

# IMPROVING STUDENT'S MATHEMATICAL CRITICAL THINKING ABILITY AND SELF REGULATED LEARNING USING OPEN-ENDED APPROACH

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Received: August 5<sup>th</sup>, 2020; Accepted: September 15<sup>th</sup>, 2020

## Abstract

This study is an experiment with pretest posttest control group design having a goal to examine the role of open-ended approach (OEA) on enhancing student's mathematical critical thinking ability (MCTA) and mathematical self regulated learning (MSRL). Sample of this study are 59 seventh grade students from two classes selected randomly from 5 classes in a Junior High School in Garut. Instruments of this study were an essay MCTA test, and a MSRL Likert model scale. The study found on MCTA and on MSRL students getting treatment with OEA obtained higher grades than the grades of students taught by SA. The first group students attained MSCA and MSRL at fairly good grade level, while the second group students obtained at medium grade level, and they still encountered some difficulties on solving MCTA tasks. Besides that, the study also found there is high association between MCTA and MSRL and student performed active learning during OEA lessons.

**Keywords:** mathematical critical thinking ability, self-regulated learning, open-ended approach

## Abstrak

Penelitian ini adalah desain kelas kontrol eksperimen pretest posttest yang memiliki tujuan untuk menguji peran pendekatan open-ended (OEA) pada peningkatan kemampuan berpikir kritis matematika (MCTA) siswa dan kemandirian belajar matematika (MSRL). Sampel penelitian ini adalah 59 siswa kelas tujuh dari dua kelas yang dipilih secara acak dari 9 kelas di Sekolah Menengah Pertama di Garut. Instrumen penelitian ini adalah tes esai MCTA, dan model skala Likert MSRL. Studi yang ditemukan pada MCTA dan pada MSRL yang mendapatkan pembelajaran dengan OEA memperoleh nilai yang lebih tinggi daripada nilai siswa yang pembelajarannya dengan SA. Siswa kelompok pertama mencapai MSCA dan MSRL pada tingkat kelas yang cukup baik, sedangkan siswa kelompok kedua diperoleh pada tingkat kelas menengah, dan mereka masih menghadapi beberapa kesulitan dalam menyelesaikan tugas-tugas MCTA. Selain itu, penelitian ini juga menemukan adanya hubungan yang tinggi antara MCTA dan MSRL dan siswa melakukan pembelajaran aktif selama pelajaran OEA.

**Kata Kunci:** kemampuan berpikir kritis matematis, pembelajaran mandiri, pendekatan open-ended

**How to Cite:** Yulianti, Y., Sumarmo, U., Kustiana, A. (2020). Improving Students Mathematical Critical Thinking Ability and Self Regulated Learning Using Open-Ended Approach. *JIML*, 3 (3), 133-144.

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## INTRODUCTION

Based on observation on teaching-learning mathematics process when we visit to a Junior High School in Garut in 2018, we get following important information (Susanti, Helmi, Resnawati, Yulianti, Hermansyah, Mellyana, Nurwahidah, 2018). Most students were accustomed to learning in small groups. They performed to enjoy to learn mathematics content in student worksheets and complete the problems (Figure 1). Students discussed actively and presented the results of their group work in front of the class voluntary (Figure 2). However, there were few students still having difficulty solving problems accompanied by the formula used, and they asked for help to the teacher (Figure 3).



**Figure 1.** Students accustomed learned in small group



**Figure 2.** Students presented their work in front of the class



**Figure 3.** Students encountered difficulty and asked for the teacher's help

Sometimes, students had difficulty on accompanying the rule used in solving the task in student work sheet. Those student's difficulty pointed out that student had not mastered yet sufficient mathematical critical thinking ability (MCTA). Illustration of low student's MCTA were found as well in some of previous studies (Kurniawati, Kusumah, Sumarmo, Sabandar, 2014, Palinussa, 2013, Retnaningsih & Sugandi, 2018, Sumarmo, Kusnadi, Maya, 2018, Widyaningtiyas, Kusumah, Sumarmo, Sabandar, 2017) that students taught by ordinary teaching attained MCTA at low grade level, while students getting treatment with variety inovative teaching approaches attained MCTA at medium grade level. Apart from the findings above, the positive student's learning behaviour above were in line with findings of some studies (Aminah, Kusumah, Suryadi, and Sumarmo, 2017, Murni & Sugandi, 2017, Qohar, & Sumarmo, 2014, Retnaningsih, & Sugandi, 2018, Romlah, Sumarmo, Syaban, 2018) which detected that by implementing various teaching approaches students obtained mathematics self regulated learning (MSRL) at fairly good grade level. Those findings pointed out that students encountered more difficult to solve MCTA than to perform good MSRL.

