Self-Regulated Learning for Creative Mathematics Teaching to Secondary School Students Through Mobile E-Learning Applications

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Abstract—This study aims to determine the effect of self-regulated learning (SRL) on creative mathematics teaching through the "zoom" mobile e-learning applications. SRL is learning that refers to activities to control and regulate the learning process independently of students to find creative ideas. This quantitative research uses a quasi-experiment approach. Participants in this study were 53 students at a secondary school in Malang, Indonesia. Participants were divided into two groups, namely 26 students in the experiment group and 27 students in the control group—the grouping was based on the purposive random sampling technique. The design of this study used the Nonequivalent Pre-Test and Post-test Control-Group design because the implementation of SRL was only for the experimental group and the control group implied the conventional strategy. Still, both groups were given pre-test and post-test. The data analysis technique used t-test independent analysis to determine the effect of self-regulated learning on creative mathematics teaching in mobile e-learning applications. Data analysis using SPSS 23 application. The results show that the implementation of self-regulated learning provides success for creative mathematics teaching through the "zoom" mobile e-learning applications, where students offer many creative solutions for various forms of cube nets. This study suggests that educators consider implementing SRL strategies to increase students' creativity in the "zoom" mobile e-learning applications.

Keywords—teaching mathematics, creativity, self-regulated learning, secondary school students.

1 Introduction

Mathematics plays an essential role in the cognitive development of students. Rajab et al. (2021) research state that the different students' mathematical abilities affect their cognitive style [1]. The students' mathematical abilities positively affect the development of their cognitive competencies [2]. The higher the students' cognitive level, the higher the success rate of students' mathematical thinking [3]. The success in mathematical thinking is shown in students' mathematical achievements. Students' mathematics achievement is positively correlated with an increase in self-regulation and intrinsic motivation [4], especially in secondary school students.

However, mathematics is a learning that is still difficult for secondary school students to accept. Kosel et al. (2021) revealed that most secondary school students are not interested in mathematics [5]. The disinterest in mathematics is caused by the low interest of students in mathematics. Students' low interest in mathematics can be increased through creative learning that involves increasing motivation, cognitive support, and independent learning behavior [2], [6]. In fact, creative learning is also tricky to manifest in distance learning. Songkram (2015) and Tønnessen et al. (2021) said that the success of creative learning requires supporting factors from the use of technology, especially in mobile e-learning applications [7], [8].

Several studies [9]–[13] have used mobile e-learning applications as the primary medium in increasing students' competence in acquiring new concepts. Acquiring new ideas and concepts often refers to creativity [14], [15]. On the other hand, research by Gede Putra Kusuma (2021) states that the use of mobile e-learning applications requires other supporting factors to improve students' learning outcomes. This study suspects that other supporting factors can affect the implementation of creative learning. On the other hand, creative learning can be developed by independently controlling learning behaviour and performance [16]. The main dimensions of self-regulation are controlling behaviour, thinking, performance, and self-reflection [17].

Research related to self-regulated learning, which refers to creative learning to get new ideas, has been reviewed by several studies, including self-regulated learning supports adaptive abilities and flexible actions to get original ideas [18]; students' higher-order thinking [19]; and improving students' understanding [20], [21] during the learning process. However, research by Capron Puozzo & Audrin (2021); Liu et al. (2021); Moham-madi Orangi et al. (2021); Porter & Peters-Burton (2021); Tu (2021); Xu et al. (2021) has not proven that SRL has an effect on the success of creative learning ([2], [18], [20]–[23]). In addition, the material objects of these studies ([20], [21], [23]) are non-mathematical. On the other hand, participants in Porter and Peters-Burton's research (2021) are teachers [23], and participants in research by Liu et al. (2021); Mohammadi Orangi et al. (2021); Tu (2021); Xu et al. (2021) are college students with abstract thinking patterns ([2], [18], [20], [22]). Abstract thinking is the primary basis for thinking at the highest level, namely creative thinking [24]. On the other hand, the participants in this study were secondary school students aged 13-15 years, and the participants' thinking patterns were concrete. Piaget (in Solso et al., 2008) stated that students' thinking in concrete cognitive patterns is not yet possible for complex thinking and creative thinking [25].

