Improving elementary teacher competency to develop the abilities of students' creative thinking through mathematics problem posing and problem solving strategy

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Introduction

The Indonesian National Curriculum (2006) has proposed that mathematics taught at the elementary level should develop logical, analytical, systematic, critical, and creative thinking. Mathematics should also help develop working cooperatively in groups. Rapidly changing technology and limited natural resources encourage one to be creative in solving real-life problems.

Teachers play an important role in learning. Lee said that reform can move only as fast as teachers can move (2010). This means that for the direction and curriculum goals to be successful, teachers must actively contribute to and support it. Kattou et al. (2009) said that any effort to foster creativity in the classroom will ultimately depend on the teacher. Thus, teachers' conceptions and knowledge of creativity are of great importance and are needed to develop students' creativity.

Despite this, based on the results of Siswono, Abadi, & Rosyidi (2008) who surveyed 130 primary school teachers, teachers do not emphasize fostering the creative thinking ability of students. The survey showed that 56.1% of teachers never ask students to create their own questions and 52.3% of teachers do not teach students to solve problems in various ways. Of the sample surveyed, 55.4% of teachers never helped students develop imagination.

Shriki (in Kattou, et al., 2009) explained that a creative environment should include open-ended activities and non-routine problems that give students freedom to apply imaginative ideas to finding methods or solutions. Teachers must make an effort to improve students' ability to think creatively. Kattou, et al. (2009) stated that most teachers acknowledge the importance of creativity, but many of them do not include it in their teaching. Teachers still focus on a single right answer, do not allow mistakes, and ignore ideas, competition, evaluation, insufficient knowledge, drill works or emphasis on curriculum. This shows the need for teachers to actively increase students' creative thinking.

This research aims to help mathematics teachers develop learning strategies to improve students' creative thinking. It aims also to determine the capabilities of teachers' creative thinking and their ability to plan and implement these strategies for mathematical problem solving and problem posing.

Teaching to improving students creative thinking

Creative thinking could be viewed as a mental activity that is used to construct an idea or notion of the "new." An effort to encourage creative thinking in mathematics is used

for the concept of a problem in a task situation. It includes problem solving and problem posing. Mathematical problem solving could be defined as the student's process in solving a mathematical problem. The steps to this process are: understanding the problem; devising a plan or strategy; carrying out the plan; and looking back or examining again. Pehkonen (1997) stated that problem solving is a way to improve creativity as a product of students' creative thinking. Mathematical problem posing practices students in constructing a problem in mathematical terms based on some given information, then finding a solution. Problem posing could be given after or before they solve a mathematical problem. Evans (1991) explained that problem formulation or problem posing and problem solving are important components of creativity.

In the classroom, learning revolves around the teacher. According to Kattou, et al. (2009), one component to ensure creative teaching in mathematics is teachers' professional domains. 'Professional domain' refers to the role of teachers and their methods towards enhancing creativity. To support professional competence, they need a teaching model to develop capabilities of students' creative thinking. One model is the problem solving-posing based learning (PSP-BL). It was developed in 2008 as a research product of Siswono, Abadi, & Rosyidi (2008). The model consists of a manual containing examples of lesson plans, syllabi, worksheets, and assessment sheets. Their research points out the role of problem solving and problem posing to encourage creative thinking in mathematical learning situations.

The PSP-BL model has a general flow of introduction, main activity, and closing. Introduction is the phase to motivate students to engage in the learning process and communicate apperceptions, goals, and prerequisite material. In the main activity phase, students are given the opportunity to actively construct knowledge based on their experiences or individual knowledge. It is important that students communicate their understanding, thus students are given chances to present their ideas to other students or their teacher. The teacher and other students give a scaffolding to guide them to advance beyond their current level of knowledge. The last phase is closing, which consists of reflection, summary, and future exercises. Reviewing a summary is a way to present knowledge economically so that is easier to learn again and internalize.

To quantitatively assess students' capabilities in creative thinking, teachers could use levels of students' creative thinking proposed by Siswono (2008). Level 4, Very Creative: Students satisfied all components of creative thinking, i.e. displayed flexibility and novelty in solving and posing problems. Level 3, Creative: Students were fluent and were flexible and demonstrated novelty, in solving or posing problems, but not in both. Level 2, Quite Creative: Students were able to show flexibility and novelty in solving and posing problems without fluency. Level 1, Almost Not Creative: Students were able to show fluency without novelty and flexibility in solving and posing problems. Level 0, Not Creative: Students were not able to show any components of creativity. These levels could be used as a rubric to assess students' capabilities in creative thinking.

Students demonstrate fluency in problem solving when they are able to obtain many solutions. Students are said to be flexible in problem solving when they are able to solve a problem using many different methods or express a solution in more than one way. Students demonstrate novelty in problem solving when they are able to examine a

problem and answer with many solutions or answers, then generate another solution that is different. A solution is considered to be "different" when it has a different pattern or is unusual for students of this grade level.

