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Creative Problem Solving to Improve Students’ Higher Order Thinking Skills in Mathematics Instructions

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Abstract—The 21st century skills requires students not only have the conceptual knowledge, but also must have the skills to think and skill in the application of knowledge. High order thinking skills (HOTS) is one of the skills that students required to face the competition in the 21st century. One effort that can be done to improve students’ HOTS namely through the implementation of creative problem solving (CPS) models in mathematics instruction. CPS can be implemented in mathematics instructions through the steps: (1) finding the objective of the problems (objective-finding); (2) analyzing facts or informations from the problems (fact-finding); (3) analyzing the important questions from the problem (problem-finding); (4) exploring ideas to solve the problem (idea-finding); (5) analyze the advantages and disadvantages of the ideas found (solution-finding); and (6) making the conclusion from the process of problem solving (acceptance-finding). CPS can improve students’ HOTS because: (a) the product or outcomes of learning by using CPS can be used to evaluate high order thinking skills; (b) present a meaningful learning activities; (c) effectively used individually or groups; (d) empower students to construct the knowledge; (e) as a variation in learning activities that involve problem solving; (f) fostering the understanding that not all the problems have only one solution that is right; and (g) presentation of challenging problems (creative problem) can attract and motivate students to learn.

Keywords: creative problem solving, higher order thinking skills, mathematics instructions

I. INTRODUCTION

In this modern era everyone is required to have a variety of skills. Skills expected as mentioned in “21st century skills” covers creativity, reasoning, and problem solving. These skills can be seen as a higher order thinking skills (HOTS). In order to achieve these objectives various attempts have been made, one of which is through curriculum renewal. In Indonesia, curriculum which leads to increased student HOTS stated in “Curriculum 2013”.

Implementation curriculum 2013 in Indonesia is not without obstacles. Retnawati [1] state that junior high school math teachers in Indonesia are still experiencing difficulties in implementing the curriculum in the classroom. The scientific method is becoming a pillar of the curriculum 2013 also can not be implemented effectively. This condition causes students’ HOTS in Indonesia is still low.

Still lack students’ HOTS in Indonesia apart caused by unreadiness of teachers, it can also be caused by use of the learning model that is less varied. Many literature states that HOTS can be enhanced through learning model that involves students in problem solving activities. It means, HOTS not only can be improved through the scientific method, but also need to try various learning models that oriented on improving students’ HOTS.

One of learning models that can be used to improve students’ HOTS is Creative Problem Solving (CPS). This article will explore what the CPS and implemented in mathematics instructions, as well as its implications for the improvement students’ HOTS.
II. DISCUSSION

A. Higher Order Thinking Skills

Many experts define HOTS with different approaches and viewpoints. Resnick [2] argues that HOTS is hard to define, but easily recognizable by its characteristics. Further, Resnick [2] reveals some of the characteristics of HOTS, namely: (a) non-algorithmic, meaning that the action steps can not be fully determined at the beginning; (b) complex, meaning that steps can not be seen/predictable directly from a certain perspective; (c) generating a lot of solutions; (d) involve differences of opinion and interpretation; (e) involves the application of multiple criteria; (f) involves uncertainty; (g) requires self-regulated in the process of thinking; (h) involves the meaning impressive; and (i) requires effortful.

Some of expert opinions relevant to definition HOTS as proposed by Thomas & Thorne [3] which states that the higher order thinking skills is thinking at level higher than just remembering facts or retell something audible to others. Furthermore Thomas & Thorne [3] states that the higher order thinking skills requires one to do something towards the facts, that is understand it, conclude, connect it with others facts and concepts, categorize, manipulate, putting the facts together in new ways, and apply them in finding a new solution of the problem. Lewis & Smith [4] states that higher order thinking skills occurs when a person obtains new information and stored it in memory and associates and or rearrange and extend information to achieve the goal or find a possible answer from confusion conditions. From opinions of experts it can be concluded that the HOTS require existence thinking process that more complex to face a situation or solve a problem.

If it is associated with thinking skills, HOTS can be seen as critical thinking and creative thinking [5, 6, 7,8], problem solving [6, 9], logical thinking, reflective thinking, and metacognitive [8], and decision-making [6]. Whereas if it is associated with cognitive processes in Bloom's taxonomy, the term HOTS often contrasted with the term LOTS (Lower Order Thinking Skills). Cognitive process analysis, synthesis, and evaluation are categorized as HOTS, while knowledge, understanding, and application are categorized as LOTS [10, 11]. Still relevant categorization HOTS and LOTS in Bloom’s taxonomy, different opinions expressed by Thompson [12] which categorizes the analysis, synthesis, and evaluation as HOTS, knowledge and understanding as LOTS, while applications in the category HOTS or LOTS.