Bassically, MCTA and MSRL are important mathematics learning out comes should be mastered by and improved on high school students. At least there are two reasons support that statement. First reason, MCTA is attached in the goal and vision of mathematics teaching (NCTM, 2000, Indonesia Mathematics Curriculum 2013), among other is: to improve student's potency to become a critical, creative, logical, accurate, and innovative individual. Secondly, the reason is in line with Peter's conception (2012) that is: when student think critically, he will solve any problem effectively, he did not accept information without checking its truth, and he worked responsibly followed by logical reasoning. Then, the need for students to have a good SRL is in line with Yang's opinion namely (as cited in Hargis & Kerlin, 1992): students with high SRL tend to learn better in their own control, able to evaluate, and to manage their learning effectively, to save their time in solving their tasks, and to manage their time efficiently.

Some definitions of critical thinking ability (CTA) among other things are as follow critical thinking ability are: a. Ability to clarify some thing accompnied with relevant reason (Fisher, 1995); b. Ability to give reasonable reflective thinking and derive conclusion based on trusted activities (Ennis, as cited in Baron, & Sternberg, (Editor), 1987, and Hassoubah, 2004); c. Ability to decide trustworthy resources, to discriminate relevant and unrelevant data, and to recognize unwritten asumption, happened bias, and viewpoint, (Bayer,2002, as cited in Hassoubah, 2004).

As MCTA task involves HOTS mathematics skill, students need to own good MSRL. Some experts (Butler, 2002, Schunk and Zimmerman, 1998, as cited in Sumarmo, 2006), define SRL in different expressions, but they contain some similar components, namely: to plan self learning objective; to select strategy; and to monitor, to evaluate learning processes and to compare them to a certain standard.

Referring to learning process, Polya (1975) offers that mathematics teacher's task is not only to convey mathematics content but the more important things are: to perform proper behavior to student's condition, to esteem student's thinking, to motivate student to think and to learn better. In addition, Indonesia Mathematics Curriulum 2013 suggests that mathematics hard skill such as MCTA and mathematics soft skill that is MSRL have to be improved run together. When researchers analyze the steps of open-ended approach (OEA) deeply, we predict that OEA will comform to support Polya's and Indonesia Mathematics Curriculum 2013 suggestion. Two studies (Fatah, Suryadi, Sabandar, Turmudi., 2016, Irawan & Surya, 2017) reported the advantages of OEA in developing students' MCTA and geometry learning outcomes.

Those afformentioned arguments and findings stimulate researchers to excecute a study to analyze the role of MTA and student's cognitive stage, on obtaining student's MRA, and MSC and then we compile research questions as follow.

1. Are MCTA grade and its normalized gain, and MSRL grades of students getting treatment with OEA better than the grades of students taught by PBL?
2. What are student's difficulties on solving MCTA tasks?
3. Is there any association between MCTA and MSRL?
4. What are student's activities during OEA lessons?

Besides afformentioned reasons that MCTA should be improved on high school students, there are other reasons namely: a. Students who are used to think critically, they will also be able to solve problems effectively (Peter, 2012); b. Critical thinkers tend to work carefully in getting conclusions, to admit own mistakes, diligently digging for information, to be patient in getting a proof, being tolerant of different views, and to respect the strengths of others ideas (Johnson, 2007).

Further, apart from the notion of critical thinking ability (CTA) have been described, some authors propose the other notions of CTA, namely: a. Critical thinking is process of analyzing, explaining, developing, and selecting ideas, through classifying, comparing, contrusting, testing argument, evaluating induction and deduction, and determining priority (Gokhale, 1995); b. Critical thinking ability is ability to organize and to evaluate a reason systimatcally. (Hassoubah, 2007); c. Critical thinking is a directed process to solve problem, to derive conclusion, and to carry out ascientific reseacrh (Yohnson,2007); d. Mathematical critical thinking is ability to combine ability, disposition, initial knowledge, strategy and reasoning ability, to obtain conclusions, and to assess mathematical situations (Glazer, 2002)

Based on those experts' conception on MCTA, then Hendriana, Rohaeti, Sumarmo (2016) summarize indicators of MCTA as follow: a. To analyze assumption of an argument; b. To examine the truth of argument, statement, and or process of enumeration; c. To formulate questions, explanation, and to derive conclusion based on given information accompanied with rational reasoning; d. To identify relevant and irrelevant data or information of a mathematics problem; e. To compile answer or to solve mathematical problem accompanied logical reasoning; f. To interact with other people.

