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IDENTIFYING CREATIVE THINKING PROCESS OF STUDENTS THROUGH MATHEMATICS PROBLEM POSING

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This research tries to identify student creativity in problem posing task, student creative thinking process and the level of student creative thinking in problem posing task based on a particular text-picture. The research is conducted through qualitative approach to seventh grade students of Junior secondary school at Surabaya (SMPN 4 Surabaya).
The result from the problem posing task indicate that there are 18,18% students as creative group, 68,18% students as less creative group, and 13,64% students as uncreative group. All students didn't find difficulties to work on this task. However, the creative and less creative group enable construct a better result because they at all times revised problem when they faced a hindrance. An opposite situation occurs for uncreative group. The level of creative thinking indicates that the creative students are at 4 or 5 level, the less creative students are 1, 2 or 3, and the uncreative students are at 0 or 1 level.
Keywords: problem posing, creative problem solving model, creativity, creative thinking process, the level of creative thinking

1. Introduction

Creativity is a subject which is often neglected within mathematics teaching. Usually teachers tend to set up logic as the most important and creativity is inferior in mathematics learning. In fact Indonesian Curriculum 2004, Competencies Standard (2003) promotes the importance of creativity, creative activity and creative thinking. One of mathematics teaching and learning goals in that curriculum is to develop creative activity which involved imagination, intuition and investigation by developing divergent thinking, originality, curiosity, making prediction and conjecture. Thus, we need a method to stimulate (arise) creativity in mathematics teaching. One method is problem posing. Problem posing has been used to refer both to generation of new problems and to the reformulation of give problem (Silver, et.al, 1996).

Problem posing or problem finding has long been viewed as characteristic of creative activity or exceptional talent in many fields of human endeavour (Silver, 1997). He gives an example from Getzels and Csikszentmihalyi research. They studied artistic creativity and characteristic problem finding as being central to the creative artistic experience. Henle offered the view that in particular cases the important creative task may be precisely to pose a question rather than to answer one (Lewis, 1998). Leung (1997) argued that creativity is similar to problem posing in its multiplicity in nature. Psychologist identified it as a special construct other than intelligence. Given "creating a problem" characteristic of problem posing and the "bring into being" nature of creativity one might see problem posing as a kind of creativity. Haylock (1997) asserted that problem posing situations can provide opportunities for pupils to demonstrate considerable creativity. The description above posited that problem posing is high mark of creativity.

Problem posing along with problem solving is central to the discipline of mathematics and the nature of mathematical thinking (Silver, 1997). When mathematicians engage in intellectual work of their discipline, it can be argued that the self-directed posing problems to solve it an important characteristic. Mathematical thinking as a cognitive approach to a problem that is both logical and mathematically sounds (Dunlop, 2001). Problem posing is a valid tool for the teaching of mathematical thinking and to foster creative thinking of students.

Silver (1997) argued that the connection to creativity lies not so much in problem posing itself, but rather in the interplay between problem posing and problem solving. It is in this interplay of formulating, attempting to solve, reformulating and eventually solving a problem that one sees creative activity. Both the process and the product of this activity can be evaluated in order to determine the extent to which creativity is evident. He proposes the forms of cognitive activity to asses the creativity product. There are fluency, flexibility and novelty. For problem posing, fluency mean student generate many problems to be solved; flexibility mean students pose problems that are be solved in different ways, students use what if-not approach to pose problems; novelty mean students examine several problems pose then pose a problem that is different.

Several researches about relationship creativity and problem posing have been conducted by Leung, Leung and Silver (1997). She explored the relationship between general verbal creativity and arithmetic problem posing. That research emphasized more in creative product of problem posing using three component of creativity than creative process which emphasized in cognitive aspect.

I try to explore student's performance or creative thinking process through problem posing. I believed if problem posing is viewed as cognitive activity and learning is as information processing, so

being needed cognitive approach to understand student's creative thinking process in problem posing. Creative thinking process includes synthesizing ideas, generating new ideas, and applying ideas (Krulik & Rudnick, 1995). This information will give cognitive process scenery when student work out the task and help teacher identifies student's difficulties in creative thinking.

