Problem based MHM-Strategy to enhance junior high school students mathematical creative problem solving ability and mathematical disposition

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Abstract. This article presents the results of research on the development of mathematics learning with problem based Mathematical Habits of Mind (MHM) strategy to enhance mathematical creative problem solving (MCPS) ability and mathematical disposition. Quasi experimental research with posttest control group design involved 146 eighth grade students from two State Junior High Schools in Subang regency, each consisting of two classes. The instruments used were tests MCPS ability and mathematical disposition. Research data of students pretest, posttest, and normalized gain scores for MCPS ability were analyzed using two-way ANOVA and Mann Whitney. Based on data analysis results, it is found that there is a significant difference in the enhancement of students MCPS ability and mathematical disposition of students between the experimental and control groups at the high and medium school levels. On the other hand, there is a difference in mathematical disposition in terms of school level. Meanwhile, there is an interaction effect between problem-based MHM strategies and school levels on the student’s mathematical disposition. Conclusion, that the enhancement of MCPS ability of students who were taught with problem-based MHM strategy is significantly greater compared conventional learning in terms of school level.

1. Introduction
Problem solving is one of the main goals in learning mathematics even as the heart of mathematics at all levels of school Umar [1]. The national council of supervisors of mathematics states "learning to solve problems is the main reason for learning mathematics" (NCTM) [2]. Problem solving is not a separate topic, but a process that must be able to absorb all programs, and provide a context where concepts and skills can be learned (NCTM) [2]. This ability is needed by students, this is related to the needs of students to solve the problems they face in everyday life. Therefore, the ability to think mathematically, especially concerning doing math (mathematical activity) which is knotted in mathematical creative problem solving (MCPS), needs to get special attention in the process of learning mathematics.

Referring to the opinion of Mitchell and Kowalik [3] that the notion of mathematical creative problem solving comes from the word creative, problem solving. Creative means many new and unique ideas in creating solutions and having value and relevance; problem means a situation that presents challenges, opportunities, interrelated; temporary solving, meaning planning a way to answer or find answers to a problem. Thus, literally MCPS can be interpreted as the ability to plan a new or unique...
way / idea to answer a problem that is being faced. On the one hand, MCPS is a component in the high
order thinking skills, and on the other hand, the ability of MCPS is very important for everyone in
solving the problems they face, so it is necessary and continues to be developed through mathematics
education.

Kusumah (Isrok’ atun) [4], said that the ability of MCPS is to include high-level thinking skills, is
also one of the characteristics desired by the workforce. The full characteristics are: (1) having
confidence; (2) have achievement motivation; (3) mastering basic skills, such as writing, speaking and
computer literacy skills; (4) mastering thinking skills, such as asking questions, making decisions,
thinking analytically, and thinking critically; and (5) mastering interpersonal skills, such as the ability
to work together and negotiate. Of these 5 characteristics, it shows that the ability of MCPS is one of
the main focuses of mathematics learning. Through learning mathematics, students are expected to have
the ability to think logically, analytically, systematically, critically, and creatively, and have the ability
to work together (Depdiknas) [5].

Meanwhile, the purpose of learning mathematics in the mathematics curriculum (Kemendiknas) [6]
include: students can solve problems and have an attitude of respecting the usefulness of mathematics
in life, attitude of curiosity, attention, and interest in learning mathematics, as well as attitudes tenacious
and confident in solving problems. NCTM [2] named the objective in the affective aspect above with
the terms mathematical disposition. Similarly, Katz [7], argues that mathematical disposition contains
confidence, perseverance, interest, and flexible thinking in exploring various alternative solutions to
problem solving strategies. As part of the purpose of learning mathematics, the ability of mathematical
creative problem solving and mathematical disposition is a necessity and is very important to be
developed in students who study mathematics.

