Using puzzle to encourage students to do problem posing

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Abstract. Problem posing is very important in learning mathematics. Many studies have indicated that problem posing can improve the ability to solve mathematics problems. Therefore it is necessary to encourage students systematically to do problem posing. This research tries to pack problem posing in puzzle frame in order to increase student’s interest and ability to do problem posing. The puzzle game which is then directed to problem posing is assured can arouse students’ enthusiasm, thus encouraging their involvement in problem posing activities. Two groups of junior high school students each consisted of 31 and 32 students selected as samples. The first group follow mathematics class with problem posing learning model that preceded by playing a puzzle but still in a mathematical environment. The second group follow the mathematics class with problem posing learning model only. At the end of the research student's interest and ability to do problem posing are compared by using MANOVA test. Wilks' Lambda test results $F = 10.8$ on significance $(p) = 0.002$. Based on these findings, it is concluded that the problem posing learning model in mathematics that is preceded by playing puzzles can increase students' interest and ability to do problem posing.

1. Introduction

Naturally, in the daily interaction people tend to ask a question if they want to know something. Children tend to ask everything they seen, heard or felt. Different things happen in the classroom. Children tend to be reluctant or shy to ask questions. Despite being encouraged to ask questions, the child is still reluctant to ask questions. There are several reasons that allegedly motivate students to be reluctance to ask questions. First of all, the students feel embarrassed to be seen as too stupid by his friend for always asking. For the second one, students feel less confident with the question asked, whether the question is useful. For the third, students are difficult to ask questions because they are not aware of the problems faced.

Conditions above occur also in learning mathematics. Mathematics teachers often complain, why students rarely ask during learning. In addition to the embarrassment and lack of confidence, the inability of students to realize the problems faced is the dominant reason. The low ability of students to be aware of problems in learning mathematics can occur because during the learning students only
trained for problem solving. In fact, in learning mathematics, not only problem solving skills that must be pursued but creativity of mathematics must also be obtained, therefore, learning mathematics must consist of two aspects, namely problem posing and problem solving [1].

The problem posing theory was applied by Freire to awaken the oppressed at once against the bank concept of education that became the beloved of the oppressors [2]. Freire's attention focused on the awakening of the oppressed. The oppressed are encouraged to fight for their humanitarian rights that the oppressors oppose. Bank concept of education considers education such as depositing money in the bank. Students are considered as empty boxes to be filled with knowledge. There is no opportunity for students to ask or even to argue. They are only welcome to receive what is given by the teacher. Problem-posing education is an approach to education where teacher and student approach a problem together [3].

Problem posing and problem solving has been identified to be central theme in mathematics education [4]. Problem posing has been used as both a metric of conceptual understanding and also as a pedagogical tool [5]. Activities in mathematics learning are dominated by problem posing and problem solving. The problem solving approach in learning mathematics is used to practice conceptual understanding and application of concepts. Problem posing is mostly used to extract information from students regarding concepts that have not been understood. The information is then used by teachers to provide remedial feedback. Submission of problems from students may also be related to advanced materials. When this happens, the teacher's feedback will become enrichment for the students.

Problem posing is a crucial component for mathematics discipline [6]. The proposed problem is formulated from a concrete situation [7]. Students can pose problems in learning mathematics if they already realize they have not understood the problem. If the proposed problem gets a solution from a friend, then their knowledge will increase and trigger a new problem to be raised. This process will be continued, where the process of problem posing and problem solving will follow a cycle that occurs repeatedly. When the process occurs in a sustainable manner, the student's ability in mathematics will increase continuously.

Problem posing refers to creating a completely new problem or revising the problem to be resolved [8]. Problem posing may occur before, during, or after the settlement of a problem. In an effort to solve a problem, students may ask questions before starting to find the solution of the problem. Similarly during problem solving, if deemed necessary, then the student may ask a related question or problem. Even after solution is obtained, students may pose another identical problem. That process occur continuously, so each task can cause one or more other tasks. When students formulate new problems, it can foster the sense of ownership that students need to take for constructing their own knowledge [9].

