

THE ROLE OF PROBLEM BASED LEARNING ON IMPROVING STUDENTS' MATHEMATICAL CRITICAL THINKING ABILITY AND SELF-REGULATED LEARNING

Musriana Retnaningsih¹, Asep Ikin Sugandi²

¹Muhammadiyah Prof. Dr. Hamka University, Jakarta, Indonesia

²IKIP Siliwangi, Bandung, Indonesia

¹musriana.retnaningsih@gmail.com, ²asepikinsugandi@gmail.com

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Abstract

This study is a pre test-post test experimental control group design having a goal to analyze the role of problem based learning on students' mathematical critical thinking ability and self regulated learning. The study involved 60 eighth grade students of an MTs, a mathematical critical thinking test, and a mathematical self regulated learning scale. The study found that on mathematical critical thinking ability, its gain, and on mathematical self regulated learning, students getting treatment with problem based learning approach attained better grade than that of students taught by conventional teaching. The first group students obtained at fairly good grades level, while the students taught by conventional teaching attained at medium grades level. The other findings, there was fairly good association between mathematical critical thinking ability and mathematical self regulated learning.

Keyword: Mathematical Critical Thinking, Mathematical Self-Regulated Learning, Problem Based Learning

Abstrak

Penelitian ini adalah suatu eksperimen berdisain pretes-postes kelompok kontrol, bertujuan menelaah peranan pembelajaran berbasis masalah terhadap kemampuan berpikir kritis dan kemandirian belajar matematik siswa MTs. Penelitian melibatkan sebanyak 60 siswa kelas delapan, satu set tes berpikir kritis matematik dan satu set skala kemandirian belajar. Penelitian ini menemukan bahwa dalam berpikir kritis, keuntungannya, dan kemandirian belajar matematik, siswa yang mendapat pembelajaran berbasis masalah mencapai mutu yang lebih baik dari pada siswa yang mendapat pembelajaran konvensional. Siswa kelompok pertama mencapai mutu yang cukup baik sedangkan siswa kelompok kedua memperoleh mutu sedang. Selain itu ditemukan pula asosiasi yang cukup antara kemampuan berpikir kritis matematik dan kemandirian belajar.

Kata Kunci: Pembelajaran Berbasis Masalah, Kemampuan Berpikir Kritis Matematik, Kemandirian Belajar.

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INTRODUCTION

Mathematical critical thinking (MCT) and self regulated learning (SRL) are important mathematical ability and attitude should be improved on high school students. Some reasons which supporting that statement among others are: a) Mathematical critical thinking ability (MCTA) and part of SRL attitude are attached in the goals of mathematics teaching such as students should possess logical, critical, creative, innovative thinking abilities, and possess accurate, objective, opened thinking, self confidence, curious, interest, persevere, persistent

attitudes (Departemen Pendidikan Nasional, 2013); b) Some experts (Anderson as cited in Lestari, 2013, Peter, 2012, Johnson as cited in Pertiwi, 2011, Lunenburg, 2011) stated the importance of possessing MCTA by students. The statements among other things are: "Student who think critically will tend to evaluate the truth of received information and to think self-reliantly" (Anderson, as cited in Lestari 2013; "when a student think critically, mathematical content is transformed into mathematical thinking" (Lunenburg, 2011); "Students who are able to think critically are able to solve problem effectively as well" (Peter, 2012); "Critical thinker tends to behave carefully in taking decision, to confess foolishness fastly, to get new information eagerly, to be patient in investigating a proof, to be tolerant on new viewpoint, and to confess the better viewpoint of other people (Johnson, as cited in Pertiwi, 2011).

Those aforementioned argument illustrated that MCTA not only support to improve other mathematical abilities but also to promote positive mathematical disposition such as SRL. Based on some experts' opinion (Ennis as cited in Baron and Sternberg (Editors), 1987, Gokhale, 1995) Hendriana, Rohaeti, Sumarmo (2017) elaborate MCTA indicators as follow: a) To focus oneself on a question; b) To analyze, to clarify, to examine the truth of argument or statement, the truth of solution and process of enumeration; c) To consider trusted resources, to identify sufficiency of data; to identify relevant and irrelevant data; d) To deduce, to induce and to analyze them; e) To formulate explanation, hypothesis, and conclusion; f) To interact with other people. To notice those indicators of MCTA, researcher predicts that for executing a MCTA task students need to possess strong a mathematical disposition such as SRL. Bandura (as cited in Sumarmo, 2006) have three main components, namely: to design self-learning objective; to select strategy; to monitor and to evaluate cognitive and affective processes and to compare them to a certain standard.