Educational institutions have roles and responsibilities to equip students with abilities that are useful
for their lives in the future. Such roles and responsibilities do not appear to be optimally implemented.
McGregor’s [8] study shows that about two-thirds of Americans in their 16s to 25 years of age state that
educational institutions do not provide them with the essential abilities needed to face life’s challenges.
These capabilities include critical thinking skills, creative and problem-solving abilities. Furthermore,
the results of research by Kaur et.al [9], which states that even though students have been trained in
problem solving abilities, but in general they are still weak in mathematical creative problem-solving
abilities. This is because both results of the study indicate that the problem-solving ability refers to Polya
[10], namely the ability to understand problems, plan problem solving, solve problems, and re-check.
The learning provided does not facilitate students to think divergent-converging and has not yet referred
to aspects of mathematical creative problem solving (MCPS) abilities.

There are several learning strategies that can potentially develop MCPS capabilities simultaneously,
such as problem-based learning. Problem-based learning is learning that uses problems as triggers for
student learning processes (CIDR) [11]. Through the presentation of contextual problems, students are
invited to understand, link between concepts, and apply concepts and principles to problem solving.
Thus rationally, problem-based learning provides opportunities for students to achieve better
understanding and ability of MCPS. Millman and Jacobbe [12] offer another learning strategy namely
the Mathematical Habits of Mind (MHM) strategy as a strategy to develop thinking habits in solving
problems. This strategy includes 6 components, namely: exploring mathematical ideas, reflecting the
suitability of the answer to the problem, identifying problem solving strategies that can be applied,
asking yourself about the activities that have been done, formulating questions, and constructing
examples. Through the development of the habit of thinking above, it is expected to grow conscientious,
diligent, happy to work, flexible thinking, and self-confidence which are components of students'
attitudes toward mathematics or mathematical dispositions. The second advantage of this learning, is
the idea of combining the two learning into a problem-based MHM strategy for enhancing mathematical
creative problem solving (MCPS) skills of junior high school students.
For more details, the problem of this research was formulated in the form of questions as follows:
(1) Are there differences in the enhancement of MCPS abilities and mathematical disposition of students who get learning with problem based MHM strategies with students who get conventional learning? (2) Is there any interaction effect between problem-based MHM strategies and school levels on the student’s mathematical disposition? Likewise, the objectives of this research are as follows: (1) To describe comprehensively about enhancement MCPS ability and mathematical disposition of students who get learning with problem based MHM strategies and conventional learning. (2) Analyzing the effect of interaction between problem based MHM strategies and school level on the student’s mathematical disposition. The results of this study are expected to be utilized by subsequent researchers who want to conduct more detailed research on the application of problem based MHM strategies to increase MCPS and mathematical disposition of students or other mathematical thinking abilities.

2. Methods
This research is a quasi-experimental research design in the form pre-test post-test control group design. This study aims to develop MCPS abilities and mathematical disposition of students. The design of this study is illustrated as follows [13]:

\[ \text{O} \quad \text{X} \quad \text{O} \]

\[ \text{O} \quad \text{O} \]

Description: X = Problem based MHM strategy
O = Pretest = Posttest

The sample included in this study were 146 seventh grade students from two state junior high schools in Subang Regency, each consisting of two classes, namely the experimental class and the control class. Experimental classes were taught with problem based MHM strategies and control classes get conventional learning. The instrument used was the MCPS ability test and the scale of student’s mathematical disposition. Data on student’s enhancement the MCPS ability were obtained through the posttest of MCPS, while data on mathematical dispositions of the student were obtained using the disposition scales. Furthermore, data for pretest, posttest, and normalized gain of MCPS ability were analyzed by two-way ANOVA and Mann-Whitney test. For the assumption of normality and homogeneity, variance is carried out prior to using the combined statistical tests.

