The relationship between creative thinking and mathematical proving abilities among junior high school students

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Abstract. The study aimed to determine the relationship between creative thinking and mathematical proving abilities among junior high school students who were taught using Missouri Mathematics Project (MMP) learning model. Missouri Mathematics Project (MMP) learning model has five steps, that is, review, development, cooperative working, seat work, and assignment. This study involved 31 seventh-grade students selected using purposive sampling technique. To collect the data, this study employed mathematical creative thinking ability and mathematical proving ability tests. The data of participants’ scores from each test were analyzed using Spearman’s Rank correlation coefficient (ρ). The result of analysis showed that ρ-value is 0.015. It means that there is a significant positive correlation between creative thinking and mathematical proving abilities among junior high school students who are taught using Missouri Mathematics Project (MMP) learning model.

1. Introduction
Law No. 20 of 2003 on National Education System states that the curriculum is a set of plans and arrangements concerning objectives, content, and lesson materials and ways used as guidelines for the implementation of learning activities to achieve educational goals. Article 37 stated that the curriculum of elementary and secondary education must contain the lesson of Mathematics. Mathematics as the basic science of all fields of science is very important to know. Therefore, mathematics should be taught in all levels of formal education, from elementary school to university levels. The importance of mathematics can be seen from the benefits and usefulness of mathematics in everyday life, also for the development of science. Thus, the improvement of the curriculum by the Ministry of National Education include the ability to think logically, analytically, systematically, critically and creatively as the Competency Standards of Mathematics Subject contained in Curriculum 2006.

The creative thinking ability is necessary for students considering that today science and technology are developing very rapidly and enabling anyone to obtain information quickly and easily from various sources and anywhere in the world. This has resulted in rapid changes in the order of life and global change in life. If students are not supplied with creative thinking skills then they will not be able to process, assess, and get back the information which needed to face the challenge. Therefore, the creative thinking ability is an important skill in mathematics. The focus and attention on improving the ability of creative thinking in mathematics is rarely developed. Though this ability is necessary for students to have the ability to obtain, manage, and utilize information to survive in an ever-changing, uncertain, and competitive state.

The results of TIMSS (Trend in International Mathematics and Science Study) 2011 of mathematics for grade VIII junior high school students in Indonesia, report that Indonesia ranked 38th out of 42 countries with an average score of 386, while the international average score is 500. PISA (Program for International Student Assessment) 2012 showed similar results, Indonesia ranked 64th out of 65 participating countries with an average score of 375 on the achievement of mathematics learning outcomes. The results of TIMSS and PISA studies indicate a lack of students’ ability to solve non-routine problems were only able to solve simple problems. This shows that the lack of ability of
students in mathematical high order thinking is caused by the lack of mathematical creative thinking. Creative thinking is the representation of high order thinking.

One of the factors causing the low ability of students' mathematical creative thinking is the limited ability of mathematical proving. Proving encourages students to think in high order so that they can develop creative thinking skills. Proving is one material that is not easy to teach. Senk states that among 1520 high school students for Euclid Geometry lessons is only 30% of those students who achieve a writing proof level in 75% and only 3% of these students achieve an ideal score [10]. Other facts also show that many students experience difficulties in solving the problem of proving. Grob, et al. state that many students face serious difficulties with consistent reasoning and arguments, particularly on mathematical proving [2]. It is seen from the mistakes made by students in arguing the process of proving so their learning achievements are decreasing.

In addition, mathematics learning in high school doesn’t pay attention to this problem of proving. This may be because the problem of proving is not found in the question of National Final Examination (UAN) either at the junior high school level or in Senior High School (SMA). In fact, problem of proving are much learned at a higher level of education (university level).

One of the ways to develop students' abilities in mathematics lessons is to design a learning that will be held in the classroom. Richards stated that students will not be active learners by accident, but by design [3]. Students become active not by chance, but because of the design of learning. Teachers should choose methods, strategies, approaches, or learning models and formulate the steps that will be taken during the teaching and learning process in the classroom.

One of the learning models that can improve the ability of creative thinking and mathematical proving of students is Missouri Mathematics Project (MMP) learning model. The MMP learning model focuses on five essential elements. According to Joyce and Weil state that this learning model has five basic elements, namely (a) Syntax (syntax), that is, learning operational steps; (b) Social system, is the general feeling and norm in learning; (c) Principles of reaction, describes how teachers should see, treat, and respond to students; (d) Support system, that is, any means, materials, tools, or learning environments that support learning; (e) Instructional effect (instructional impact), that is, learning results obtained directly based on the goals to be achieved; (f) Nurturant effect (impact accompaniment), which is the intended outside of the result of learning [11].