As if it is associated with Bloom's taxonomy revision proposed by Anderson & Krathwohl [13], the dimension of cognitive processes HOTS includes the process of analyze, evaluate, and create, while the dimensions of knowledge HOTS include conceptual knowledge, procedural knowledge, and metacognitive knowledge. (see. Table 1)

![Table 1. HOTS IN BLOOM’S TAXONOMY REVISION](image)

Based on the theories that has been presented, the indicator HOTS in general can be developed through aspects of critical thinking and creative thinking, where these aspects are a major component in the process of higher order thinking skills, according the definition of HOTS noted previously.

Operationally, higher order thinking skills be detailed into indicators based on aspects of critical thinking and creative thinking. According to Ennis [14] critical thinking is "reasonable, reflective thinking that is focused on Deciding what to believe or do". Eggen & Kauchak [15] which states that critical thinking is the ability and the tendency of a person to make and do assessment toward conclusions based on evidence. Based on those two opinions, the critical thinking can be interpreted as an attempt to process and evaluate the information on a situation or issue based on strong evidence and logical. Critical thinking
is characterized by ability to analyze and evaluate. The ability to analyze emphasis on the ability to specify a substance into its component parts and seeing the relationships between the parts. Anderson & Krathwhol [13] argues that the ability to analyze operationally characterized by their ability to differentiating, organizing, and attributing. Still according to Anderson and Krathwohl [13], to evaluate the ability can be defined as the ability to make an assessment (judgment) based on the criteria and certain standards. It is characterized by the ability of checking and critiquing.

In a lot of levels of thinking that has been compiled by experts, many of which put creative thinking as the highest levels of thinking. Krulik & Rudnick [7] states that "creative thinking is thinking that is original and reflective and that produces a complex product. ...includes synthesizing ideas, generating new ideas, and determining reviews their effectiveness. ... the ability to make-decisions ... ". Pressesisen [6] argues that creative thinking is using the basic thinking processes to develop or find a new idea or product, aesthetic, and constructive. Creative thinking is emphasized on how to use the information or materials that are known to generate original ideas and elaborating perspective. Based on those opinions, creative thinking is emphasized on how to process the existing information to generate new ideas or products. In other words, the ability to think creatively characterized by ability to create. More specifically Anderson & Krathwohl [13] argues that the ability to create can be characterized by ability to formulate/make hypotheses (generating), planning, and producing.

Based on the description that has been presented about the indicators of higher order thinking skills, the indicators that will be used to measure students' higher order thinking skills are summarized in table 2 below.

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<tr>
<th>HOTS Aspect</th>
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<td>Critical Thinking</td>
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<td>Differentiating</td>
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B. Creative Problem Solving

Creative problem solving (CPS) is seen as one of the forms of variation in problem-based learning. One important and his experience.

Giangreco, Cloninger, Dennis, and Edelman [16] argues that the implications of the use of creative problem aspect that will be developed through this model is creativity of students in mathematics instructions. Bohan & Bohan [17] suggests that if we want students to be creative, we have to offer them something to be creative through knowledge. Thus through the application of creative problem solving, the students have the opportunity to be involved in the creative process in order to build knowledge based on prior knowledge solving in learning for students include:

1. Engage students in solving various problems and challenges in real life which a key characteristic of effective education.
2. Encourage students to believe that they can solve the problem, either independently or with the support of others in the class.
3. Offer opportunities for students (with either high or low academic ability) to assist in solving the challenges faced by them or their classmates and assign all students as a valuable contributor.
4. Offer opportunities for students to engage in the overall class according to their educational needs of each.
5. Offer the opportunity for students to learn and practice problem solving skills in a sustainable to address the relevant challenges.
6. Aspects of collaborative, non-judgmental, and action-oriented of creative problem solving encourage a sense of togetherness in addressing the challenges of concern to groups of students.

7. Encourage and strengthen many academic and affective skills (eg, observation, analysis, evaluation, took a point of view, build other ideas, synthesize ideas).

As for the implications of creative problem solving for teachers in learning [16], namely:

1. Encourage teachers to be open to the possibility that there is more than one correct answer.
2. Encourage teachers to continue to be learners and especially open themselves to learning from the students in their classes.
3. Provides a method to reduce the pressure in learning through group activities in problem solving.
4. Increase the capacity of teachers in teaching all students by identify the options that exist for teaching heterogeneous groups, adapting other options that already exist, and creating new options.
5. Encourage teachers to design attractive learning approaches and actively taking into account the contribution of the students.