Based on ideas of some of experts (Butler, Corno and Randi, Hargis, Kerlin, Paris and Winograd, Schunk and Zimmerman, Wongsri, Cantwell, and Archer as cited in Sumarmo, 2006), then Sumarmo (2006) summarize the indicators of SRL such as: a) to possess intrinsic learning initiative and motivation, b) to perform habit to diagnose learning need; c) to determine learning objective and target, d) To monitor, to manage, and to control her or his learning; e) to consider that difficulty as a challenge; f) to use and to seek relevant sources; g) to choice and to apply learning strategy; h) to evaluate learning process and learning outcomes; i) to possess self concept and self efficacy. Yang (as cited in Sumarmo, 2006) finds that students with high SRL: tend to learn better in their own control, are able to control, to evaluate, and to manage their learning effectively, to save their time in solving their tasks, and to manage their time efficiently.

Those aforementioned above strengthens opinion that (MCTA) and SRL should be improved well on high school students. However, some studies (Kurniati, Kusumah, Sabandar, Herman, 2015, Kusnadi, 2016, Sinurat, 2014, Sumarmo, Hidayat, Zulkarnaen, Hamidah, Sariningsih, 2012, Suheri, 2014, Tamsil, 2015, Widyaningtyas, 2015) found that student's MCTA were still at medium-low level or not conform yet our expectations. This unsatisfying condition motivates researcher to select a certain mathematics teaching approach for improving student's MCTA and SRL accordingly. A kind of mathematics teaching called problem based learning (PBL) has characteristics: a) positioned students as a problem solver through collaborative activities, b) encourage students to solve a non routine problem; c) to facilitate students to explore various alternative information; d) train students to present their findings, and e) accustom students to reflect their thinking when solving a problem.

Rusman (2010) brings up ten main characteristics of problem based learning, as follow: a) A problem as a starting point in learning; b) The problem is real problem and unstructured; c) The problem needs multi perspective; d) The problem should challenge student to think; e) Learning self directed is important f) To evaluate information resources is

essential in problem based learning; g) Learning collaboratively, communicatively and cooperatively; h) Improving inquiry and problem solving skills are as important as mastering a content well; i) Open situation in synthesizing and integrating; j) Problem based learning involves evaluation and reviews on learning experience and process.

There is different role of a problem in PBL and in conventional teaching. In PBL, first problem is presented in the begining a lesson as a starting point for understanding a concept, then for implementing it on other situation, and then for improving other mathematics abilities as well. In conventional teaching, a problem is presented at end of a lesson as excercises of implementation of concept on a specific and broader situation.

Some of studies with high school students reported the superiority of PBL than conventional teaching on improving MCTA (Noer, 2010, Ibrahim, 2011, Ismaimuza, 2010, Sumarmo, Hidayat, Zulkarnaen, Hamidah, Sariningsih, 2012). Those studies reported that the students taught by PBL attained medium grades level on MCTA and those grades were better than the grades of students taught by conventional teaching. Like that, some studies also reported the supperiority of PBL than conventional teaching on improving students' SRL (Rohaeti, Budiyanto, Sumarmo, 2014, Mashuri, 2012, Mulyana and Hendriana, 2015, Sugandi, 2013).

To observe characteristics of PBL, traits of MCTA and SRL, and some findings of superiority of PBL on improving MCTA and SRL, motivate researchers to carry out a study having goals:

- a. To analyze the role of PBL on improving students' MCTA and SRL;
- b. To analyze students' difficulties on solving MCTA;
- c. To analyze association between MCTA and SRL.

METHOD

This study is a pretest-posttest control group design having a goal to analyze the role of PBL on students' MCTA and SRL. The design of this study is as in the following diagram.



