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Ill-Structured Mathematical Problems to Develop Creative Thinking Students

Abdillah[1], Ajeng Gelora Mastuti[1] and Muhajir Abd. Rahman[2]
[1]*Jurusan Pendidikan Matematika, IAIN Ambon, Indonesia*
[2]*Jurusan Pendidikan Agama Islam, IAIN Ambon, Indonesia*

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Abstract: One of the main challenges facing lecturers is preparing their students to face the transition from acquiring knowledge of problem-solving skills to the challenges they will face after graduation. This study presents ill-structured mathematical problems (ISMP) to develop students' creative thinking. This research was conducted by giving a two-point ISMP pre test to 130 students in the fourth and sixth semester of the Mathematics Study Program and Mathematics Education on two state Islamic religious college campuses. Researchers evaluate and categorize students' abilities based on indicators of ISMP solving ability. Furthermore, six research subjects were selected from students who had the potential to think creatively. The results show that the presentation of ISMP is useful for developing students' creative thinking. In solving ISMP Students create diverse and correct answers, done in many different ways, and create a variety of different answers and correct. The development of creativity of students looked after given ISMP second, with the increasing variety and correct answers, the emergence of a variety of different ways, and creation a variety of different answers and correct. This happens because the ISMP has several solutions, has a specific context and complex situations; and in accordance with everyday life so that students feel they experience the problem.

1 INTRODUCTION

There is several research results that show the problems related to knowledge gained by students in learning (Daniels, et al., 2007, Akinmola, 2014). Many teachers in the learning process provide quite structured problems. However, problems in the real world usually faced with ill-structured problems. We argue that if only using a well-structured problem as an example of the learning leads students not to be prepared for the problems they will face in their professional lives (Daniels, et al., 2007). Furthermore, the demands of the new century (21st century) require all students to gain an understanding of concepts, skills with positive skills and attitudes in mathematics if they want to succeed (Akinmola, 2014). This shows the importance of the knowledge gained by students in learning to achieve success in solving problems in real life.

There are many research results that show the importance of problem-solving (Akinmola, 2014, Bradshaw & Hazel, 2017, Yu, et al., 2015). Revealed that the importance of problem-solving skills through learning and application of mathematics appear in everyday life and at work (Akinmola, 2014). Scientific and technology-based problem solving for workers requires a strong foundation of mathematical knowledge. Mathematical problem solving has become an important aspect (Bradshaw & Hazel, 2017). Therefore it is important for us to equip students with the skills needed to solve problems. Highlight that "problem-solving is specific high-level procedural knowledge (Yu, et al., 2015).

Some opinions about Ill-structured problems are presented by Abdillah & Mastuti (2018), Jonassen (1997), Kitchener (1983), Voss & Post (1988), and Wood (1983). Ill-structured problems presented to students are problems that involve unknown elements, have several concept relationships, several solutions, solution pathways that require a person to express personal opinions because of their unique interpersonal activities (Abdillah & Mastuti, 2018). Ill-structured problems is vague, as well as goals, seemingly unclear. In addition, constraints are also not clearly stated (Voss & Post, 1988). The same

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thing was expressed by Wood (1983) that ill structured problems seem unclear because the problem or one of the elements of the problem is unknown. In this case, the ill structured mathematical problems are the types of ill structured problems faced in the practice of everyday life, containing mathematical content, involving unknown elements, having several concepts, several solutions, pathways of solutions that require someone to express a personal opinion because it is related to unique human interpersonal activities.

Ill-structured problems arise from specific contexts, have the following characteristics: first, aspects of the situation are not concrete; second, the problem is not well defined; third, this problem is based on real-life situations and has openness; and finally, complex situations are presented (Hong & Kim, 2016). Ill-structured problems as authenticity, complexity, and openness are the properties of Ill-structured problems (Kim, et al., 2011). Authenticity means that it is in accordance with everyday life, with math homework or problems that describe real life outside of school (Palm, 2008). A problem can be said to have authenticity if the problem covers the context of everyday life and is relevant enough to deduce an integral part of the actual situation.

