an example:

> It is known that the price of 5 shirt and 3 pants is Rp. 600.000,- while the price of 2 shirt and 1 pants is Rp. 210.000, -. Please definethe price of each shirt and pants!

To solve the problem, firstly, students need to create a mathematical model and then apply the method of elimination or substitution or mixed methods. This task complexity can be increased by replacing the thing that students try to figure it out, for example:

> It is known that the price of 5 shirt and 3 pants is Rp. 600.000, - while the price of 2 clothes and 1 pants is Rp. 210.000, -. Suppose that Rudy buy 3 shirts and 2 pants, how much money that should be paid by Rudy.

Another example:

> A linear function is defined as f (x) = ax + b with x ∈ R. If f (-2) = -8 and f (5) = 13, determine f (7)!

This problem is an extension of the linear equations system of two variables problem. Students should be able to associate two concepts, namely the function concept and the linear equations system of two variables to solve this problem. By applying the concept of value function, students will obtain two linear equations with two variables. Next with the the linear equations system of two variables completion method, the student can determine the values of a and b, as well as the function of f (x). The final step of completion, students use f (x) to determine the value of f (7).

2. In the discussion of Solid in VIII class, after discussing the volume formula, in the 3rd phase, the problems are given to determine the volume of blocks, cubes, prisms, etc. (pictures and sides' sizes are provided). To solve these problems, students only need to remember the volume formula and do the substitution. Therefore, it only requires low order thinking skill. The level of students' thinking can be improved by giving problems in form of story. To solve this problem, firstly, students need to interpret it, make the picture, and use the volume formula of solid. The example of problem that stimulate moderate order thinking is:

   The base of a pyramid is a parallelogram in which the base and a height of the parallelogram are 12 cm and 10 cm for each. Suppose that the pyramid volume is 600 cm^3, please determine the height of the pyramid!

   The required thinking process becomes higher (think medium).

   Furthermore, in the 5th phase of problem solving based learning model, the teacher design more complex problem for the group activities, for example:

   a. The base of a pyramid is a parallelogram in which the base and the height of the parallelogram are 12 cm and 10 cm for each. Suppose that the volume of the pyramid is equal to the volume of the cuboid in which its length, width, and height are 15 cm, 10 cm, and 4 cm respectively, please determine the height of the pyramid!
   b. A bathtub is shaped a cuboid with inner size is 1 m long, 0.7 m wide, and 0.8 m tall. Determine how many liters of water that is needed to get the tub full.

5. Instructional effect and Nurturant effect

Each learning model is always expected to produce instructional effect and nurturant effect. Instructional effect is the result of learning that is directly obtained through directing students to the expected goals, such as students' mastery on the Xmaterial. While the nurturant effect is other learning result produced by a teaching and learning process, as the result of the learning atmosphere creation experienced directly by the students without direct direction from the teacher, for example "the ability of mathematical communication, autonomous of learning, etc." (Ratumanan, 2016). Regarding to the effect of this learning, Joyce & Weil (2009) confirms that.

"The effects of an environment can be direct-designed to come from the content and skills on the which the activities are based. Or effects can be implicit in the learning environment ... the description of the effects of the model can validly be Categorized as the direct or instructional effects and the direct or nurturant effects. The instructional effects are led by the learner in certain directions. The nurturant effects come from experiencing the environment created by the model."

Learning through problem solving based learning model places students as subjects in teaching and learning activities. The teacher will act as facilitator and motivator who facilitate and motivate students to learn. In the learning activity, the teacher only give brief explanation about the learning material in the 2nd phase, then the learning activity and problem solving is done by

students in the 3rd phase and 5th phase. Beside activities in both phases are useful to enhance the understanding of concepts, principles, and skills, it also improves students' high order thinking skills. In both phases, students solve problems in small groups, discuss, mutually shared, help each other in completing the group task. This situation will give effect on the improvement of students' cooperative skills.

In the 4th and 6th phases, students present their work and discuss in the large group. There is a process of sharing among groups, beside,there are criticism and new questionsthat are possibly appeared to stimulate students' thinking process. The confirmation given by the teacher in this phase will strengthen students' understanding toward the material that is discussed.

Mathematics learning using problem solving based learning model, is expected to generate instructional effect and nurturant effect. The details of those two effects are presented as follows.