3. Result and Discussions

3.1. Result

3.1.1. Creative Problem-Solving Ability (MCPS). The results of the data analysis of students MCPS ability in experimental class and control class consisting of data: pretest, normality test, and difference test of two means based on learning can be shown in the tables below.

| School Level | Learning Strategy | N  | Pretest Score Mean | SD  | Normality          | Mann-Whitney Test            |
|--------------|-------------------|----|--------------------|-----|--------------------|----------------------------|
| High         | Problem based MHM | 39 | 6.26               | 2.91| Not normality      | significantly different     |
|              | Conventional      | 38 | 9.53               | 3.93| Normality          |                            |
| Moderate     | Problem based MHM | 35 | 4.89               | 3.23| Not normality      | not significantly different |
|              | Conventional      | 34 | 4.91               | 3.28| Not normality      |                            |
Based on Table 1, it appears that for the high school level the average pretest of students in the control class (conventional) is higher than the experimental class (problem-based MHM strategy), while for the moderate school level the average pretest of students in the experimental class is not much different from the students in the control class. In addition, the results of the normality test for high school level in the experimental class showed a probability value (sig. 2-tailed) less than the significance level $\alpha = 0.05$, which means that the data is not normally distributed, while for conventional classes the probability value (sig. 2-tailed) is more than the significance level $\alpha = 0.05$, which means the data is normally distributed. For the moderate school level, both data classes are not normally distributed. Because one data or both are not normally distributed, then for the mean difference test using non-parametric Mann-Whitney statistical test, the results of calculations for high school level obtained probability value (sig. 2-tailed) less than the significance level $\alpha = 0.05$, which means that there is a difference between the experimental class students and the control class, while for the moderate school level the probability (sig. 2-tailed) values are obtained more than the significance level $\alpha = 0.05$, which means there is no difference between the experimental class students with control class.

**Table 2. Recapitulation Posttest of Student MCPS Ability.**

| School Level | Learning Strategy | N   | Posttest Score Mean | SD | Normality                     | Mann-Whitney Test                      |
|--------------|-------------------|-----|---------------------|----|-------------------------------|---------------------------------------|
| High         | Problem Based MHM | 39  | 55.90               | 9.17| Not normality                 | significantly different                |
|              | Conventional      | 38  | 47.11               | 7.15| Not normality                 |                                       |
| Moderate     | Problem Based MHM | 35  | 60.86               | 9.81| Normal                        | significantly different                |
|              | Conventional      | 34  | 45.35               | 9.85| Not normality                 |                                       |

From Table 2 it is known that for the high school level, the average MCPS ability of the group of students who got learning with problem-based MHM strategies was 55.90 higher than those who received conventional learning was 47.11. Likewise, for the moderate school level the ability of the MCPS group of students who got learning with a problem-based MHM strategy was 60.86 higher than that of conventional learning was 45.35. After testing the mean difference of the four sample groups, the results showed that the two levels of school both high and moderate school level, obtained a significant difference in the ability of students' MCPS between those who learned with the problem-based MHM strategy and students who received conventional learning.

**Table 3. Recap of N-Gain Data Test Results of Student MCPS Ability.**

| School Level | Learning Strategy | N   | N-gain Mean | SB  | Normality       | Mann-Whitney Test               |
|--------------|-------------------|-----|-------------|-----|----------------|-------------------------------|
| High         | Problem Based MHM | 39  | 0.52        | 0.09| Normal          | significantly different       |
|              | Conventional      | 38  | 0.44        | 0.07| Not Normality   |                               |
| Moderate     | Problem Based MHM | 35  | 0.59        | 0.103| Normal         | significantly different       |
|              | Conventional      | 34  | 0.39        | 0.097| Not Normality   |                               |

Based on Table 3 above, it can be explained that the to levels of school both high and moderate school level, there are differences in the ability of MCPS students to gain learning with problem-based MHM strategies with students who get conventional learning. That is, enhancement the ability of MCPS who get learning with problem-based MHM strategies is better than students who get conventional learning.

**3.1.2. Analysis of Student Mathematical Disposition.** The following are the results of data analysis of the achievement of Mathematical Disposition based on the school level for students in the experimental
class and control class consisting of pretest data, normality test data, and different test of two means based on learning can be shown in the tables below.