In terms of complexity, Jonassen (1997) considers that the attributes of complexity contain: the uncertainty of concepts, rules, and principles needed to solve problems, or how the problem is organized. The relationship between concepts and rules and principles do not set. In terms of openness, Jonassen (1997) said: first, some evaluation criteria must exist to solve problems; second, the clarity of the purpose of the problem is not presented; third, students must express personal opinions and beliefs about the problem; fourth, it is recommended that students judge and maintain problems. Shin, et al. (2003) says that the nature of openness allows students to place various interpretations of problem-solving and to justify their interpretation.

2 METHOD

This research data was obtained from the granting of two ISMP pretest points to 130 students in the fourth and sixth semester of the Mathematics Study Program and Mathematics Education from two state Islamic religious college campuses, in two provinces in Indonesia. Researchers evaluate and categorize students' abilities based on indicators of ability to solve structured problems. Furthermore, six research subjects were selected from students who had the potential to think creatively. The selection of research subjects is based on the quantity of achievement of indicators of structured problem-solving abilities conducted by the subjects in completing the ISMP pretest. In addition, researchers also pay attention to the results of direct observations related to the verbal communication skills of prospective subject students.

The approach used in this study is to use a qualitative approach with a type of descriptive-explorative research (Miles & Huberman, 1984). When viewed from the purpose of this study is to produce a description of the development process of students' creative thinking in the face of their professional life through the provision of ISMP. To reveal or obtain a description of the subject's thinking process in completing the ISMP, the researcher applies the think-aloud technique to the subject. The researcher tries to conduct a thorough and in-depth examination (by exploring) the subject about what is done, written, spoken, body movements, or even what they think when completing the ISMP. Therefore researchers act as key instruments, their existence is absolutely necessary and cannot be represented by others or with something else (Creswell, 2013). In terms of obtaining data, researchers used assistive instruments such as ill-structured mathematical problems (ISMP), audio and audiovisual recording devices (Handy cam) as supporting instruments. The ISMP used is as follows:

1) The price of one shirt in Toko A (Store I) is Rp. 5,000, - more expensive than the price of one shirt in Toko B (Toko II). Shop B gives a 10% discount for the purchase of each shirt. Shop A gives a special price, that is, if someone buys more than one shirt, they will get a 40% discount on the second purchase of each shirt. If you want to buy 3 clothes, then how do you get the cheapest purchase costs? Give an explanation about buying clothes in both stores!
2) There are two shoe stores, namely Toko S (Shop I) and Toko P (Toko II). To attract buyers, each store has its own way of attracting buyers' attention. Shop P gives a 15% discount on the purchase of each pair of shoes. Toko S gives a 35% discount on the second purchase of each pair of shoes, but the price of a pair of shoes at Toko S is Rp. 6,500, - more expensive than the price of a pair of shoes in Shop P. If you want to buy 3 pairs of shoes, to pay the cheapest purchase price explanation of shoe purchases in both stores.

3 RESULTS AND DISCUSSION

The following is a discussion about ill-structured mathematical problems to develop students' creative thinking. The problem presented contains two important things: first, there is no standard procedure used to solve the problem; the second raises a dilemma in the form of a choice between buying three pairs of shoes or clothes in Toko I, three pairs of shoes or in a shop II, two pairs of shoes or clothes in Toko I and one pair of shoes or clothes in Toko II, or one pair of shoes or clothes in the Shop I and two pairs of shoes or clothes in Toko II; the third purchase problem in Toko 2s not well defined; fourth, problems in both stores are based on real-life situations and have openness; and fifth, a complex situation is presented, how to make the cheapest purchase costs?.

Related to the solution of ill-structured problems Kitchener (1983) argues that ill-structured problems have several solutions or possible solutions. Another possibility is that there is no solution at all, that is, there is no agreement between problem solvers or not based on consensus on the right solution if2one by the group. So according to Jonassen (1997) in the process of solving ill-structured problems, one must make judgments about problems and2an maintain their opinions. As a result, one must express personal opinions or beliefs about the problem (Abdillah, et al., 2017). Thus the solution to students' structured mathematical problems in this discussion is the unique interpersonal activity of students known at the time of think aloud. Other supporting data is the result of clarification at the time of the interv1w.