1. Instructional effect

   Instructional effect that can be developed through the application of the problem solving based learning model are as follows:

   a. The mastery of learning materials

      Learning activities in 2nduntil 6th phase allow students to mastery learning materials when if it is compared to conventional learning. In the problem solving based learning model, students are actively involved in the whole learning process. This is very influential on the students' memorization level, the knowledge in form of mathematical material will be mastered better, and stored longer in students' memory. In the 3rd and 5th phase, there is a process of sharing and developing among the peer tutors, weak students will provide question and learn from the students who considered clever; otherwise clever students will help to explain for weak students. This process is effective in improving students' mastery of learning materials. According to Ratumanan (2016), by working together, helping each other, and mutually contributing ideas, it is expected that the learning materials that is learned or discussed in the group can be understood better rather than it is learned individually.

   b. Problem solving skill

      In the 3rd and 5th phase, students work together in small groups to solve mathematics problems that are ranged from the simple to the complex one. In the 3rd phase there are still routine questions, however they are supplemented with non-routine questions or problems. By doing problem solving activities in the group continually, the problem solving ability of students will increase gradually.

   c. High order thinking skills.

      Learning through the problem solving based learning model can stimulate students' thinking process. All phases, especially the 2nd until 6th phases require students' involvement in the learning process mentally. In the 2nd and 3rd phases, thinking activities are still categorized to low and middle order thinking (knowledge, understanding, and application of mathematical knowledge). In the 5th phase, namely the extension of problem solving, students are faced with more complex problems and demand higher order thinking processes (reasoning). In the 4th and 6th phases, in presentation and discussion, there is a possibility of the emergence of questions or criticisms that require students' critical thinking. Questions "why", "how", "is there any other way", etc. can arise from students and teachers to groups who present their tasks. Questions like these, not only stimulate students to think more accurately and comprehensively, but also think more critically. Thus, the application of the problem solving based learning model will functioned effectively in improving students' higher-order thinking skills gradually.

2. Nurturant effect

   The nurturant effects through the application of the problem solving based learning model are discussed as follows:

   a. Cooperative Skills

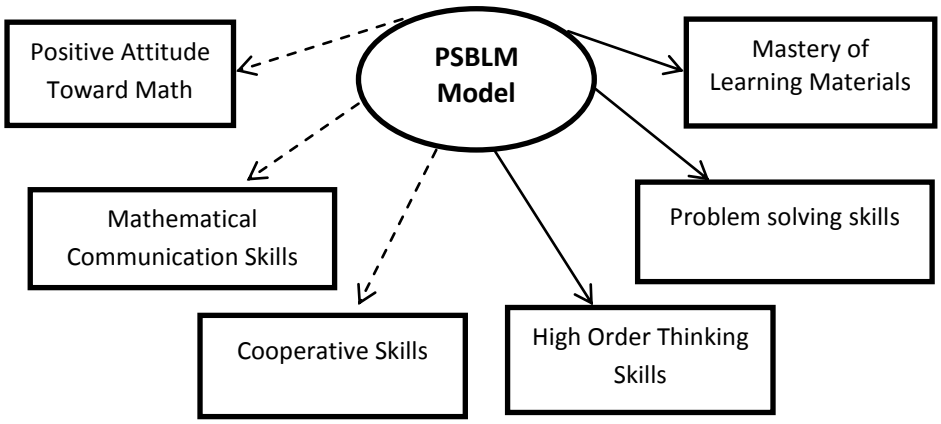
      The cooperativeskills are an important skill that is considered helpful in determining one's success in life and in work. In the cooperative skills there are many other skills that existed inside of it such as the skill to interact, the skill to listen with empathy, the skill to accept and appreciate differences, the skill to express differences opinion in an acceptable way, the skill to communicate in polite manner, etc. These skills can be developed through the learning that applies cooperative settings. The problem solving based learning model engages cooperative settings in learning. In the 3rd and 4th phase students is worked together in small groups to complete group

tasks in form of problem solving. In the 4th and 6th phase, each group delivers their work and shares it together. This kind of learning setting is able to develop the cooperative skills of each student.

b. Mathematical Communication Skills.
Mathematical communication is an important aspect that demands great attention in learning mathematics. Communication in mathematics is one of the other common basic skill, they are reasoning skill and problem solving skill (Baroody, 1993; NTCM, 2000). The mathematical communication in this context is the interconnected events in which the delivery and reception of mathematical messages that is occurred within a classroom environment. Mathematical messages here relate to mathematical material that is learned by students in teaching and learning activities (Ratumanan, 2016). In the mathematics learning by using problem solving based learning model, students are also directed to explain the thinking process and the obtained result of problem solving. In contrast, other students are expected to respond by correcting with logical arguments toward the mentioned knowledge construction and problem solving. By doing this process continuously, it is expected that the mathematical communication skill of students can increase.

c. Positive attitude towards mathematics.
In the problem solving based learning model, students are actively involved in teaching and learning activities, both in learning the material and in problem solving activities. Learning activities is occurreddynamically and fun. This situation affected on the opinion of mathematics as a difficult lesson, evenmore as frightened subject, can be changed gradually. Thus learning mathematics through the problem solving based learning model is able to build a positive attitude towards mathematics.