Table 4. Recapitulation of Data Result of N-Gain Student Mathematical Disposition

| School Level | Learning Strategy       | N    | N-Gain | Normality | Mann-Whitney Test |
|--------------|-------------------------|------|--------|-----------|-------------------|
| High         | Problem Based MHM       | 39   | 0,33   | 0,27      | Not Normality     |
|              | Conventional MHM        | 38   | 0,19   | 0,11      | Normal            |
| Moderate     | Problem Based MHM       | 35   | 0,26   | 0,20      | Not Normality     |
|              | Conventional MHM        | 34   | 0,18   | 0,10      | Normal            |

From the statistical test results, it appears that for the high school level the enhancement mathematical disposition a significant difference, meaning mathematical disposition enhancement the group of students who are learning with problem-based MHM strategies is better than the group of students who get conventional learning. In contrast to the moderate school level the enhancement in mathematical disposition is not significantly different, meaning enhancement in mathematical disposition of groups of students who get learning with problem-based MHM strategies are no different from groups of students who get conventional learning.

3.1.3. Effect of Interactions between Problem Based MHM Strategies and School Levels on Student Mathematical Disposition. To find out whether or not there is an interaction effect between learning strategies and school level (high and moderate) on enhancement Mathematical Disposition is done using the two-way ANOVA statistical test. This is based on the basic assumption that if the data is normally distributed, it is necessary to conduct a two-way ANOVA test. However, based on previous data, it shows that the average increase in Mathematical Disposition based on school level is not normally distributed, so that a two-way ANOVA test cannot be performed. Thus, an analysis of the effect of interaction on enhancement Mathematical Disposition is done descriptively from the resulting graph. The results are as follows.

Figure 1. Interactions between Problem-Based MHM Strategies and School Levels on Student Mathematical Disposition.
From the graph it appears that the average enhancement in mathematical disposition of students who have a problem-based MHM strategy is higher than conventional learning. However, for moderate school level, students who get learning with problem-based MHM strategies experience a significant increase compared to high school level. The two lines shown in the graph appear to intersect. This shows the influence of the interaction between the learning strategy and the school level on mathematical disposition enhancement.

3.2. Discussions
The results of the study show that students who get learning with more problem-based MHM strategies in developing MCPS abilities and student dispositions towards mathematics. In other words, the role of problem-based MHM strategies is superior to the conventional role of learning in developing students' MCPS abilities. This is as the results of the N-Gain data analysis recapitulation of students' MCPS abilities presented in Table 3 above, shows that the average enhances in experimental class students who get learning with problem-based MHM strategies is greater than that of control class students who get conventional learning. Thus, it was concluded that there were significant differences in enhancement the ability of MCPS students who got learning with problem-based MHM strategies with students who received conventional learning in terms of high and moderate school level. The rationale above can be explained as follows: in a problem-based MHM strategy, students collaboratively practice mathematical thinking habits to solve the contextual problems provided by the teacher. This is supported by the results of Jacobbe's research (Millman and Jacobbe) [12] which shows that the use of problem-based MHM strategies can improve student performance in solving problems. These mathematical thinking habits help students build knowledge and at the same time develop the ability of MCPS. The habit of mathematical thinking like the above if it takes place continuously, will provide opportunities for the ability of MCPS and the growth of mathematical disposition of students towards mathematics learning.

The habit of students who are built through learning with problem-based MHM strategies is to identify problem-solving strategies that can be applied to solve problems on a wider scale and ask themselves whether there is "something more" than the mathematical activities that have been done. Such habits allow students to build their own knowledge or concepts and strategies to solve problems. Such habits are in line with the philosophy of constructivism. According to Hein (Mahmudi) [14], constructivism assumes that students must construct their own knowledge. Such habits allow students to develop the potential of mathematical creative problem solving. Constructivism and mathematical creative problem solving have the same ideas or keywords, namely constructing or creating. Individuals are said to be mathematical creative problem solving if they are able to create or construct. Instead Alexander [15] said that learning with the philosophy of constructivism is part of the mathematical creative problem-solving process.

