The relationship between self regulated learning and mathematical creative thinking ability

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Abstract. This study aimed to analyze the relationship between students' Self Regulated Learning (SRL) and Mathematical Creative Thinking Ability (MCTA). A quasi experimental was applied in this research. The sample consisted of 173 eighth grade students taken from high and medium level schools in Indramayu, West Java province, Indonesia. The sample was divided into three groups with three different learning models. One group used the 5E Learning Cycle model with metacognitive techniques (LCM), and the other two groups each used the 5E Learning Cycle (LC) and Conventional Learning (CL) models. The data were collected through test of MCTA and SRL scale. The results of the study concluded that there is a significant positive correlation between SRL and MCTA. There is a strong correlation between students' SRL and MCTA in group with the LCM model, meanwhile in groups, with LC and CL model the correlation in the medium level.

1. Introduction
Self-regulated learning (SRL) is an important component of education [1–3]. According to [4], SRL is a constructive and active process in which students determine their learning goals, try to monitor, regulate, and to control cognition, motivation, and behavior by being guided and limited by contextual goals and characteristics in the environment. SRL refers to the self-directive processes and self-beliefs that enable learners to transform their mental abilities [5]. According to Zimmerman, SRL contains a process of monitoring learning activities, evaluating learning outcomes, or difficulties in learning and adjusting [6]. The management thoughts, emotions, behaviors and their environments carried out by self-regulated learners to reach their learning goals that will bring up their creative ideas.

Creative thinking ability is very important to be developed in the 21st century [7]. However, from the results of the 2015 PISA study about student achievement in mathematics is still low. In addition, the result study from the 2015 TIMSS, according to Rahmawati cited in [8], the high-order thinking abilities of students still need to be improved.

Creativity is the ability to generate ideas for original ideas or the ability to develop new solutions to problems in a particular context [9,10]. According to Guilford, components, divergent production includes fluency, flexibility, originality. Another component is sensitivity to the problem and evaluation in developing and evaluating creative ideas [11].

Meanwhile, creativity in mathematics according to Haylock, Jensen, Kim, et al. as explained by [12] involves components of fluency, flexibility, and originality. fluency is the ability to generate many ideas, flexibility is the ability to solve problems in a variety of approaches or different ways, and originality is the ability to come up with new and unique ideas. Furthermore, according to Holland in [12], some components of mathematical creative thinking are fluency, flexibility, originality, elaboration, and
sensitivity. Thus the aspects of sensitivity, fluency, flexibility, and originality in solving problems will be owned by students who have mathematical creative thinking ability.

Based on consideration of the importance of SRL and the ability to think creatively for students, knowledge of the relationship between these two aspects is needed. This knowledge can be used as a teacher’s reference in determining learning models to improve students’ SRL and creativity. Therefore a study of the correlation between SRL and creative thinking ability needs to be done.

The correlation research between SRL and creative thinking ability is still limited. The research has been reported by [2,13,14]. The other researchers reported a correlation between SRL and some students’ mathematical abilities [15–18]. Meanwhile, [19,20] showed that there is no correlation between students’ SRL and mathematical abilities.

Lack of previous studies in the research area, researchers are encouraged to conduct a study of the correlation between SRL and MCTA of junior high school students. More specifically, the correlation between SRL and MCTA will be examined among students who use the 5E Learning Cycle model with metacognitive techniques (LCM), students who use the model 5E Learning Cycle (LC), and students who use conventional Learning (CL).

The LC model has five stages, engage, explore, explain, elaborate, and evaluate [21]. LCM is a learning model that integrates metacognitive techniques into LC. The metacognitive techniques are used is self-asking. The question focuses on three categories adapted from Beeth, namely intelligibility, wide-applicability, and plausibility [22]. In this study, LCM was chosen as the model because of the various advantages of the model. In addition, the study that examining the correlation between SRL in mathematics and students MCTA using the LCM model is still limited.

In this study the correlation between SRL and MCTA was carried out on different learning models. This aims to further convince researchers about the presence or absence of the relationship between SRL and MCTA and to see the strength of the relationship.

2. Method
The quasi-experimental was employed with a pretest-posttest control group design. The population in this study were junior high school students in Indramayu, West Java. The researchers used 173 eighth-grade students from schools representing high and medium level schools as sample of this study. The school selection was carried out randomly from all the junior high schools in Indramayu, Indonesia. From each school level, three classes were chosen randomly, one class using LCM, another one class using LC, and the other class using CL.

LC stages in this study referring to the stages proposed by [21]. The first stage of learning process with the LC model that is, when the teacher engages in presenting problems or questions related to the concepts to be learned by students. In the exploration stage students in groups explore and other activities to find new ideas or find formulas, while the teacher acts as a facilitator. In the explanation stage, students explain their findings or understanding to other students. Next, the teacher gives reinforcement or clarifies the explanation. In the elaborate stage, students work on exercises both for understanding and expanding concepts. At the evaluation stage, the teacher gives a test. In the LCM model, some of the questions students asked themselves were, “What concepts that can be used to solve this problem?”, Should I believe this idea? "Am I able to understand the concept?" whether a problems in daily life can be solved by the concepts that I have learned?”

In this study, the researcher used the SRL scale and MCTA test as the instrument to collect the data. SRL scale consists of 42 valid items. The SRL indicator is based on the opinions of Butler, Corno and Randi, Kerlin, Paris and Winograd, Schunk and Zimmerman, Wongsri, Cantwell and Archer, and Sumarmo as explained by [19]. These indicators are: a) Initiative and motivation for intrinsic learning; b) The habit of diagnosing learning needs; c) Setting the learning goals; d) Monitor, organize and control learning; e) View difficulties as challenges; f) Utilize and find relevant sources; g) Selecting, implementing learning strategies; h) Evaluating the process and learning outcomes; i) Self-efficacy.