Krismanto puts five steps of the Missouri Mathematics Project (MMP) learning model as follows. Step I: Review, teachers and students review what has been covered in past lessons. They are: assignment, look up, or make estimation. Step II: Development, the teacher presents new ideas and extensions of earlier mathematical concepts. Students are notified of learning objectives that have “anticipated” about the learning objectives. Development will be more reasonable when combined with exercise controls to ensure that students follow the presentation of the new material. Step III: Cooperative Working, students are asked to respond to a series of questions while the teacher oversees the students to avoid misconceptions. In this controlled exercise the students' response is very beneficial for teachers and students. Teachers should include specific details of group responsibility and individual rewards based on the achievement of the material being studied. Step IV: Seat Work, for the exercise/extension to learn the concept presented, the students are assigned to do the problems independently. Step V: Assignment, teacher gave assignments to students about the material they have learned [6].

2. Mathematical Creative Thinking

Evans argues that creative thinking is detected in four forms: sensitivity, fluency, flexibility, and originality [1]. Sensitivity to problem situations involves the ability to identify problems, able to distinguish irrelevant facts relevant to the problem, including relevant concepts. This sensitivity includes what a person recognizes in relation to the identified problem, such as related concepts, appropriate methods for solving the problem. This sensitivity will arise more clearly when there is a stimulus provided in the problem or clue and challenge provided by the teacher. This sensitivity can trigger the individual to continue his efforts to perform activities of observation, exploration so they can bring up their ideas. Fluency can be seen by a variety of ideas or questions, planning and using various methods to solve the problem. Flexibility can be viewed as a variation that actually demonstrates the wealth of ideas or alternatives and efforts of the concerned in building the idea towards the solution. Originality is seen as the emergence of the idea of the concerned without getting
help from others. The authenticity comes in various forms, from simple or informal to develop into more complete. Originality in this case is relative. Because for those concerned it is an original (new to him), but for others it is nothing new.

Getzles and Jackson put forward a way to measure the ability of mathematical creative thinking with open-ended problems [9]. The use of open-ended problems has become a trend in today's mathematical learning. Mathematical learning utilizing the use of open-ended problems provides an opportunity to further explore students' thinking skills comprehensively and can accommodate different characteristics of students [8]. Guilford mentions five indicators of creative thinking, namely: (1) Sensitivity is the ability to detect, recognize, understand and respond to a statement, situation, or problem; (2) Fluency is the ability to generate many ideas; (3) Flexibility is the ability to propose a variety of solutions or approaches to problems; (4) Originality is the ability to spark ideas in original and rarely given by most people; (5) Elaboration is the ability to add a situation or problem so that it becomes complete, and elaborate in detail, in which there are tables, graphics, pictures, models and words [4]. Therefore, mathematical creative thinking that will be measured in this study is the ability to think fluency, flexible, originality, and elaboration.

3. Mathematical Proving Ability
Educational Development Centre suggests that evidence is a logical argument that establishes the truth of a statement [5]. The argument derives its conclusions from the premise of statements, other theorems, and definition. Logical means every step in the argument is justified by the preceding steps. In the process of proving, may involve diagrams, verbal sentences, symbolic, or computer programs. Griffiths states that mathematical proving is a formal and logical way of thinking that begins with the axiom and moves forward through logical steps to a conclusion [5].

The purpose of conducting the verification according to the Educational Development Centre is to: (1) establish facts with certainty, (2) gain understanding, (3) communicate ideas to others; (4) challenges; (5) make something beautiful [5]. The evidence may also be aimed at: (1) communication (communication) which means the language of evidence can be used to communicate concepts and argue ideas with others; (2) the discovery of new result means by investigating the logical consequences of definitions and axiomatic systems, theories can be developed; (3) a justification of a definition means one can show that a definition can reveal the intuitive essence of a concept by showing that all the essential properties of the concept can be derived from the proposed definition; (4) developing intuition means that by testing the logical definition of a concept one can develop conceptual and intuitive understanding of learned concepts; (5) providing autonomy (meaning autonomy) means teaching students how to prove can enrich their insights to construct and validate free mathematical knowledge. The method of proving is necessary to convince the truth of statements or theorems that are generally in the form of implications or bi-implications. Evidence of implication statement according to Martono, among others, consists of direct evidence method, and indirect evidence (contradiction) [10].

4. Methodology
The method used in this research is correlational research. Correlational research for this study is to determine the relationship between the two variables. Correlational method can examine the relationship or effect of cause and effect. Sudjana and Ibrahim describes correlation research method is the study about the relationship of two or more variables [13]. This is similar to Sukmadinata that the study of the relationship (associational study) is also called correlational studies (correlational study) that examined the association between two things, two or more variables [15]. Trianto argues that the purpose of a correlational study is to declare the size relationship between two variables or more [16].