Notes:

X: problem-based learning (PBL)

O: pretest and posttest of MCTA test and SRL post-scale

----- : no random sampling

Population of this study are eighth grade students in a MTs in Jakarta and subjects are 60 eighth grade students from two classess selected ramdomly from 6 eighth grade existed classess. The study involves two instruments those are MCTA test anf a SRL scale. The MCTA consists of 6 items which its characteristics as follow: content validity (jugded by conselor- lecturer), item validity (IV); reliability test $r = 0.729$; Discriminat Power (DP) and Difficulty Index (DI); and the SRL scale with reliability $r = 0.899$.

The result of IV, DP and DI is shown in the table 1

Table 1. Recapitulation of the Tryout Test MCTA

| Test number | r | DP | DI | Conclusion |
|-------------|----------------|-------------------|----------------|-----------------|
| 1 | 0.410 (Medium) | 0.333 (Enough) | 0.569 (Medium) | Test Item Valid |
| 2 | 0.748 (High) | 0.736 (Very Good) | 0.590 (Medium) | Test Item Valid |
| 3 | 0.553 (Medium) | 0.278 (Enough) | 0.283 (Hard) | Test Item Valid |
| 4 | 0.734 (High) | 0.437 (Good) | 0.463 (Medium) | Test Item Valid |

| | | | | |
|---|-------------------|----------------|--------------|-----------------|
| 5 | 0.801 (Very High) | 0.274 (Enough) | 0.241 (Hard) | Test Item Valid |
| 6 | 0.806 (Very High) | 0.326 (Enough) | 0.23 (Hard) | Test Item Valid |

In the following we attached sample of MCTA and SRL scale.

Sample of MCTA test

1. Fattah and Zain are shopping at the same store. Fattah buys 2 chocolates and 3 candies for Rp.36.000,00. While Zain buy 3 chocolates and 5 candies for Rp.72.000,00. Determine the price of each chocolate and candy ! Check the truth of your answers and explain it.
2. In an office park, there are some cars and motorcycles. Total number of wheels of the vehicles are 210 wheels. The parking cost of a car and a motorcycles are Rp.5.000,00 and Rp.2.000,00 a day consecutively. Number of motorcycles are more than cars. Determine the maximum costs, and accompanied with your reason.

Sample of SRL Scale Items

| No. | Statement | Very Rarely | Rarely | Often | Very Often |
|-----|---|-------------|--------|-------|------------|
| 1 | Ask to a friend or teacher, when face a difficult problem of Straight Line Equation and System of Two Linear Equations. | | | | |
| 2 | Feel less prepared when face a test of Straight Line Equations and System of Two Linear Equations. | | | | |
| 3 | Try to learn some books for completing a difficult task of Straight Line Equation and System of Two Linear Equations. | | | | |
| 4 | Lazy to recheck solution of Straight Line Equations and System of Two Linear Equations problem has already done | | | | |

RESULT AND DISCUSSION

Description of students' MCTA, N Gain of MCTA, and SRL are attached in Table 2.

Table 2. Description of Students' Mathematical Critical Thinking Ability, Mathematical Self Regulated Learning In both Teaching Approaches

| Variables | Stat | PBL | | | N | Conventional | | | N |
|-----------|-----------|----------|-----------|--------|----|--------------|-----------|--------|----|
| | | Pre-Test | Post-Test | N Gain | | Pre-Test | Post-Test | N Gain | |
| MCTA | \bar{X} | 10.47 | 38.7 | 0.55 | 30 | 10.37 | 33.6 | 0.45 | 30 |
| | % | 16.88 | 62.47 | | | 16.72 | 54.19 | | |
| | SD | 0.2 | 1.62 | 0.31 | | 0.21 | 1.47 | 0.27 | |
| SRL | \bar{X} | | 86.6 | | 30 | | 75.83 | | 30 |
| | % | - | 67.6 | - | | - | 59.24 | - | |
| | SD | | 1.39 | | | | 1.48 | | |

Note:

MCTA: Mathematical Critical Thinking Ability,
 SRL : Self Regulated Learning

Ideal Score: 62
 Ideal Score:128

Based on the data in Table 2, in pretest there was no different grades of students' MCTA in both teaching approaches and both are classified at very low level. But after learning, on MCTA and its Normal Gain, and SRL, students getting treatment with PBL attained better grade than students taught by conventional teaching. However, both students' grades of MCTA were still at low-medium level (62.47% and 54.19% out of Ideal Score), both students' N Gain were at medium grade level (0.55 and 0.45), Like that, on SRL first group students obtained at fairly good grade level (67.63 % out of Ideal Score), and second group students attained at medium grade level (59.24% out of Ideal Score). After testing the normality and homogeneity of relevant data, testing hypothesis of those learning outcomes (posttest and postscale) were attached in Tabel 3.