Overall, the fundamental problem in this research is the success of creative mathematics teaching to middle school students with concrete thinking patterns through self-regulated learning using mobile e-learning applications. Creative learning has been applied in several studies for participant cases with abstract patterns, but this research is aimed at participants who are still at the level of concrete thinking to be creative by using self-regulated learning. Thus, this research contributes knowledge to the community, especially educators in the world, so that they consider self-regulated learning in every creative mathematics teaching plan. Therefore, this research is original and essential, so this study aims to determine the effect of self-regulated learning (SRL) on creative mathematics teaching to secondary school students through the "zoom" mobile e-learning applications. Based on the research objectives, the research questions are as follows.

1. How is creative mathematics taught to secondary school students through the “zoom” mobile e-learning implementations without self-regulated learning?
2. How is creative mathematics taught to secondary school students through the “zoom” mobile e-learning implementations after the implementation of self-regulated learning?

2 Literature review

This study aims to identify the effect of implementing self-regulated learning (SRL) in creative mathematics teaching to secondary school students.

2.1 Self-Regulated Learning (SRL)

SRL is a new learning strategy approach that effectively improves student learning performance [26]. SRL refers to learning involving students' beliefs, motivation, cognition, and self-regulation [27]. In SRL, students reflect on previous knowledge development and find new ideas to improve their higher-order thinking skills [23]. Higher-order thinking with the highest level is creative thinking [24]. Developing SRL strategies for increasing creative thinking is very effective learning [20].

Several studies examine the SRL strategy. SRL strategy is a cognitive learning approach that actively controls Learning [28]. SRL strategy can be said to be an effective learning strategy to improve the performance of complex tasks through an independent evaluation and adaptation process [29]. SRL is also professional teaching that applies reflection and guides students to new ideas [23]. SRL strategy in solving complex problems can awaken students' creative process [19]. This follows the opinion of Mohammadi Orangi et al. (2021) that learning strategies that lead to self-regulation can increase adaptive abilities and flexible actions that produce more original and creative ideas [18].

However, research by Van Alten et al., (2020) states that students cannot imply self-regulated learning [30]. Muwonge et al. (2020) state that 12.5 percent of students show low self-regulated learning [31]. This is because mastery of self-regulated learning takes a long time [32]. This shows a contradiction. Therefore, this study investigates the effect of self-regulation on creative mathematics learning.

2.2 Creative thinking and creative learning

Creative thinking refers to higher-order cognitive resources by generating responses or ideas that are original and useful [33]. *Creative thinking* is a cognitive process directed at spontaneous and original thoughts through open-ended questions [14]. When thinking creatively, individuals reflect on the experience of knowledge in reality to find original ideas [34]. So, creative thinking is supported in effective creative teaching and learning.

Creative learning is currently a demand in the development of modern education. Research by Ayyildiz and Yilmaz (2021) encourages teachers to create creative learning to improve the creative behavior of students [16]. Creatively designed learning can improve the production process of students' creative ideas [15]. Creative learning that involves self-regulation to solve problems in heterogeneous group discussions positively improves students' academic performance [35]. Creative teaching also has an effect on increasing students' creative thinking and psychomotor excellence. Creative learning links students to finding and generating new ideas [36] But, creativity learning requires supporting factors from the use of technology [7], [8]; for example, mobile e-learning applications. Therefore, this study predicts that mobile e-learning applications can support the success of creative learning.

2.3 The use of 'Zoom' mobile e-learning applications

The use of technological devices is the primary model in distance learning in the context of the digital world [10]. One of the developments of technology tools in teaching is the development of mobile e-learning applications. Research by Nawaila et al. (2022) and Papadakis et al. (2021) state that the design of digital literacy mobile applications is effective for creative e-learning for children [9], [37]. Innovative and creative mobile applications aim to measure competence and acquire new concepts [11]. The development of mobile applications is a medium and tool to support the teaching process [12], [38]. This contradicts the research of Kusuma et al. (2021), namely, the use of mobile applications from learning platforms requires other supporting factors so that these mobile applications can contribute to improving student learning [39].