Furthermore, Ill-structured problems are a type of problem encountered in the practice of everyday life, so this problem usually raises the dilemma of choice (Jonassen, 1997). Because Ill-structured problems are not only limited by the content domain learned in class, the solution is not convergent. This problem also allows requiring the integration of multiple content domains. Have many alternative problems to solve (Abdillah, et al., 2017). Furthermore, Abdillah et al. (2016) argued that in exploring decision making one would need a theory as a guide. The student's decision in choosing several choices made is an alternative action from a series of actions or strategies made by students. These actions can be done intuitively, analytically or interactively. However, because this problem lies in the practice of everyday life, it is far more interesting and meaningful for students to define problems and determine whether information and skills are needed to help overcome the problems at hand.

As a result of the problem of ill-structured mathematical problems that are given repeatedly to the student, the student's creative process is revealed and develops when solving the problems presented. The development of student creativity, as seen from the problem-solving strategy plan for ISMP (1), students use guess and test strategies in completing with the direct substitution of the equations made. In ISMP (2), in the planning phase of completion, students first organize and represent the data and then make an equation to list alternative equations that might occur.

When viewed from creative thinking component, students' thinking in solving the problems of ill structured mathematical problems presented by the researcher is fulfilling the criteria of creative 4inking (Silver, 1997). Silver (1997) 4plains that to assess the ability to think creatively children and adults can be done using "The Torrance Test of Creative Thinking (TTCT)". The three components used to assess the ability to think creatively through TTCT are fluency, flexibility and novelty. The following describes the fulfillment of the three components experienced by students.

The first component, namely fluency, by making diverse and correct answers to solving problems. This can be seen in students when making three alternative solutions, namely (a) total expenditure in Toko I is equal to total expenditure in Toko II, so that they can make choices freely, (b) buy all clothes in Toko I, (c) buy all clothes in Store II. Structurally, the model of students' creative process in solving problems of ill-structured mathematical problems in fluency components can be seen in Fig. 1., in the green dotted line.

Events make diverse and correct answers in solving the structured mathematical problems carried out by students in line with what was expressed, that this happens because students must develop their representational and strategic fluency (Silver, 1997). In addition, they consider the unclear situation of the problems they face, then they solve a number of problems, produce solutions for each of the different problems.

The second component of flexibility is students solve problems in different ways. This can be seen from the following explanation:

1) Students unravel that each shirt in store B gets a 10% discount, so that the total expenditure in store A is equal to total expenditure in store B, then Store A must apply the first clothes purchase at normal prices, second clothes

purchase at 40% discount, and purchase of third clothes 44% discount.

2) Students examine that the choice will fall on store B, which is choosing to buy all the clothes in store B if the third shirt in store A does not get a discount. In accordance with the editor of the mathematical problem, the third shirt in store A has no information, so if the price of one shirt in store A is 25,000, then the first shirt purchase is the normal price of 25,000, the second purchase of clothes gets a 40% discount of 15,000, and the purchase of the third shirt is back again to the normal price of 25,000. Means the total expenditure in store A is 65,000 if the purchase of the third shirt does not get a discount. So it's more expensive than buying clothes all at B.
3) Students examine that to choose to buy all the clothes in store A, the condition is that the third shirt in store A must apply a 44% discount and above. Because the application of a 44% discount for the purchase of a third shirt in store A will cause the total expenditure in store A equal to the total expenditure in store B. Thus if store A applies a discount above 44% for the purchase of a third shirt, then the total expenditure will be obtained in the store A is smaller or cheaper than total expenditure in store B.

Student events solve ill-structured mathematical problems in a variety of different ways because they are complex and unstructured problems, thus providing opportunities and opportunities for students to display various methods of solution (Silver, 1997). Structurally, the student's creative process model in solving ill-structured mathematical problems in the flexibility component can be seen in Figure 1, in the orange dashed line.