Table 3. Testing Hypothesis of Mean Difference of Mathematical Critical Thinking Ability, And Mathematical Self Regulated Learning on Both Teaching Approaches

| Variables | Teaching Approach | \bar{x} | SD | n | Sig(2-tailed). | Sig(1-tailed). | Interpretation |
|-------------|-------------------|-----------|------|----|----------------|----------------|--|
| MCTA | PBL | 38.73 | 1.62 | 30 | .022 | .011 < .05 | MCTA _{PBL} > MCTA _{CT} |
| | CT | 33.60 | 1.47 | 30 | | | |
| N-Gain MCTA | PBL | .55 | .31 | 30 | .020 | .010 < .05 | N-Gain MCTA _{PBL} > N-Gain MCTA _{CT} |
| | CT | .45 | .27 | 30 | | | |
| SRL | PBL | 86.57 | 1.39 | 30 | .000 | .000 < .05 | SRL _{PBL} > SRL _{CT} |
| | CT | 75.83 | 1.48 | 30 | | | |

Note: MCTA: Mathematical Critical Thinking Ability
SRL : Self Regulated Learning
Ideal score: 62
Ideal Score: 128

Findings on students' MCTA of this study were similar to findings of other previous studies (Jumaisyaroh, Napitupulu, Hasratuddin, 2014, Kurniati, Kusumah, Sabandar, Herman, 2015, Kusnadi, 2016, Sinurat, 2014, Sumarmo, et.all, 2012, Suheri, 2014, Tamsil, 2015 Widyaningtiyas, 2015) which found that students' MCTA were still at medium-low level or not conform yet to our expectations. However, findings on SRL that was at medium-fairly good grade level of this study was rather different with findings other studies such as (Aminah, 2016, Jumaisyaroh, et.all, 2014, Mulyana and Hendriana, 2015, Qohar and Sumarmo, 2014, Rohaeti, Budiyanto, Sumarmo, 2014, Setiawati, 2014, Sumarni and Sumarmo 2017) that on SRL students obtained at fairly good grade level. Findings of students' difficulties on solving MCTA test were attached in Table 4.

Table 4. Mean Score Of Each Item Of Mathematical Critical Thinking Test of Students In Both Teaching Approaches

| Teaching approach | Stat.Desc | No.1 | No 2. | No.3 | No.4 | No.5 | No.6 | Entirely |
|------------------------------|-------------|-------|-------|-------|-------|-------|-------|----------|
| | Ideal score | 8 | 8 | 10 | 12 | 12 | 12 | 62 |
| Problem Based Learning (PBL) | \bar{x} | 6.57 | 6.83 | 4.83 | 10.33 | 4.83 | 5.33 | 38.73 |
| | % of IS | 82.08 | 85.42 | 48.33 | 86.11 | 40.28 | 44.44 | 62.47 |
| Conventional Teaching | \bar{x} | 5.77 | 4.77 | 4.90 | 9.67 | 3.67 | 4.83 | 33.6 |
| | % of IS | 72.08 | 59.58 | 49.00 | 80.56 | 30.56 | 40.28 | 54.19 |

Based on the data in Table 4, students face difficulties in item numbers 3.5 and 6 which scores less than 60% of the ideal score of 48.33; 40.28; and 44.44 in the PBL and 49; 30.56; and 40.28 in the conventional teaching.

Finding of this study on students' MCTA that was at low-medium grade level illustrated that MCTA test was still as difficult mathematics task. From Table 4, it was found that students faced difficulties on solving MCTA items no. 3.5 and 6 that is about checking the truth of a given revelation and then solving it and composing answers or solving mathematical problems with the reasons. This is because students are not able to analyze and evaluate an information in a matter that berbetuk matter non routine story logically, accurately, broadly, deeply. Students are also less able to express a clear argument. To overcome those students' difficulties teacher should be examined first students' understanding on the prerequisite of mathematics content will be taught. When students' mastering of that prerequisite content were still low so teacher should carry out remedial teaching and then gave various non-routine and different level of difficulties mathematical critical problems, from relative easier and increase to more difficult gradually. Beside that, for reaching better meaningful mathematical understanding, it was suggested to ask students to write mathematical rules, or concept that involved in each step of enumeration.