Problem posing has defined as a means of instruction where the students construct questions in response to different circumstances, namely real life situations, another mathematical problem, or the teacher [10]. The quality of the problem posed by the students in learning mathematics can be used as an instrument to measure the student achievement in mathematics. On the other hand, the process problem posing followed by problem solving that occurs iteratively over and over can be a medium of learning mathematics for students. By utilizing the existing thinking skills, students can take advantage of the existing situation to redefine or revise the given problem. Problem posing skills can be developed by giving students an ill-formulated or partially formulated problem and asking students to redefine it [8]. The main activity of problem posing is to compose new questions based on given mathematical tasks [11].

Problem posing education aims to strengthen the student's skills of thinking critically or contemplating on the object of knowledge and reasons for his/her existence [2]. Students can compose a new problem from existing problem only if they understand the existing problem and can solve it. They will then think creatively and reasonably to formulate the next problem. If this condition occur continuously, the student's critical thinking skill will arise significantly. When this condition is achieved, the student will start acquiring knowledge through a feeling of epistemological curiosity [2]. At a time even they can formulate really a new problem, without analogize from the other problem.
Problem posing has long been viewed as a characteristic of creative activity or exceptional talent [8]. According to their ability students must be create a new problem. On the other hand they may be re-compose an existing problem. It means, students compose the existing problem in their own version. The do it in order to make the problem easier to solve. The students can be use heuristics approach, such as analogy, working back, or may be divide the problem into several parts. This process need not only critical thinking but also creative thinking. In addition, this process refers that the students not to be easy to give up but they must try again and again. They must maintain their tenacity and their adversity to learn.

Empirical experience shows that the problem posing learning model that have been applied in learning mathematics so far have not been able to encourage students to be active and creative to pose a meaningful problem. Students tend to be passive, just wait the problems from their teacher. Posing the problem is often done in a forced way, just to meet the requirements. This is seen from the frequency of posing problem and the quality of the problem posed. It appears that shyness and lack of self-confidence are still the dominant factors that influence the problem posing. In other words, overcoming shyness and a lack of confidence to pose problems should be treated first. A commitment to creating an environment in which problem posing is a natural process of mathematics learning is required [12].

There are several activities that students can do in learning mathematics with problem solving model. As a first step, students can ask questions to complete the previous problem solving. Furthermore, students can raise the problem by analogy of the problem already exists and has been resolved. With slight modifications to the denomination or variables of an existing problem, students can pose new problems. Analogy can also be done by changing the context of the problem. Mathematical problems for application in one field can be modified for application in other fields. At the end, it is expected that students are able to pose complex problems from simpler previous problems.

Well-designed problem-posing tasks for students also require skilled teachers who can manage the complexities of such contexts [13]. The role of teachers that is very important in learning with the problem posing is to create a natural atmosphere, so that student interest can be raised. Experienced and skilled teachers begin problem posing by not strictly limiting problems students can ask. What the teacher wants is a student willing to pose a problem. If the student is willing to pose a problem, then the problem limits and the quality of the proposed problem can be corrected while proceeding. Teachers' skills in this situation include the ability of self-management in order to serve students optimally.

This research tries to train students to be active and creative to pose problems in learning mathematics. The tried technique is to package the process of the problem posing into similar activities that are often done in everyday life, such as puzzles. The main target is to increase student interest and student ability to pose a problem. When their interest has grown, then the next goal is to improve the ability to create and pose a problem. There is a common characteristic between puzzles and problem posing, such as one person or may be group raises a problem to another and the other tries to find a solution or answer.

Puzzle means to offer or represent to a person a problem difficult to solve [14]. Puzzle also means about facts or events that need to be searched logically according to chronology or analogy. Puzzles can be made in various fields, such as mathematics, natural science, history, geography, economics, or general things in everyday life. Puzzles can pose a concept, principle, or procedure. At the initial level, the puzzle material is limited to concepts, then gradually increasing to more complex things, such as principles or procedures.

Puzzle can exercise (over oneself, one's brain, etc.) over some problem or matter [16]. It's a question or problem that requires thought, skill, or cleverness to be answered or solved [17]. Puzzles can add knowledge and insight. It needs sufficient reference so someone can ask a question or puzzle to his friend. Conversely, a friend who must answer also needs references and reasoning enough to be able to answer a question or statement of a received puzzle. When students are already
engaged in a puzzle game, then they will do their best to answer the puzzle posed by a friend. Furthermore, they will do their best to also find new problems that will be given to their friends. If the puzzle is done in a mathematical frame, then the understanding of the mathematical concepts of students will be improved.