The third component, novelty makes various answers that are different and correct in solving problems. This can be known from the students' strategies in solving problems. Looking for a third shirt discount in store A so the results can be accumulated with the purchase of second and third clothes, then compared with the purchase of three clothes in store B. Therefore students make various different and correct answers. This happens because ill-structured mathematical problems result from real life experience and require the integration of various variables in particular contexts, the resulting solution will require integration in several content domains (Jonassen, 2004). Furthermore, the importance of solving this type of problem is to understand solution to change and generate new solutions

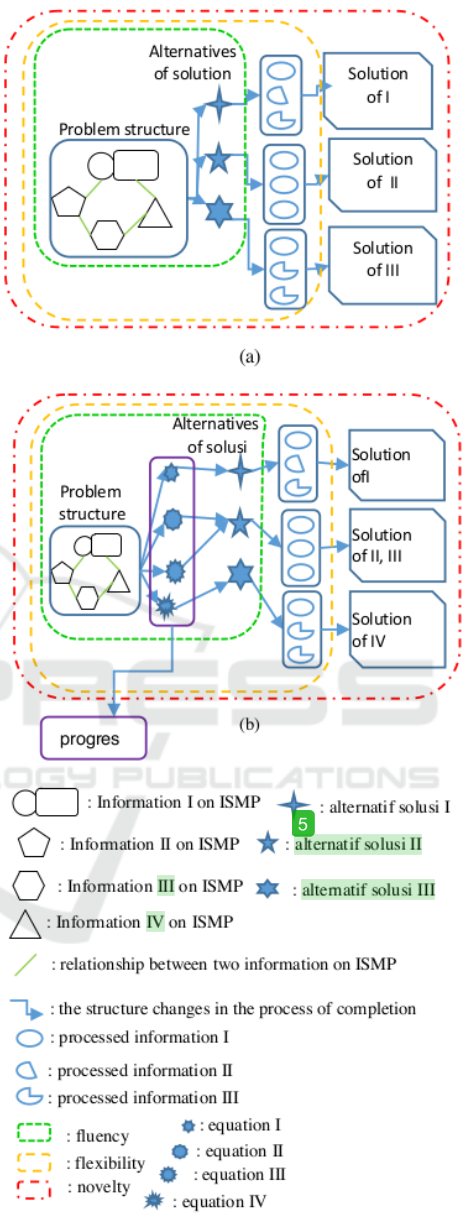

Figure 1: (a) Structure of the process of student creativity in Ill-Structured Mathematical problems in components of fluency, flexibility, and novelty, (b) Structure of the process of development of student creativity in Ill-Structured Mathematical problems in components of fluency, flexibility, and novelty.

(Mayer & Wittrock, 2006). Thus in solving ill Structured Mathematical Problems, students must have cognitive skills that include creative thinking (including different and convergent thoughts), tolerance for new things, and cognitive flexibility.

In Figure 1a, the process structure of Student Creativity in Completing Structured Mathematical Problems in Components of Fluency, Flexibility, and Novelty. In figure 1, the structure changed from the figure (a) to figure (b) shows the development of creativity related to the development of creative thinking students in completing ill-structured mathematical problems. This is in line with several research results (Collins, 2014; Jaarsveld & Lachmann, 2017; Silver, 1997; Ulger, 2018, Yu et al., 2015). Ill-structured problems are important and can develop creative thinking because it allows individuals to re-imagine problems, generate new solutions, and reconstruct ideas (Collins, 2014). The development of the components of students' creative thinking because they complete ill-structured problems tends to be driven by open problems expressed in a way that allows the creation of specific targets and perhaps some appropriate solutions (Silver, 1997). Furthermore, the activity of formulating problems in the thinking process will improve and complement individual understanding of the principles relevant to the task (Jaarsveld & Lachmann, 2017).

4 CONCLUSIONS

The provision of ISMP is useful for developing students' creative thinking. In solving ISMP students make diverse and correct answers, carried out in a variety of different ways, and make different and correct answers. The development of student creativity is evident after the second ISMP is given, namely increasing the variety of answers and correct, the emergence of various different ways, and making various different and correct answers. This happens because the ISMP has several solution paths, has a specific context and complex situations; and in accordance with everyday life so that students feel they experience the problem.

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