Based on the contradiction regarding the need for supporting factors, creative learning positively correlates with academic performance [35]. Creative teaching improves student performance control [16]. In addition, creative teaching can affect students' psychomotor and thinking excellence [40]. The process of controlling performance, self-regulating thinking, and self-reflection are core dimensions of self-regulated learning [17]. The issues from the above studies refer to the presumption of the positive contribution of self-regulated learning to creativity lessons.

2.4 SRL strategy in creatively mathematics learning

The research related to implementing the SRL strategy in creatively mathematics learning is explicitly examined in the literature. Research by Leo & Muis (2020) states that self-regulation learning strategies can help students regulate their cognition independently and find new ideas to solve mathematical problems successfully [41]. The success of mathematical problem solving is based on the positive and original setting of students' motivation, beliefs, perceptions, and cognitive support [3]. Li et al. (2020) state that self-regulation in the learning process is a profile of SRL application [42]. SRL describes individual student behavior that encourages learning and the discovery of new ideas [26]. Learning that involves the function of self-regulation can integrate students' creative thinking with complex mathematical understanding [6], [43], [44]. Huang and Lee (2015) state that the role of creative learning depends on the self-efficacy and self-regulation of students [45].

The development of creatively learning strategies needs to be considered by teachers so that students are more independent in determining original ideas [46]. Creatively learning requires intervention to improve students' higher cognitive abilities [47]. Creatively learning strengthens students' knowledge, understanding, and creativity [48]. A creatively learning environment positively impacts students, where students are free to give their perceptions in an original, flexible, imaginative, and unprocedural manner [49]. Capron Puozzo & Audrin, 2021; and Taneri & Dogan (2021) stated that learning designed to increase students' creativity by self-regulation during the learning process to find new ideas could provide creative results and a better understanding of the material [21], [50]. The studies above have not proven the impact of the SRL strategy implementation for teaching mathematics creatively, especially for secondary school students. We know that secondary school students are in a concrete thinking pattern that contrasts with higher-order thinking, such as creative thinking [24]. So, this contradiction will be the basis of this research stated in the research question; namely, this research wants to determine whether self-regulated learning affects the success of creative mathematics lessons? Other studies have never investigated this research, and this research can contribute knowledge information for the community and educators, where this information considers educators to use self-regulated learning in the preparation of creative lesson plans for secondary school students.

3 Methodology

3.1 Study design

This study is a quantitative study with a quasi-experimental approach (Azwar, 2008), because this study divided participants into two groups: the experimental group and the control group. The experimental group applied self-regulated learning (SRL) through mobile e-learning applications, while the control group applied the conventional learning strategy. This research design used the Nonequivalent Pre-Test and Post-test Control-Group design [51], where the control group and the experimental group received pre-test and post-test. Pre-test to test students' initial creativity, and post-test to examine the effect of self-regulated learning on students' creativity. This test will refer to research questions about testing the success of creative mathematics teaching to secondary school students through the "zoom" mobile e-learning applications.

3.2 Participants

The participants in this study were 53 secondary school students from state secondary school 1 Turen Malang (initials of school name = school T) and private secondary school Santa Maria II Malang, Indonesia (initials of school name = school S). Participants are second-year secondary school students. Participants in each school were divided into two groups, namely 26 students in the experimental group and 27 in the control group. The purposive random sampling technique was used in this study because the selection of the participants was based on the objectives and research questions, namely junior secondary school students aged 13-15 years in the second study year, and they used "zoom" mobile e-learning applications. The group distribution of each school is shown in Table 1.