Puzzles are often done by children at home, in the community, or at school during breaks. The puzzle has the same characteristics as the problem posing. During a puzzle game, one party asks a question to the other party and the other party tries to answer. Questions are submitted in accordance with the agreement. Puzzles can be done individually or in groups. The atmosphere of play with the cheerfulness that characterizes children is evident in puzzle activities. Informal impression allows students to engage in puzzle activities freely as without pressure.

The problem posing is considered the student as a formal activity, resulting in frequent shame or lack of confidence to do. The puzzle on the other hand is considered the student as an informal activity, so they are willing to perform casually without any burden. Relaxing conditions and no burden can spur the open mind to bring up new ideas. If the problem posing is preceded by a puzzle, then the student's interest to make a problem can be grown, so that they can then process the problem solving effectively. The change from puzzle activity to problem solving activity is done slickly, so students do not feel it. Conversely, if the filing of the problem is done immediately without the preceding puzzle exercises, then the shyness and lack of self-confidence of students will remain.

This study tried to increase the student’s interest and ability to do problem posing in learning mathematics by using puzzle. For this objective, the following problems were researched: 1) how are the student’s interest and ability to do problem posing in learning mathematics preceded with puzzle compared with those without preceded without puzzle? 2) what are the obstacles faced by students in learning mathematics by problem posing preceded by puzzle? 3) If there are any obstacles, what are the suggestions given to the students?

2. Methods
The research use quasi experiment approach. Two groups of junior high school students in grade of eight at Singaraja (Bali) were selected as sample by using cluster sampling technique. The first group consisted of 31 students was experiment group that follow mathematics class with problem posing learning model that preceded by playing a puzzle but still in a mathematical environment. The second group consisted of 32 students was control group that follow the mathematics class with problem posing learning model directly.

At the end of experiment, student's interest and ability to do problem posing were measured. Student's interest was measured by using questionnaire while student’s ability to do problem posing was measured by evaluating posed problems using rubric that was specially formulated for that purpose. Finally, student's interest and ability to do problem posing from experiment group and control group were compared by using MANOVA preceded by data normality test, data homogeneity test, equality of covariance matrices test, and multicollinearity test.

3. Results and Discussion
Saphiro-Wilks test for data normality test found that all of data were normally distributed and Pearson correlation found that no co-linearity between student's interest and ability to do problem posing. Levene test found that variance of data were homogeneous and Box’s M test found that matrices of covariance were homogeneous also.

From MANOVA, Wilks’ Lambda test results $F = 10.8$ on significance rate($p$) = 0.002. It means students with problem posing preceded by puzzle and students with problem posing directly have different interest and ability to do problem posing. Furthermore, tests of between-subjects effects results $F = 28.35$ on significance ($p$) = 0.002 for student’s interest and $F = 18.28$ on significance ($p$) = 0.005 for student’s ability to do problem posing. The results show that student’s interest from group with problem posing preceded by puzzle was better than that from group with problem posing directly. On the other side, ability to do problem posing from group with problem posing preceded by
puzzle was also better than that from group with problem posing directly.

Puzzle exercises was able to enhance students' interest in doing problem posing. The relaxed environment that characterizes the puzzle brings them to a relaxed condition when it comes to problem posing. This condition make students can communicate openly without any burden, either with colleagues or with teachers. Such a free condition makes them able to think deeper, analyze more closely, and reason more quickly. In addition their perception also become more opened in relaxed condition. Those situations will arise students' interest to do problem posing. On the other side, those situation can enhance students' ability in formulating and solving problems.

Interview with some students found that the puzzle, even though in the mathematical contents were able to bring them into the playing situation. The exchange of ideas happens smoothly without fear of being wrong. Therefore, they feel faster in finding new problems. Initially they tried to imitate the problem posed by his friend with a little modification. Over time the modifications of the problem they make were increase significantly. One day they were able to formulate their own problems that will be posed. The posed problem was really new, it is not from modification of existing problem.

The role of teachers in packing problem posing and puzzle is crucial. At the beginning, the teacher is not too strict limiting the problems posed by students. Teachers still tolerate, even if the problem that students ask in the game was far from the mathematical content to be discussed. The main objective at this early stage was to foster students' interest in posing a problem. Therefore, as long as the problem was true or reasonable, even if the issue was slightly out of context, the teacher was not paying much attention. If there were any shortcomings or errors in the proposed problem, the teacher will make improvements.