The population in this study is all students of class VII SMP Negeri 11 Balikpapan East Kalimantan Province academic year 2013/2014. The sample of research was determined based on purposive sampling which is sampling based on certain consideration [14]. The sample already represented the population because the students' abilities are balanced. The sample in this study consisted of 31 students. The instruments used in the study were involved: test of creative thinking and mathematical proving. The test of creative thinking consists of 4 subjective type test item. The test of
mathematical proving consists of 2 subjective type test item. Content validity was established for the test. Reliability of the test was established through Cronbach’s Alpha coefficient was found to be 0.62.

5. Results and Discussion
The aim of this study was to determine the relationship between creative thinking and mathematical proving abilities among junior high school students who were taught using Missouri Mathematics Project (MMP) learning model and to determine how strong the correlation between creative thinking and mathematical proving abilities. Quantitative data were obtained through the test of creative thinking ability and mathematical proving at the end of the learning on 31 students who obtained the MMP learning model.

5.1 Normality test
The normality test was intended to see whether the data obtained comes from a normally distributed population or not. The normality test was performed by using Shapiro-Wilk statistic test with the test criteria is if the p-value (Sig.) is greater than the α = 0.05, then H₀ is accepted. Here is the test hypothesis:

H₀: The sample is from a normally distributed population
H₁: The sample comes from a population not normally distributed

The result of normality score test of mathematical creative thinking post-test can be seen in the following table:

| Class  | Shapiro-Wilk Statistic | Df | Sig. | Result   |
|--------|------------------------|----|------|----------|
| MMP    | 0.928                  | 31 | 0.039| H₀ Rejected |

From Table 1 above, it was found that the post-test score of mathematical creative thinking ability of MMP class students has Sig value. < α = 0.05 so that H₀ is rejected, in other words the post-test score of MMP class students comes from a population that is not normally distributed. Similarly, the result of normality score test of mathematical proving post-test of MMP class can be seen in the following table:

| Class  | Shapiro-Wilk Statistic | Df | Sig. | Result   |
|--------|------------------------|----|------|----------|
| MMP    | 0.910                  | 31 | 0.013| H₀ Rejected |

From Table 2 above, it was found that post-test score of mathematical proving ability of MMP class student has Sig value. < α = 0.05 so that H₀ is rejected, in other words the post-test score of MMP class students comes from a population that is not normally distributed.

5.2 Nonparametric test
Nonparametric test that will be used to determine correlation between creative thinking and mathematical proving abilities was Spearman correlation test. The hypotheses tested were:

H₀: There is no correlation between post-test of creative thinking and mathematical proving ability of students who are taught using MMP learning model.
H₁: There is a correlation between the post-test of creative thinking and mathematical proving ability of students who are taught using MMP learning model.

The following test results show the correlation of post-test score of creative thinking and mathematical proving ability.
Table 3: Relationship between Creative Thinking and Mathematical Proving

|                      | Proving | Creative Thinking |
|----------------------|---------|-------------------|
|                      | Correlation Coefficient | 1.000 | 0.432* |
|                      | Sig. (2-tailed) | | |
| Proving              | N | 31 | 0.015 |
|                      | 31 |   | 1.000 |
| Creative Thinking    | Correlation Coefficient | 0.432* | 1.000 |
|                      | Sig. (2-tailed) | | |
|                      | N | 31 |   |
|                      | 31 | 0.015 |   |

Table 3 shows that $p$-value is 0.015 at 0.05 level of significance. This implies that there exists significant positive relationship between creative thinking and mathematical proving abilities among junior high school students who are taught using Missouri Mathematics Project (MMP) learning model. These results explain that mathematical proving has built in mathematical creative thinking ability.

The results of data analysis, show that there exists significant positive relationship between creative thinking and mathematical proving abilities among junior high school students who are taught using Missouri Mathematics Project (MMP) learning model. It means that if the students’ mathematical proving ability increases then it will result in the increase of students’ mathematical creative thinking ability. Conversely, if the students’ mathematical proving ability decreased it will result in the decreasing ability of students’ mathematical creative thinking. The result of correlation test between creative thinking ability and mathematical proving in MMP class has correlation coefficient of 0.432. This shows that there is a moderate correlation between creative thinking and mathematical proving abilities. It means that each student will rank almost equally well on both verification and creative thinking tests. If a person obtains a high ranking on a proving test will also rank high on a creative thinking test, and vice versa.

The main factor that causes mathematical proving ability to influence the ability of mathematical creative thinking is because the ability of mathematical creative thinking is a high-level thinking skills that required many other mathematical skills, one of which is the mathematical proving ability to support such high-level thinking skills. In this research the mathematical proving of MMP class was still low. As a result, the achievement of mathematical creative thinking ability was equally low. Therefore, the correlation between students’ mathematical proving and creative thinking was also not high.

6. Conclusion
Based on the findings and discussion, the study revealed that there was a significant positive relationship between creative thinking and mathematical proving abilities among junior high school students who were taught using Missouri Mathematics Project (MMP) learning model. The findings suggest that mathematical creative thinking ability has caused increase in mathematical proving ability and vice versa.

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