Result of observation in elementary school (Siswono, 2004a) and junior secondary school indicated that students have competence to pose a problem creatively. Those problems seemed to have originality, imaginative, and varieties. The creative product and creative thinking process of student will give the level of student creative thinking which is useful to classifying and assessing their ability in creative thinking. To identifying creative thinking process is needed a means for guiding pace or step that someone achieved original, effective product and inventive. That step is mentioned as *creative process* which includes creative thinking process. This research determined "creative problem solving (CPS)" as a tool for tracing creative thinking. CPS is broadly applicable process providing an organizing framework for specific creative and critical thinking techniques to help design and develop new and useful outcomes for meaningful and important challenges, concerns and opportunities (Isaksen, 2001). CPS consists of 3 major components, namely understanding problem, generating ideas and planning for action. The first major component included stage of objective finding, data/fact finding and problem finding. The third component includes stage of solution finding and acceptance finding (idea implementation). The stage of problem finding and idea finding need creative thinking and others stages require a traditional logic and analytical thinking.

Students have various background and different abilities. They possess different potential in thinking pattern, imagination, fantasy and performance. Therefore, students carry out different level of creative thinking. Based on hierarchy of thinking by Krulik & Rudnick (1995) and three component of creative product by Silver (1997), Siswono (2004b) proposed a hypothetical-theory of level of creative thinking (LCT). The description of LCT is described the following.

Level 5: Result of student's task satisfied *all* criterion of creativity product. Student can synthesize ideas, generate new ideas from mathematical concepts and real life experience, and applying ideas to construct some problems also revised when they find a hindrance.

Level 4: Result of student's task satisfied *all* criterion of creativity product. Student can synthesize ideas, generate new ideas from mathematical concepts and *little real life experience*, and applying ideas to construct some problems also revised when they find a hindrance.

Level 3: Result of student's task satisfied *all* criterion of creativity product. Student can synthesize ideas, generate new ideas *only* from mathematical concepts, and applying ideas to construct some problems also revised when they meet a hindrance.

Level 2: Result of student's task satisfied *just one or two* criterion of creativity product. Student can synthesize ideas from mathematical concepts or real life experience, and generate new ideas *only* from mathematical concepts or real life experience. He/She hasn't applied all ideas to construct some problems, but he/she can revise a problem when they looked a hindrance.

Level 1: Result of student's task satisfied *just one or two* criterion of creativity product. Student can not synthesize ideas from mathematical concepts or real life experience, and generate new ideas *only* from mathematical concepts or real life experience. He/She hasn't applied all ideas to construct some problems, also revised a problem when they looked a hindrance.

Level 0: Result of student's task did *not* satisfy *all* criterion of creativity product. Student can not synthesize ideas from mathematical concepts or real life experience, and generate new ideas. *They just recall* their ideas.

Derived from the background, this research is trying to identify student's creativity in problem posing task and to know students creative thinking process and level of creative thinking student in problem posing with text-picture information. Problem posing is conducted by giving students a text-picture information without actual question and ask them to create as much as problems (routine problems) as they could. Text-picture information is a visual condition with some verbal narration. In this research we use food and vegetable as visual conditions also describe that situation in connection to food seller. Students reached Fluency, if they could generate or construct more than 5 problems and could be solved; Flexibility, if they pose problems that could be solved in more than one different ways

although they just write down one solution; Novelty if they produce various problems which is different in context (real life experience) and mathematical concepts. The number of various problems must be minimal 50% of all numbers they posed.

2. Method

This research is conducted by qualitative approach to 7th grades students of Junior Secondary School at Surabaya (SMP Negeri 4 Surabaya). There are 44 subjects, and for an in depth-interview we determined 3 students from the creative group which is consist of 2 students (male and female) with high mathematics ability and 1 student (female) with modest mathematics ability; 11 student from the less creative which is consist of 4 students (2 male and 2 female) with high mathematics ability, 3 students (1 male and 2 female) with modest mathematics ability and 4 students (2 male and 2 female) with low mathematics ability; and 3 students from the uncreative group which consist of 1 student (male) with high mathematics ability and 2 students (male and female) with low mathematics ability. We classified students in term of high, modest, and low mathematics ability based on them mathematics score test.

Research procedures are:

(1). Giving a problem posing task (PPT) to all students in one class to know students creativity in problem posing.

(2). Analyzing PPT result based on criteria of creativity that is fluency, flexibility and novelty. Problem analyzed is the mathematics problem which can be solved. Analyze conducted to a collection of problem which is yielded by student.

(3). Classifying students in creative, less creative and uncreative group. Student classify into the creative group if he/she fulfils the third categorize of creativity product, the less creative group if he/she fulfils just one or two categorize of creativity product, and the uncreative group if he/she doesn't fulfill all categorize of creativity product.

(4). Choosing student to be interviewed to explore their creative thinking process and level of creative thinking. Conducting interview and analyzing the result.