From this study also found that there were interactions between problem-based MHM strategies and school levels of mathematical disposition. On the other hand, students in the experimental class who get learning with problem-based MHM strategies have better mathematical disposition than students who get conventional learning. This finding shows that learning with problem-based MHM strategies is relatively appropriate to develop the overall MCPS ability of students or both groups of students. In addition, such learning tends to be more suitable for developing mathematical disposition of students in learning mathematics. Isro'atun [4] said that cognitive factors reflected in the school category are in line with affective factors, namely mathematical dispositions and the development of mathematical thinking abilities. Meanwhile Maxwell [16] revealed that dispositions and abilities are two different things. It is possible, the student shows a high mathematical disposition, but if he does not have enough knowledge or abilities related to the substance of the material, then he also will not have high mathematical abilities.
4. Conclusion
Based on the results of data analysis, findings, and discussion, it was concluded that the problem-based MHM strategy showed a superior role than conventional learning variables. In other words, there are differences enhancement in the ability of MCPS students to gain learning with problem-based MHM strategies with students who get conventional learning. On the other hand, students in the experimental class who get learning with problem-based MHM strategies have mathematical disposition or a positive attitude towards mathematics better than students who get conventional learning. There is an interaction between problem-based MHM strategies and school level on students' mathematical disposition.

The implication of this study is that problem-based MHM strategies provide greater benefits to students in developing MCPS abilities or other mathematical abilities, and mathematical disposition or positive attitude towards students in mathematics.

5. References
[1] Umar W 2016 Strategi Pemecahan Masalah Matematis Versi George Polya dan Penerapannya dalam Pembelajaran Matematika. Kalamatika FKIP UHAMKA 1 59
[2] NCTM 2003 Programs for Initial Preparation of Mathematics Teachers http://ncate.org/
[3] Mitchell W E & Kowalik T F 2001 Creative Problem Solving.. (NUCEA: Genigraphict Inc)
[4] Isrok’atun 2014 Model Pembelajaran Situated Creation and Problem Based Instruction (SCPBI) untuk Meningkatkan Creative Problem Solving (CPS) Siswa. Bandung: Laporan Hibah Disertasi Doktor. Tidak diterbitkan.
[5] Depdiknas 2006 Kurikulum 2013. Standar Kompetensi Mata Pelajaran Matematika Sekolah Menengah Pertama dan Madrasah Tsanawiyah. (Jakarta: Depdiknas)
[6] Kementerian Pendidikan Nasional dan Kebudayaan 2013 Struktur Kurikulum Nasional 2013 Mata Pelajaran Matematika Sekolah Menengah Pertama dan Madrasah Tsanawiyah. (Jakarta: Kemdikbud)
[7] Katz L G 2009 Dispositions as Educational Goals. http://www.edpsycinteractive.org/
[8] McGregor D 2007 Developing Thinking Learning. (Poland: Open University Press)
[9] Kaur B & Ban-Har Y 2010 Mathematical Problem Solving in Singapore Schools http://www.worldscibooks.com/
[10] Polya G 1985 How to Solve It. A New Aspect of Mathematical Method (New Jersey: Princenton University Press)
[11] Center for Instructional Development & Research 2004 Problem-Based Learning http://depts.washington.edu/
[12] Millman R S & Jacobbe T 2010 Fostering Creativity in Preservice Teachers Through Mathematical Habits of Mind http://dg.icme11.org/
[13] Ruseffendi H E T 2005 Dasar-Dasar Penelitian Pendidikan & Bidang Non-Eksakta Lainnya. Bandung: Tarsito
[14] Mahmudi A 2010 Pengaruh Pembelajaran dengan Strategi MHM Berbasis Masalah terhadap Kemampuan Berpikir Kreatif Matematis dan Persepsi terhadap Kreativitas. Educationist UPI
[15] Alexander K L 2012 Effects Instruction in Creative Problem Solving on Cognition, Creativity, and Satisfaction among Ninth Grade Students in an Introduction to World Agricultural Science and Technology Course. Disertasi pada Faculty of Texas Tech University http://etd.lib.ttu.edu/
[16] Maxwell K 2010 Positive Learning Dispositions in Mathematics www.education.auckland.ac.nz/