The natural atmosphere that was impressed in the puzzle game was carried away as they entered the problem posing. The impression that the problem posing was formal activity can be forgotten. Teacher expertise in transforming puzzle games into problem posing activities strongly supports the successful increase of student interest in doing problem posing in learning mathematics. Disposition of problem complexity and the adjustment of problems with the context by experienced teachers can make the process of problem posing better and more systematic [13]. At the end, it will lead to the improvement of student interest and ability to do problem posing.

There was no significant obstacle take place during the experiment. The obstacles that were estimated occurred while experiment such as student difficulty to find mathematics puzzle and student difficulty to move from puzzle to problem posing. But until the end of the experiment students were able to find the appropriate mathematics puzzle, despite they were vary in consuming time. In addition, students also moved smoothly from puzzle to problem posing. But once again, they were vary not only in consuming time but also in the quality of the posed problem.

4. Conclusion

Puzzle exercises bring a positive influence on the increased interest and ability of students to do problems posing in learning mathematics. Students who follow mathematics learning with problem posing model preceded by puzzle exercises have better interest and problem posing abilities than students who follow mathematics learning with problem posing directly. Mathematics that is still considered difficult and scary for some students can be arranged by creating a relaxed and informal atmosphere. If students still think that math is difficult and scary, then their learning achievement is difficult to improve.

Puzzle games can create a relaxed and informal atmosphere, so it is suitable to be applied as a first step in mathematics learning, such as in mathematics learning with problem posing. Active student involvement in learning should still be pursued by creating an atmosphere that can attract students' interest. The expected final goal is better learning outcomes, not just cognitive but also affective and psychomotor. Mathematics is learned to be applied, so the various skills that exist in mathematics should be excavated. All that can be achieved if students are actively involved in learning, such as in problem posing.
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References
[1] Xia X, Chuanhan L and Wang B 2008 Research on Mathematics Instruction Experiment Based Problem Posing Journal of Mathematics Education 1 153-163
[2] Durakoglu A 2013 Paulo Freire’s Perception of Dialogue Based Education, International Journal on New Trends in Education and Their Implications 4 102 - 107
[3] Freire P 2005 Pedagogy of the Oppressed New York: Continuum
[4] Pittalis M, Christou C, Mousoulides N and Pantazi D A P 2004 Structural Model for Problem Posing, Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education Paulo Freire’s Perception of Dialogue Based Education 49–56.
[5] Yoonsuck C and Timothy A M 2012 From Problem Solving to Problem Posing, Brain-Mind Magazine 1 7 - 8
[6] Sengul S and Katranci Y 2012 Problem solving and problem posing skills of prospective mathematics Procedia - Social and Behavioral Sciences 69 International Conference on Education and Educational Psychology (ICEEPSY 2012): Elsevier Ltd 1650 – 1655
[7] Stoyanova E N 1997 Extending and exploring students’ problem solving via problem posing Retrieved from http://ro.ecu.edu.au/theses/885
[8] Silver E A 1994 On mathematical problem solving For the Learning of Mathematics.
[9] Lavy I and Shriki A 2007 Problem Posing as A Means for Developing Mathematical Knowledge of Prospective Teachers Proceedings of the 31st Conference of the International Group for the Psychology of Mathematics Education 3 129-136.
[10] Ghasempour Z, Bakar M N and Jahanshahloo G R 2013 Innovation in Teaching and Learning through Problem Posing Tasks and Metacognitive Strategies International Journal of Pedagogical Innovations 1 53-62
[11] English L D and Watters J J 2004 Mathematical Modelling With Young Children Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education, 2004 2 335–342
[12] Lin P 2004 Supporting Teachers On Designing Problem-Posing Task As A Tool Of Assessment To Understand Student’s Mathematical Learning, Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education 257–264
[13] Singer F M, Ellerton N and Cai J, Problem-posing research in mathematics education: new questions and directions Educational Studies in Mathematics 83 1-7
[14] Webster A M 1983 Webster’s Ninth New Collegiate Dictionary (Springfield Massachusetts: Merriam-Webster Inc)
[15] The American Heritage Dictionary 1985 (Boston Massachusetts: Houhton Mifflin Company)
[16] Dictionary.com http://www.dictionary.com/browse/puzzle
[17] Webster M, Learner’s Dictionary http://www.learnersdictionary.com/definition/puzzle.