Thus the creative problem solving in the learning process can trigger the implementation of active learning. Active here is not only focused that learning is solely centered on the student (student center), but teachers are also required to play a role in creating interesting circumstances of learning and in accordance with the needs of students, and to be able to develop creativity of students.

Associated with the implementation of creative problem solving in mathematics instructions, Bohan & Bohan [17] argues that this model has several characteristics, include: (1) help promote the kind of math class discussion becomes interesting and students excited to work; (2) presenting meaningful activities for students; (3) effectively used individually, cooperative groups, or as a classroom discussion; (4) empowers students to build knowledge in the field of mathematics; (5) produce products that can be used to evaluate higher order thinking skills.

Implementation of creative problem solving in mathematics instructions should be preceded by the presentation of open problems (open-ended) and non-routine [17]. More specifically Loewen [18] states that creative problem solving must use “creative problem”. Creative problems is a problem that can be solved using many different strategies and the final answer is not singular [18]. According to Loewen term “creative problem” has differences with term “problems” in general (traditional problem). The difference can be observed through the following scheme:

![Creative problem vs Traditional problem diagram](image-url)
From the scheme shows that the traditional problems can be solved using different strategies, but the final answer is singular, whereas creative problem can also be solved using many strategies but produced no single solution.

According to Loewen [18], the advantages of the use of creative problems than traditional problem, namely:
1. Creative problem develop an understanding that not all the problems have only one correct solution.
2. Creative problem is more exciting, so it can add interest. With increasing interest in this, then it can increase the motivation in learning mathematics.
3. Creative problem can stimulate students to continue to consider ways to solve the problem.
4. Creative problem can come up with creative ideas for a problem solver, where this is one of the objectives to be achieved in the learning of mathematics.

In reality, not all mathematics problems can be presented through creative problem that has many solutions. In this case the creative problem solving can be facilitated with the filing of the problems that can be solved through a lot of ways (multiple ways). Pepkin [19] states that although creative problem solving is usually related to a problem that has many solutions, such as those found in management, math usually involve only one solution, but geometry and other material of math often pose a problem where there are a lot of ways to get the same solution. It can be concluded that one of the characteristics of the problems that could be used in the implementation of creative problem solving is a problem that can be solved in many ways (open process).

Based on the description above, it can be concluded that the creative problem solving can be implemented through the filing of a problem as the starting point of learning, the problems that may be filed in the creative problem solving that is open ended problems or creative problem, namely the problem that has many ways of settlement and many of the solutions, and the problems an open process, which is a problem that has many ways of settlement and a single solution.

Giangreco, et al [16] states syntax of creative problem solving that was adopted from Osborn (1993) and Parnes (1992) include:
1. Visionizing or Objective-Finding, which at this early stage, problem solver increase their awareness through imagining (imagined) potential challenges given.
2. Fact-Finding, where problem solver collect much information as possible about the challenges that selected by using all their senses and perceptions. By asking "who, what, where, when, why, and how". Problem solver completed this phase by identifying the facts that they believe are most relevant to the challenges.
3. Problem-Finding, where the purpose of this phase is to clarify the challenges or problems by redefining with new and different ways. By repeating the challenge as a question, "In what ways might I/we...?"; and by asking the question "Why?" or "What would really me/us to accomplish?" This process is repeated until a problem solver restate the problem in a way that the most reasonable and the most attractive for them.
4. Idea-Finding, this phase aim to generate as many ideas as possible that could potentially be used to solve the challenges or problems. At this phase problem solver try to make new connections between ideas by analogy, the manipulation of ideas, or create a new association from another ideas.
5. Solution-Finding, which at this phase problem solver will consider various criteria and was chosen to evaluate the advantages of the ideas put forward. Problem solver using criteria to assist in selecting the best solution.
6. Acceptance-Finding, where problem solver fix or repaire solution to be more easily applied. The goal is to transform ideas into action through the development and implementation of action plans.

C. Why CPS can improve students’ HOTS?

Models of teaching can be used to improve students' higher order thinking skills is a model of teaching in which involves a problem solving activity. One model of teaching that involves problem solving activity
that is creative problem solving. Noller [20] states that creative problem solving can be defined as a process, method, or system to approach a problem in an imaginative way and produce effective action. The same thing was stated by Treffinger [21] that creative problem solving is a framework in which individuals or groups can use it to: formulate the problem, have the opportunity or challenge; generate and analyze a lot of new ideas; and planning and implementing new solutions or action programs effectively. From both these opinions seem that creative problem solving is one alternative that can be used to solve the problem through a process of creative thinking.