Research Method

Participants of this research are 40 elementary teachers from 20 public schools and 20 private schools. The research was performed with pretest-posttest single group design at third grade, fourth grade, and fifth grade levels. The schools were selected because they were near residential areas and have varied students' backgrounds.

The procedure included designing and conducting a workshop twice. Before the workshop, teachers are asked to solve a task as a pretest mathematics problem solving and posing, then a last workshop is conducted posttest. After these activities, teachers designed teaching materials and implemented them at each school with a pretest-posttest single group design.

Descriptive study was conducted with a semi-structured interview with each teacher at each grade level to evaluate the creative thinking abilities of teachers, and how their capacity to use the model and their belief in the goal of learning enhances creative thinking. The instruments used in this study were (1) Test of Creative Thinking (TCT) to determine the teacher capability of creative thinking, two different sets for the pretest and posttest; (2) the observation sheet to determine the ability of teachers to manage and conduct the model of PSP-BL during the learning activity; (3) the observation sheet of learning situation to determine the practicality or feasibility the learning process; (4) a questionnaire to determine students' responses after the session; (5) a semi-structured interview guide in order to explore the creative thinking abilities of teachers, obstacles encountered, and the belief in the implementation of this learning. Descriptive analysis was conducted by comparing the level of ability creative thinking and increasing teachers' creative thinking. Qualitative analysis was conducted by reduction data, presenting data, and creating inferences.

Results of research and discussion

Teachers' capabilities in solving and posing problems

Capabilities in creative problem solving and problem posing are prerequisites to apply the PSP-BL model. The teacher must know how to design learning materials including assessment, thus it is important to first determine their capabilities in creative thinking. In the pre-test, 91.2% of the teachers were at level 0, 2.9% at level 1, and 5.9% at level 2. The mean score was 65.0, meaning that teachers could not solve open-ended problems. The majority of teachers merely satisfied the fluency category among the creative indicators. A workshop was thus conducted twice on problem solving, problem posing, creative thinking, and developing materials (lesson plan, worksheet, syllabus, assessment) to improve students' creative thinking.

After the workshop, 16.7% of the teachers were at level 0, 53.3% teachers at level 1, 26.7% teachers at level 2 and 3.3% teacher at level 3. No teacher reached level 4. The mean score was 75.0. This means that most teachers could already demonstrate flexibility and novelty in addition to fluency in solving and posing a problem. With these provisions, teachers were ready to implement the PSP-BL model in their

respective classes. These assumptions were based on the result of Panaoura's research (2014). Panaoura & Panaoura mentioned that initial conceptions about creativity were affected by their previous experiences.

Designing lesson plan

Designing lesson plans with the PSP-BL requires teachers create new content, so how teachers understand about model of PSP-BL and implement it in the classroom needs to be known. The ability of teachers for making lesson plans was assessed at the workshop, which is one of the learning materials they needed to make.

To assess teachers' skills, we used a rubric. We evaluated eight aspects: objective description, choice of learning material, organization of learning material, choice of media and other resources, clarity of learning scenario, detail of learning scenario, the suitability of techniques and learning objectives, and the completeness of the material. All aspects focused on students' creative thinking. Based on each indicator, the researcher assesses and gives s score of 1, 2, 3, and 4, with 4 as the highest and 1 as the lowest. The total score was obtained by counting the total points then dividing by the maximum point then multiplied by 100.

Based on the indicators a mean score of 3.99 or greater than 3.00 meant that a teacher could design learning materials to be available and be used in learning activities. The mean score of teachers' skill was 74.1, so it was enough to let teachers implement the materials, since the test showed they still have difficulties with designing problems to engage creativity. We planned to accompany them as partners, and to observe and support them when they implement the materials in a real classroom.

The teachers' skills in designing a lesson plan and other material influenced the learning process. Girls (1998) indicated that is one of components at creative teaching. Basic pedagogical skills such as lesson planning, classroom management, communication, and evaluation affect students' creative thinking.

Implementing of lesson plan

The implementation was conducted at 2-4 terms (one term is equal to 2 x 35 minutes) at 24 classes as target school ("sample"). There are 8 Grade Three classes, 6 Grade Four classes, and 10 Grade Five classes. When teachers were implementing the materials, two observers were present to observe and give a situation report.

Observation indicators consist of three parts: pre-learning, mean activity, and closing. Pre-learning evaluates how teachers check students' apperception and motivate them. Mean activity looks at the teacher's mastery of content, teacher strategy or approaches to improving students' creative thinking, use of learning resources/media, learning situation that triggers and maintains student engagement, assessment process and result of the session, and the use of communication. Closing evaluates how the teacher facilitates the reflection and summary, and carries out a follow-up to provide direction, or activities or tasks as remedial or enrichment.

Observers gave a score of 1, 2, 3, or 4, listed from lowest to highest. A total of 24 items were scored. The mean score of the teachers from the Grade Three classes was

78.63, Grade Four classes was 75.56, and Grade Five classes was 81.75. We can conclude that all the teachers implemented the materials well. The mean score of all teachers was 78.65. Thus, all teachers sufficiently managed the learning processes using the PSP-BL model. These results show at least one problem regarding teachers' weakness in developing students' creative thinking has been overcome (Siswono, Abadi, and Rosyidi, 2008) and provides evidence that the PSP-BL can be successfully used as an alternative learning strategy to improve the ability to think creatively.