3. Result

Result of PPT indicates that there are 8 students (18,18%) included in creative group, 30 students (68,18%) included in less creative and 6 students (13,64%) included in uncreative group. Then, based on their mathematical ability, in creative group consist of 6 students with high mathematics ability, and 2 students with modest mathematics ability. Less creative group consists of 16 students with high mathematics ability, 4 students with modest mathematics ability, and 10 students with low mathematics ability. Finally for uncreative group consist of one student with high mathematics ability and 5 students with low mathematics ability. Thereby students of junior secondary school at Surabaya (SMPN 4 Surabaya) tend to be less creative.

Result of interview pointed out that:

(1). Creative process of the creative students group. In objective finding stage, male students with high mathematics ability didn't understand an instruction that he can add a new data in their problem. He hasn't imagined a problem which be made. This condition is the same was experienced by female students with modest mathematics ability. However, male student has more attention in text than in picture data. Female student with high mathematics ability can pass this stage and imagine some problem. In data finding stage, all students can add some data which is inspired from their real life experience. In problem finding stage, male student with high ability and female student with modest ability have not planned the complexity of problem. A male student thinks a divergent problem, but he didn't know to make it. Female student didn't think at all. However, Female student with high ability planned the complexity problem, she cannot found out a new one. All students still not realize to construct a divergent problem. In generating idea stage, male student with high ability think another idea to make a new problem, but he makes some unconnected problems. His ideas come from a personal experience and subject matter. Female students connected idea among problems and their ideas come from seeing a picture and real life experiences. In solution finding stage, all students proposed an easy solution. Female student with modest ability is not sure that her solution is the best one, but female and male student with high ability are sure. In idea implementation stage, all students did not face difficulties and revised their problems when they meet a hindrance.

(2). Creative process of the less creative students group. In objective finding stage, male students with high mathematics ability didn't understand an instruction well also for female student especially in making divergent solution. Male student has more attention in text than picture data. Male and

Female student with modest mathematics ability also can not understand some instruction, but passed this stage. Male refers to picture, other than to text. Male and female students with low ability didn't understand some instruction well. He refers to text same as female students understand an instruction refer to text. Female student didn't understand refer to picture. In data finding stage, male and female students can add some data which is inspired from their real life experience and subject matter. In problem finding stage, all students already have planned the complexity of problem, but they could not. They didn't think on divergent problem. Male students with modest ability didn't find another idea except be posed. Other students have another idea. In generating idea stage, all students except one female with high ability didn't make connection among problems. Their ideas come from a personal experience and subject matter. In solution finding stage, the all students proposed an easy or not very complex solution. All students with all level ability are not sure that her solution is the best one, but one male student with low ability is sure. In idea implementation stage, all students with modest and low did not face difficulties, but students with high ability feel difficulties. They revised their problems when they looked a hindrance, except male student with low ability.

(3). Creative process of the uncreative students group. In objective finding stage, all students didn't understand an instruction well. Male and female students with high and low ability keep paying attention text and picture data, but one female student with low mathematics ability just pay attention text. In data finding stage, all students didn't add some data; they just repeat from task information. In problem finding stage, all students except one female student with low ability did not plan the complexity of problem and didn't think a divergent problem; they made easy problems. All students didn't find another idea except be posed. In generating idea stage, all students didn't think another idea to make a new problem and generate among unconnected problems. Their ideas come from more subject matter than a personal experience. In solution finding stage, the all students proposed an easy solution. All students are not sure that her solution is the best one. In idea implementation stage, all students did not feel difficulties but they did not pay attention in given information of their problems.

Result of interview pointed out that LCT students of creative group placed in level 4 or 5, the less creative group set in level 1, 2, or 3, and uncreative group placed in level 0 or 1. However, there are 5 students of less creative group which are not determined their level.

4. Discussion

Third groups included various students with different abilities indicated creativity is a special construct which is different from intelligence (Leung, 1997). However, creative thinking process of students is still unclear; almost all students didn't understand some instruction. That happened possibly because of some reason. First, problem posing as creative thinking have not been popular to students yet. They are still unfamiliar or unexperienced, so it always needs to be implemented in teaching and learning process. After they are flexible enough in task, then we can asses their creativity. Second, they haven't had experience to solve divergent problems or problem solving commonly, so just to recognize that format is difficulties. Next, instruction maybe is not meaningful for students. Sentence, diction or language is not understood easily. Therefore, it requires revisions.

To pose problems, male tend to refer more in a form of text than picture. Seemingly, problem situations are not challenging him. However, female students are more interesting in picture because information is close with their hobby in cooking. Therefore, in choosing picture context we should also consider students background or prior knowledge. Problem posed by creative group seem as an insight because they haven't planned before. This is different with less creative group. Uncreative group also haven't planned the problem but they didn't have another idea except it is already posed. Their ideas just repeat from task information.