The effect of the application of the problem solving based learning model in mathematics learning is described as follows.



——— Instructional effect
…… Nurturant effect

Figure 1. The Effect of Mathematics Learning Using the BPM Model.

The description of the components of the problem solving based learning model above can be stated briefly in the following figure.

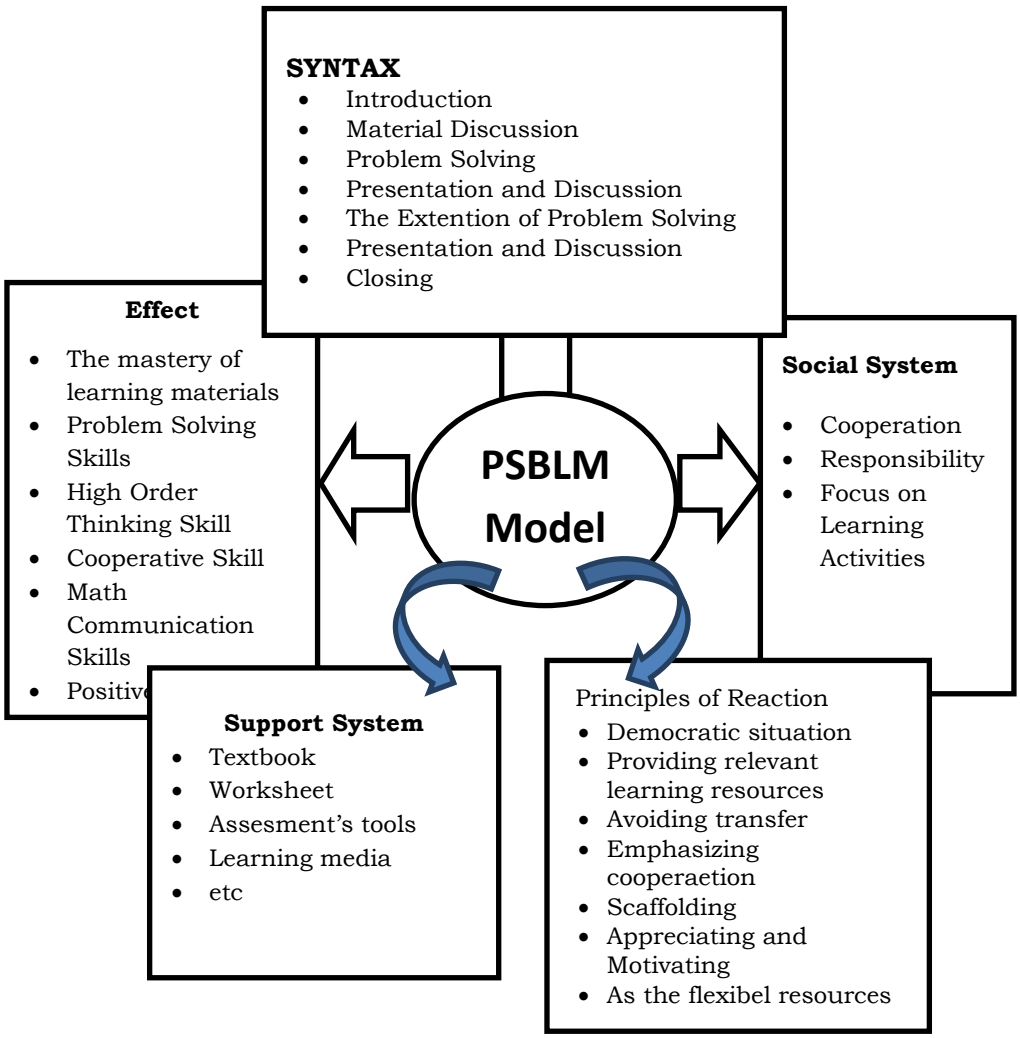


Figure 2. Components ofProblem Solving Based Learning Model.

CONCLUSION

Problem solving based learning model is a new developed model to develop high order thinking skills of students. As a new developed model, this developed model cannot be measured up how great this model's contribution toward the development of students' thinking skills. It is expected that this model can be studied further and can be engaged as one of the alternative models to develop the mathematics' skills, including the students' high order thinking skills.

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