CPS can be used to improve students' higher order thinking skills, as the opinion argued by Bohan & Bohan [17] that the product or the learning outcomes using CPS can be used to evaluate high-level thinking skills. There are several other reasons that CPS models used effectively to improve student HOTS:

1. In objectives finding phase, students are invited to analyze the objectives of the problem or challenge, it certainly can train students to think critically, where students are required not only understand the problem, but also need to know "for what" the problem is resolved.

2. In fact finding phase, students are asked to identify all the important informations contained on the problem. It can be used as a tool to train students to think critically, and can also be used as a reference that students begin to understand the problem.

3. In problem finding phase, students are asked to formulate the important questions of the problem or question relevant with the purpose of problem submission. In this case the students return required to be able to identify points that can be used as a guideline in preparing the questions, or at least the students were able to reformulate these questions in their own language. Similarly, the fact finding phase, this phase can also be used as a tool to improve students' critical thinking skills.

4. In idea finding phase, students are asked to explore ideas that can be used to solve the problem. The ideas came up expected purely arrival from result of students thinking. In this phase students can exchange opinions with friends to explore the possibility of ideas that can be used to solve the problem. Moreover, at this phase, students can also utilize a variety of learning resources that are relevant in order to find creative ideas. This process is expected to help students develop their creative thinking skills in solve the problems. This is based on presence student’s activity to create or formulate ideas that can be used to solve the problem.

5. In solutions finding, students are asked to apply the ideas that successfully formulated in ideas finding phase. In this phase, the students are expected to choose the best idea from the ideas that they found earlier. This requires students to be able to analyze the advantages and disadvantages of each idea that has been presented in the previous phase. Furthermore, students are expected to take a decision to determine which ideas will be used to solve the problem. These activities can certainly be used as a tool for students to train higher order thinking skills.

6. In acceptance finding phase, students are required to be able to make a conclusion of the process of solving the problem that they do. The formulation of this conclusion should be aligned with the formulation of the questions in problem finding phase. Thus, students are expected to make the appropriate conclusions.

Some other advantages of the implementation CPS in mathematics instructions in context of enhancement students’ HOTS:

1. Presenting meaningful learning activities, where meaningful learning can help students develop their creativity, so as to improve students’ HOTS.

2. Effectively used individually or in groups. Learning in group is needed students to exchange ideas and concepts. Such a process is needed to help improve students’ HOTS.

3. Empowering students to construct the knowledge. One of the factors that may affect the increase of students’ HOTS are familiarized students to construct the knowledge, not received the knowledge from teachers.
4. As variations in learning activities that involve problem solving. Problem solving as one of the strategies to improve students' HOTS, but it is very important to give the variation in problem solving activities, so that the students do not get bored.

5. Cultivate the understanding that not all the problems have only one correct solution. The presence of understanding of the students that there are mathematical problems that have more than one correct solution can train students to try various alternatives in finding solutions of the problems. This will further raise critical power and creativity of students.

6. Presentation of the challenging problem (creative problem) can attract and motivate students to learn. Challenging problems is the key factor in sharpening students’ HOTS, which means that teachers have a role to facilitate students through submission the creative problems.

III. CONCLUSION

Models of teaching can be used to improve students’ HOTS is a model of teaching in which involves a problem solving activity. One model of teaching that involves problem solving activity that is creative problem solving (CPS). CPS can be implemented in mathematics instruction through the steps: (1) finding the objective of the problems (objective-finding); (2) analyzing facts or informations that is critical of the problems (fact-finding); (3) analyzing the important questions of the problem (problem-finding); (4) exploring ideas to solve the problem (idea-finding); (5) analyze the advantages and disadvantages of the ideas found (solution-finding); and (6) implementing the best ideas to solve the problem (acceptance-finding). CPS can improve student’s HOTS because: (a) the product/outcomes of learning by using CPS can be used to evaluate high order thinking skills; (b) present a meaningful learning activities; (c) effectively used individually or in groups; (d) empower students to construct the knowledge; (e) as a variation in learning activities that involve problem solving; (f) fostering the understanding that not all the problems have only one solution that is right; and (g) presentation of challenging problems (creative problem) can attract and motivate students to learn.

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