Teaching performances influence student competencies. Among the Grade 3 classes, the mean score of 39.94 of students' ability in solving and posing problems in the pre-test became 74.84 in the post-test. The classical mastery of learning was 70.60% of students. Among the Grade 4 classes, the mean score of students' ability in solving and posing problems from 47.59 in the pre-test become 68.42 in the post-test. The classical mastery of learning was 72.22% of students scored. At Grade 5, the mean score of students' ability in solving and posing problems from 55.23 in the pre-test become 68.61 in the post-test. The classical mastery of learning was 73.38% of students scored. It is sufficient evidence that the PSP-BL model could have real effect in enhancing students' skill especially in solving and posing problems.

The abilities of students' creative thinking also increased. In Grade 3, the proportion of students at level 0 in the pre-test of 10.4% decreased to 9.2% in the post-test. At level 1, the proportion fell from 34.7% to 30.1%. At level 2, the proportion fell from 28.9% to 7.5%. At level 3, the proportion rose from 16.8% to 21.4%. At level 4, the proportion rose from 9.2% to 31.8%.

In Grade 4, at level 0, the proportion fell from 25.2% to 16.2%. At level 1, the proportion fell from 18.4% to 10.6%. At level 2, the proportion fell from 25.9% to 12.8%. At level 3, the proportion rose from 15.0% to 22.1%. At level 4, the proportion rose from 15.4% to 38.3%.

In Grade 5, at level 0, the proportion fell from 17.1% to 15.7% students. At level 1, it fell from 39.8% to 21.4% students. At level 2, it fell from 14.7% to 11.0% students. At level 3, it rose from 20.9% to 27.2% students. At level 4, the proportion rose from 7.4% to 24.6% students.

The trend is that the proportion decreased at the lower levels of creative thinking, but increased at the higher levels. This shows that the PSP-BL model had a positive effect on students' creative thinking and academic mastery. This is supported by Pehkonen's ideas. Pehkonen (1997) said that problem solving and posing are one approach to develop students' creative thinking (Pehkonen, 1997; Evans, 1991).

Difficulties and teachers' beliefs with applying the PSP-BL model

Some difficulties in using PSP-BL were expressed by teachers in their in-depth interviews. They were interviewed on the preparation of teaching materials, implementation of design, and evaluation/assessing.

According to them, a longer preparation time is needed for finding problems, looking for pictures or related tasks in everyday life, and designing the lesson plan, worksheets, and assessment sheet. They need over 30 minutes more than the usual time for planning, but they feel satisfied when they look at the results. Extra time is also needed during implementation because problem posing still uses unusual tasks. Teachers faced difficulties in managing activities because there are about 40 students. The criteria for assessing creative thinking is more difficult, and longer periods are needed to check students' answers because the students' answers varied; assessing novelty and flexibility is unusual and needs specific skills. Students still do not understand open-ended problems. Teachers experienced difficulties because teachers tend to emphasize memorization and rote thinking in teaching rather than creativity (Kattou, et.all, 2009).

Teachers believed that the PSP-BL model leaves a good impact on students' creative thinking because they encourage students to be more active, freely create questions, and use varied strategies. Students are interested because they are challenged to create questions that are varied and could be applied to other materials. Kattou, et.al. (2009) also said that the majority of participants believed that they can apply creative activities in teaching mathematics, such as inquiry learning, the use of open-ended tasks, cooperative learning, or realistic mathematics.

Conclusion

Teachers' performances in creative thinking are only "quite creative" because most of them are at level 1 and 2. The mean value score in solving and posing problems increased from 65.0 to 75.0, posttest. A mean score of 3.99 or more than 3.00 means that teachers could design learning material to be used in activities. The mean score of teachers' skill was 74.1. This indicated that they had sufficient competency to improve students' creative thinking. They had both didactical competence and professional competence. The competencies were not strictly increasing because the initial knowledge, motivations, and awareness of the importance of creativity were not similar. They had different backgrounds such as educational (not mathematics education), training experience, or senior/junior teacher.

All the teachers involved in the study believed that the model had a good impact on students' creative thinking because students became active student learners, free to create questions, vary learning situations, and challenge and construct problems. Nevertheless, there are some difficulties, especially in preparing worksheets and assessment sheets to measure students' creative thinking.

Based on the results, the PSP-BL model could be tried as one way to improve students' creative thinking. Actually, this model had already been used by pre-service students as a topic of their thesis. Almost all of them noticed that PSP-BL model had good impact. Therefore, it is suggested that teachers disseminate the model PSP-BL. Teachers should generate some examples to provide increased impact of creative thinking skills. During application, the teacher needs to anticipate the difficulties encountered in learning situations such as creating and searching for questions that are not routine, but open-ended.

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