Some authors define SRL more detail as follow: a. SRL is designing and observing self learning process carefully toward cognitive and affective process in completing an academic task (Hargis and Kerlin, 1992); b. SRL is ability to observe self behaviour such as to assess own-self, to determine learning goal; to accustome to work hard (Bandura as cited in Hargies, and Kerlin, 1992), c. SRL is learning process influenced by thinking, feeling, strategy, and own behaviour that oriented to a realizing goal (Schunk and Zimmerman 1998); SRL is a recursive cognitive activities cycle that holds to analyze task, to choose, to adopt, or to invent strategy for obtaining the goal of the task, and to monitor learning out comes; d. Other term of SRL namely self-direction on learning (SDL), that is self-regulation in designing, implementing, and assessing their own learning (Wongsri, Cantwell, Archer, 2002).

There are some suggestions for improving student's SRL among other are: a. Help student to execute the cycle of SRL flexibly and adaptively (Butler, 2002, as cited in Sumarmo, 2006); b. Create conducive learning environment and avoid irrelevant student's activity; help students to manage their time; promote self confidence for being uneasy panic (Schunk, 1994, as cited in Sumarmo, 2006); c. Make student realize on the meaning and the importance of having SRL; Perform teacher to behave the wished SRL attitude; Familiarize students to behave the wished SRL attitude; Carry out integrated and continous mathematics teaching-learning process (Sauri, 2010); d. Setting short and long term goal, planning self managing, promoting own self motivation, developing own attention control, executing flexible strategy, carrying out self monitoring, trying help seeking, and performing self evaluation (Zumbrunn, Tadlock, and Robert, 2011).

Shimada and Becker (1997) clarify that OEA is an approach which offer students more opportunity to acquire new knowledge and learning experience, by presenting non routine and open problem. Students should complete the problem by using various strategies to obtain more than one solutions. Sawada (1997) detailes the notion of openness of a problem into three kinds namely: processes are open, solutions or answers are open, and methods of the task are open. The open process means that the task has many correct startegies to complete it. Secondly, solutions or answers are open indicate that the problem has some right posible answers or solutions. Then the last, open methods refers to when students have executed the previou task correctly, then they able to modify the begining task situation into a new condition task and then they able to finish it. Considering to the afformentioned traits of OEA, researchers predict that OEA suitable with Polya's and Indonesia Mathematics Curriculum 2013 suggestion, that is OEA give opportunity to the students for improving their creative and critical thinking abilities as well.

Aside from the study findings that have been previously reported, in the following we reported several results of other studies. Two studies (Akhmad & Rohaeti 2018, Anggraeni, Sylviana, Hendriana, 2018) reported advantages of OEA on student's mathematical communication and creative thinikng abilities. Other studies (Fatmawati, 2014, Nurina, 2014, Rahmawati, Rohaeti, Yuliani., 2018, Tresnawati, Hidayat, Rohaeti, 2018) by using variety teaching approaches reported that students obtained MCTA at medium grade level.

As well as, other studies (Mulyana, & Hendriana, 2015, Rahmawati, Rohaeti, Yuliani. 2018, Romlah, Sumarmo, Syaban, 2018, Sumarni & Sumarmo, 2017) attained student's MSRL at medium up to fairly good grade level. Seemingly, students getting various teaching approaches still encountered some difficulties in solving MCTA tasks, but they didn't experience difficulties on behaving MSRL.

**METHOD**

This research was a pretest-posttest experiment with control group design having a goal to analyze the role of open-ended approach (OEP) on students' mathematical critical thinking ability (MCTA) and mathematical self regulated learning (MSRL). The study involved 71 seventh grade students, MCTA test, and MSRL scale. The instruments were compiled specifically for this study. Before the instruments were implemented researchers tried out them to students who had learned mathematics content of the MCTA test. Further, by using Hendriana and Sumarmo (2014) and Sumarmo (2015) as references researchers obtained description of MCTA test, MSRL scale, as attached in Table 1.