Table 1. The distribution of the experiment group and control group

	Experiment Group	Control Group	Total
School-T	14	13	27
School-S	12	14	26
Total	26	27	53

3.3 Research procedure

The research procedure consisted of five stages. The first stage is school observation, research permits for school principals and teachers, and selecting participants based on suggestions from classroom teachers that were adapted to the research objectives. Research permits were obtained in writing and orally. The second stage is the implementation of the pre-test for all participants. The third stage is the implementation of self-regulated learning for creative mathematics teaching to secondary school students through "zoom" mobile e-learning applications. Learning was carried out synchronously for eight weeks for all study participants. One week consists of one meeting, so this research consists of eight meetings. These eight meetings did not include the pre-test and post-test because the pre-test and post-test were conducted outside of these eight meetings. The pre-test was conducted one week before the first meeting, and the post-test was conducted after the eighth meeting.

All experimental and control group participants studied the same material, namely geometry. The material for the first and second meetings is related to the material of cube nets and the basic concept of a cube. The material from the third, fourth, and fifth meetings is the net of blocks and the basic concept of blocks. The material from the sixth, seventh and eighth meetings is prism nets and the basic concept of prisms.

Participants in the experimental group applied a step-by-step SRL adapted from [17]. The SRL stages in this research are the forethought and planning phase, the performance monitoring phase, and the reflection phase. In the forethought and planning phase, the teacher motivates students through open-ended questions, and students analyze the open questions creatively. In the performance monitoring phase, students are divided into six small groups, each consisting of 4-5 students. In groups, students discuss with each other; students organize their learning independently in study groups, issue new ideas, and combine ideas from each individual to become new ideas. In the reflection phase, students re-evaluate the results of their discussions with presentations to all students in the class. At the end of the lesson, the teacher and students conclude the geometrical material learned during mathematics e-learning.

Research participants in the control group did not imply the SRL strategy and only applied lecture-based learning. The control group did not form a study group; they only listened to the teacher's explanation through the PowerPoint slide. Learning also seems passive because students only listen and answer questions procedurally.

The fourth stage is the implementation of the post-test. In this study, the results of the pre-test and post-test of the experimental group and the control group were compared to identify the effect of implementing self-regulated learning (SRL) in creative mathematics teaching to secondary school students. The fifth stage is data analysis, and the sixth stage is the conclusion of the research results.

3.4 Measurement of research instruments

The measurement instrument consists of two domains, namely (1) creativity pre-test; and (2) post-test creativity. The pre-test and post-test questions consist of three questions that are adjusted to the creativity dimensions of Torrance (1968) [52], namely fluency, flexibility, and originality. Fluency shows many answers, flexibility shows many different ways, and originality shows unusual answers. The description of the test questions is shown in Table 2.

Table 2. Description of test questions

Aspect of Creativity	Description of Pre-test and Post-test Questions
Fluency	Mention as many nets as possible with a certain area
Flexibility	Mention the number of problem-solving strategies from each of the nets formed
Originality	Mention the nets of a different shape with their friends

Pre-test and post-test through validity test. Validity test using expert judgment. Four expert validators validated the pre-test and post-test, namely two expert mathematics education lecturers, one class teacher at school T, and one class teacher at school S. The validation assessment used a questionnaire of two domains: grammar assessment (five items) and material assessment (four items). All items were evaluated using a five-point Likert scale, i.e., 1 (very low) to 5 (very high). Items from the Validation Questionnaire are shown in Table 3. Meanwhile, the description of the test items is shown in Table 3.

Table 3. Items of validation questionnaire

Material Assessment	The question material about geometry follows the secondary school education curriculum in Indonesia
	Material questions according to essential competencies
	The question material about geometry follows the learning objectives
	The question material refers to every aspect of creativity
Grammar assessment	The language of the questions is easy for readers to understand
	The spelling of the language of the question according to the rules of proper writing

	The layout of the text and images is correct
	The type and size of the font used are easy to read
	The layout of the illustrations does not interfere with the writtepresentation of the questions

Validation results were analyzed using the Aiken V index through the MS.Excel application. Aken V index of pre-test questions = 0.75 > 0.6; while the Aken V index of the post-test questions = 0.83 > 0.6. This indicates that the pre-test and post-test items are valid for use by participants in the study.