MCTA test was valid and reliable with a reliable coefficient r = 0.91. The test measures aspects of creative thinking ability as explained by Guilford in [11] and Holland in [12].
3. Result and Discussion

From the results of data analysis, the achievement of students' SRL and MCTA is presented in Table 1.

| Learning Model | Number of Students | Average Score of MCTA | Average Score of SRL |
|----------------|--------------------|-----------------------|----------------------|
| LCM            | 56                 | 41.16                 | 158.32               |
| LC             | 57                 | 34.35                 | 152.42               |
| CL             | 60                 | 26.83                 | 145.32               |

The maximal ideal score of MCTA is 56
The maximal ideal score of SRL is 222

Based on Table 1, students who used LCM and LC have better SRL and MCTA than students who used LC and CL. Students' SRL and MCTA who used LC are better than students who used CL. This is possible because LCM as a model that integrates metacognitive techniques on LC. LCM models have various advantages, according to [23], metacognitive strategy training applied to the achievement of mathematical problem solving.

Table 1 showed that the higher of the mean SRL score. It also the higher of the MCTA score. Furthermore, data analysis was performed using the Tau Kendal correlation with the interpretation of the correlation coefficient based on the interpretation of [25]. At the 0.01 significance level, the results of data analysis are presented in Table 2.

| Learning Model | The Correlation Coefficient (r) | Level of Correlation |
|----------------|---------------------------------|----------------------|
| LCM            | 0.61                            | Strong               |
| LC             | 0.41                            | Medium               |
| CL             | 0.51                            | Medium               |

Table 2 shows that the group of students who used LCM model, SRL and MCTA had a stronger level of correlation compared to the correlations in the other two groups. In general, there is a significant positive correlation between SRL and MCTA.

The results of this research are in line with the results of previous studies. There was correlation between creativity and self-regulation for grade nine students [2]. There is a sufficient association between the mathematical creative thinking ability of senior high school students and SRL [13]. Mathematical creative thinking ability of senior high school students is positively influenced by SRL[14]. There was a correlation between mathematical reasoning ability and SRL [15,16]. SRL influences students mathematics achievement [17]. SRL influences the ability of problem solving [18]. However, some studies showed different results from this study. There were no associations between mathematical abilities and SRL [19]. There was no correlation between mathematical logical thinking ability and SRL [20].

In line with [17], highlight that self-regulated learners will manage their thoughts, behaviours, and emotions to achieve success in their learning. Andreasen and Press in [2] argued that a self-organizing system created a creative cognition. A self-regulating system is one component of self-regulation [1]. Regarding this opinion, someone who has self-regulated learning will always enact arrangements about what he will do. Additionally, they will extend the ways to solve the problem. At the same time, a creative process for generating new ideas requires the presence of students' SRL.

The ability to think creatively is characterized by the ability of students to produce something new and solve problems from a variety of different perspectives. These abilities will be supported by the availability of various relevant sources that can inspire students to produce creative ideas. In a creative
process according to Wallas's theory as explained by [26], preparation is the initial stage of the process. Someone prepares to solve problems by learning to think, find answers, ask others, and other activities in order to find and collect information. The preparation process will run better if supported by active student involvement in the process. Student in high -SRL will be able to do the process well. This is in line with Clarebout, Horz, and Schnotz as explained by [27] that self-regulated learners seek out additional resources. Furthermore, according to Kolovelonis, Goudas, and Dermitzaki in [27] to meet their needs, these learners manipulate their learning. At the verification stage as the final stage in the creative process as explained by [26], creative ideas that emerge must be tested against reality. Therefore, at this stage the use of self-assessing, self-directing, controlling and adjusting skills is needed. In addition, based on the results of their research [27] stated that self-regulation is important in the creative process.

Meanwhile, Treffinger in [28] states that the creative person is usually more organized in action. Their innovative plans and original products have been carefully thought out in advance by considering their impact. The existence of organized action indicates the self-regulation of students. In other words, the creative person always goes through the process of self-regulation to get the original product. In line with the results of research experts as explained by [28] shows that the characteristics of people who have the ability to think creatively that is sturdy in the establishment, have curiosity, independent in thinking and considering, resilient, do not take the opinion of the authorities for granted. These characteristics are in line with indicators or characteristics of students with high-SRL as explained by [19]. This shows the relationship between SRL and the ability to think creatively.

Furthermore, the results of students' answers on the MCTA test showed a correlation between students’ SRL and MCTA. For example can be seen from students' answers to one of the given problem in the MCTA test as presented in Figure 1.

![Figure 1. Problem in the MCTA test with translation](image1.png)

Example of the answers from student in low-SRL and student in high-SRL is presented in Figure 2.

![Figure 2. Examples of the answers from student in low- SRL (left) and student in high-SRL (right)](image2.png)
Figure 2 shows that student in low- SRL cannot answer the problem. Meanwhile, student in high-SRL can draw Right-angled triangles in a variety of different ways that indicate flexibility and fluency in thinking. Right-angled triangles made by the students show the originality aspect of thinking. In other words, the answers of student in high-SRL show the existence of higher creativity compared to student in low-SRL.

4. Conclusion
There is a correlation between SRL and MCTA. In groups with the LCM model, there is a strong correlation between students’ SRL and MCTA. In groups with LC and CL models, the correlation between students SRL and MCTA is only in the medium level.

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