**Table 1** Description of MCTA test , MSRL Scale

Instruments	n Subyect	n Instru-ment	Reliability	Item Validity	Difficulty Index	Discriminat Power
MCTA test	59	5	.68	.51 – .70	.50 - .66	.27 - .47
MSRL scale	59	30	.90	.34 – .91	-	-

In the following, we attached some samples of instruments of this research.

**Sample 1.** Mathematical critical thinking ability item test:

The length and width of a rectangle ABCD is 30 cm and 20 cm. The edges of the rectangle are cut along x cm to form a new rectangle of PQRS. Perimeter of PQRS no more than 52 cm. We will calculate the range value of x.

- a. Skets the rectangle ABCD and rectangle PQRS. Complete the figures with elements that are known and asked.
- b. Compile mathematical model for determining the range value of x. Write concept involved in the model.
- c. Solve the model and write processes in each step of the completion.

**Tabel 2.** Some statements of MSRL Scale

No	Statements	SA	A	DA	SDA
1.	I look for additional practice problem caused of my own will				
2.	I try to find out my own weaknesses in learning System of liniear Equation of two variables. (SLETV)				
3.	I think to learn SLETV without targets will ease the learning burden				
4.	I wait for teacher's help when I face difficulty to solve SLETV problem				





MSRL \ MCTA	High	Medium	Low	Total
High	8	0	0	8
Medium	0	14	2	16
Low	0	0	6	6
Total	8	14	8	30

Calculation results obtained  $\chi^2$  value was 49.688<sup>a</sup> with sig. .000 smaller than  $\alpha = 0,05$ . It showed that there was high association between MCTA and MSRL with contingency coefficient C= 0,760 or Q = 0,931.

**Discussion**

Finding on association of this research was similar to findings of other studies (Aminah, Kusumah, Suryadi, Sumarmo, 2017, Qohar, & Sumarmo, 2014, Rohaeti, Budiyo, Sumarmo, 2014, Sopian, Sabandar. 2018, Sumarni & Sumarmo, 2017) which reported there were association between MSRL with variety of mathematics hard-skill. However, those findings was different with finding of other study (Romlah, Sumarmo, Syaban, 2018) that detected there was no association between mathematical problem solving ability and mathematical habits of mind. Those findings pointed out that the existance of association between mathematical hard-skill and soft-skill was inconsistent.

Apart from those findings, the research also detected that students performed to be pleasure during the OEA lessons and students posed potitive opinion on Open-ended Approach (OEA) lessons such as: OEA motivate students to look for variety answer in solving an open-ended problem (Figure 1), OEA encouraged students to work together in small group discussion (Figure.2), and to be dared to explain group assignments in front of the class (Figure 3).



**Figure 1:** Students actively learning in small group



**Figure 2:** Students solved open-ended problem individually



**Figure 3:** Students presented their work in the front of the class

**CONCLUSION**

Open-ended approach (OEA) took better role than the role of saintific approach (SA) on improving students' MCTA and MSRL. On MCTA and MSRL, the grade of students getting treatment with OEA was at fairly good grade level, while the grade of students taught by SA was at moderate grade level. Students of both classes still experienced difficulties on solving MCTA tasks.

The other conclusion were: there was high association between MCTA and MSRL and students performed active learning, solved problem on students worksheet enthusiastically, and they were dare to present their work in front of the class during Open-ended Approach lessons.

In order to improve students' MCTA, students should be accustomed to solve problems accompanied with rules and process used in each step of the enumeration, and to practice to examine the truth of process in each step of enumeration. Further to improve students' SRL, it was suggested that students should be accustomed to manage their own learning, to examine their own learning outcomes and compare to certain standard, to work in small group, and not easily give up facing difficult problems.

### **ACKNOWLEDGEMENTS**

Thank you to Mr. Sunaryo, S.Pd., M.Pd., as the Headmaster of SMPN 3 Tarogong Kidul Garut and all staff who have given permission and provided support both morally and materially in conducting this research activity. And to friends of the Postgraduate Mathematics IKIP Siliwangi 2018-2019.

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