An interconnection idea to construct some problems of third of groups is still vague. Their ideas come from personal experience and subject matter (mathematics field). So it needs attention deeply for next research. A number of problems posed are easy, not so complex problem. Students did not seem struggle in generating their creativity. The model of problem posing task maybe caused this condition. We don't know how if it's changed, for instance by using what-if-not strategy.

All students didn't feel finding difficulties to work out this task. However, the creative and less creative group enable construct a better result because they at all times revise problem when they face a hindrance. An opposite situation occurs for uncreative group.

The hypothetical level of creative thinking students is fulfilled by some students. It means that creative thinking students in problem posing can be classified or characterized in that level. However,

levels of some students could not be determined. Based on these facts we need to improve or develop appropriate LCT by doing further research or improve experience through in depth-interview to explore student thinking.

5. Summary

This result point out that creative thinking is a different construction in thinking. Creative thinking included synthesizing ideas, generating new ideas and applying ideas (idea implementation) can be assessed by mathematical problem posing. We know that relationship between a general verbal creativity and a general problem posing ability is still unclear (Leung, 1997), but if we view a specific role of problem posing, we can find or explain a track that interlink creative thinking and problem posing. Designing a teaching process to foster creative thinking by mathematical problem posing indirectly teach students to understand a problem information. That is also useful for problem solving.

This research should be continued to explore deeply the differences of creative thinking process between male and female students, also a particular student's ability which is unclear. Thereby, revising a criteria, procedure, instrument, or level must be done in order to find the best conclusion.

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References

Dunlop, James. (2001). Mathematical Thinking. http://www.mste.uiuc.edu/courses/ci431sp02/students/jdunlap/WhitePaperII Download November 21, 2003

Haylock, Derek. .(1997). Recognising Mathematical Creativity in Schoolchildren. http://www.fiz.karlsruhe.de.fiz/publication/zdm *ZDM Volum 29 (juni 1997) No.3 Electronic Edition ISSN 1615-679X* . Download June 8, 2002

Isaksen,Scott G. (2004). CPS: Linking Creativity and Problem Solving. http://www.cpsb.com/resources/download.html. Download August 22, 2004

Krulik, Stephen & Rudnick, Jesse A. (1995). *The New Resourcebook for Teaching Reasoning and Problem Solving in Elementary School.* Needham heights, Massachusetts: Allyn & Bacon

Leung, Shukkwan S. (1997). On The Role of Creative Thinking in Problem Posing. http//www.fiz.karlsruhe.de/fiz/publications/zdm *ZDM Volume 29 (June 1997) Number 3. electronic edition ISSN 1615-679X*. Download June 8, 2002

Lewis, Theodore. (1998). Problem Posing-Adding a Creative Increment to Technological Problem Solving. *Journal of Industrial Teacher educatio*n. http://scolar.lib.rtedu/ejournal/JITE/v36nl/lewis.html. ISSN 0022-1864. Download January 24, 2002

Lowrie, Tom. (2002). Designing a Framework from Problem Posing: Young Children Generating Open Ended Task. *Contemporary Issues in Childhood*. Volume 3, Number 3. http://www.triangle.co.uk Download July 3, 2004

Silver, Edward A. (1997). Fostering Creativity Through Instruction Rich in Mathematical Problem Solving and Thinking in Problem Posing. http://www.fiz.karlsruhe.de/fiz/publications/zdm *ZDM Volume 29 (June 1997) Number 3.lectronic Edition ISSN 1615-679X*. Download June 8, 2002

Silver, Edward A., Down, J.M., Leung, S.S., and Kenny, P.A. (1996). Posing Mathematical Problems: An Exploratory Study. *Journal For Research In Mathematics Education*, Volume 27 No. 3, May 1996. p.293-309

Siswono, Tatag Y. E. (2004a). Bahasa dan Matematika: Pengalaman Observasi di kelas PMRI. *Bulletin PMRI*. Fourth Edition, Aprill 2004.

Siswono, Tatag Y. E. (2004b). *Mendorong Berpikir Kreatif Siswa melalui Pengajuan Masalah (Problem Posing).* Paper presented in Indonesian Mathematics Society Conference in Denpasar, Bali. July 23-27, 2004.

Department of National Education. (2003). *Kurikulum 2004. Standar Kompetensi, Mata Pelajaran Matematika Sekolah Menengah Pertama dan Madrasah Tsanawiyah.* Jakarta: Pusat Kurikulum-Balitbang Departemen Pendidikan Nasional