After teaching-learning process, students' SRL were still at medium-fairly good grade level. This finding actually was rational, caused of for improving SRL or other affective learning outcomes such as value and character education it need longer time. It was different with improving certain mathematical ability. Referring to Sauri's opinion (2010), students' SRL can be improved through four ways namely: a) Be aware of students to the importance of having mathematical SRL; b) teacher should perform having behavior as wished in mathematical SRL, c) students should be accustomed having behavior as wished in mathematical SRL; and d) teacher should carry out integrated and continuous mathematics teaching process.

Finding about association between MCTA and SRL was determined by using Table Contingency as in Table 5

Table 5. Number of Students Based on the criteria of High, Medium and Low Critical Thinking Ability and Self-Regulated Learning on PBL Class

| Critical Thinking | High | Medium | Low | Total |
|-------------------|------|--------|-----|-------|
| High | 4 | 1 | 0 | 5 |
| Medium | 4 | 8 | 0 | 12 |
| Low | 0 | 11 | 2 | 13 |
| Total | 8 | 20 | 2 | 30 |

Then the chi-square test using SPSS 16 obtained by use values Sig = 0.008. Because both groups $\text{sig} < \alpha = 0.05$, H_0 is rejected. This means that there is a significant association between MCTA and SRL of with contingency coefficient $C = 0.562$. It was meant there was fairly strong association between MCTA and SRL. This finding was similar to other previous studies findings (Jayadipura, 2014, Qohar, and Sumarmo, 2014, Tamsil, 2015) that there were association between MCTA with various affective mathematics learning outcomes. But, those findings was different with some other studies (Sinurat, 2014, Sumarmo, et al, 2012, Widyaningtyas, 2015) that there were no association between MCTA with various affective mathematics learning outcomes. Those findings indicated that there were inconsistent findings on the existency of association between MCTA and various affective mathematics learning outcomes.

In this study, despite students' grades on MCTA and on SRL in both teaching approaches still at low-medium grades level, but students getting treatment with PBL performed more active in learning and solving problems in Student Work Sheet compare to students activities in conventional teaching class such as in the following figures.



Figure 1, in PBL class. Students were given real questions then discussed in the group



Figure 2, in PBL class. Teachers provide scaffolding to students about the difficulties students experience independently or in groups in class.



Figure 3, in PBL class. One student presents the solution of a problem in front of the class



Figure 4. In CT class. Students listened to the teacher's explanation and then recorded it in a notebook.



Figure 5. In CT class. Students do the exercises given by teachers.



Figure 6. In CT class. Students explain answers to the exercise questions in front of the class.

CONCLUSION

Based on the findings and discussion, this study derived some conclusions as follow. Problem-based learning took better role than conventional teaching on obtaining and gaining students' MCTA, and on attaining students' SRL. However in both teaching approaches students' MCTA were still at low grade level, students still realized some difficulties on solving MCTA problems namely on about checking the truth of a given revelation and then solving it and composing answers or solving mathematical problems with the reasons. Other conclusion of this study were: on SRL, students getting treatment with PBL attained fairly good grade level, and students taught by conventional obtained SRL at medium grade level; and there was fairly good association between MCTA and SRL. Beside that, students getting

treatment with PBL performed more active learning and solving mathematical problem on Students' Work-Sheet.

For improving better students' MCTA, it is suggested to examine first students' mastering on prerequisite of mathematics content that will be learned, and motivate students to solve various level of problem difficulties. Like that, for reaching better meaningful mathematical critical thinking and understanding, ask students to write mathematics rules or principles that they used in each step of mathematics enumeration. Beside that, for improving better students' SRL, it was suggested four ways as follow: a) Be aware students to the importance of having mathematical SRL; b) Teacher should perform having behavior as wished in mathematical SRL, c) Students should be accustomed having behavior as wished in mathematical SRL; and d) Teacher should carry out integrated and continuous mathematics teaching process.

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