3.5 Data analysis

Data analysis consists of three activities. The first analysis activity is to identify the normality of the test data (pre-test and post-test). The normality test of the test data was analyzed using the Kolmogorov-Smirnov test in Table 4.

Table 4. Kolmogorov-Smirnov test

		Unstandardized Residual
N		53
Normal Parameters[a,b]	Mean	.000
	Std. Deviation	1.578
Test Statistic		.176
Asymp. Sig. (2-tailed)		.200

Table 4 shows that the number of participants (N) = 53; mean .000; Std. Deviation = 1578; test Statistics = .176. Sig. (2-tailed) = .200. Due to Sig. (2-tailed) = 0.200 > 0.05, then the data is said to be normally distributed. The normal distribution is also illustrated in Figure 1. Figure 1 shows that the residual points tend to spread between the diagonal lines. This interprets that the data is stated to be normally distributed. Therefore, the data can be continued in analyzing the homogeneity test for the pre-test and post-test data.

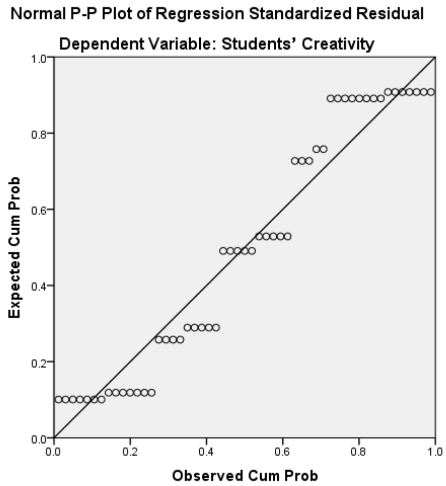

Fig. 1. Illustration of normality of test data

The second analytical activity is to identify the homogeneity of the experimental and control groups based on the pre-test and post-test data. Levene's test analyzed the homogeneity test of the pre-test and post-test data. The results of Levene's test for the pre-test data are shown in Table 5.

Table 5. Levene's test for pre-test data

		Levene's Test for Equality of Variances	
		F	***Sig.***
Students' Creativity	Equal variances assumed	.011	.917
	Equal variances not assumed		

The results of Levene's test show that Fstatistic = .011 with probability (sig.) = .917 > .05 (α=5%). Because probability (sig.) = .917 > .05, the variety of students' creativity from the experimental group and the control group based on the pre-test data was homogeneous. Furthermore, Levene's test for post-test data is shown in Table 6.

Table 6. Levene's test for post-test data

		Levene's Test for Equality of Variances	
		F	***Sig.***
Students' Creativity	Equal variances assumed	.507	.480
	Equal variances not assumed		

The results of Levene's test for post-test data show that Fstatistic = 0.507 with probability (sig.) = .480 > .05 (α=5%). Because probability (sig.) = .480 > .05, the variety of creativity of students from the experimental group and the control group based on post-test data is homogeneous.

After the test data were normal and homogeneous, the second analytical activity was an independent t-test to identify the initial creativity of students from the experimental and control groups based on their pre-test results. The pre-test results show the output of creative mathematics teaching to secondary school students through the "zoom" mobile e-learning applications without the application of self-regulated learning. Thus, the independent t-test analysis results for the creativity pre-test results will refer to the first research question.

The third analytical activity is an independent t-test to identify the effect of self-regulated learning on students' creativity through significant differences between the two groups receiving different treatment from the application of self-regulated learning. The post-test results show the output of creative mathematics teaching with the application of self-regulated learning. In the fifth stage, the researcher conducted a descriptive statistical analysis of the mean to find the source of the difference. Statistical significance (Sig.) was assumed at a p-value of less than 0.05. Data analysis was performed using SPSS version 23.0.

4 Results

Based on the research objectives, this study has two research results that answer each question. The first result answers the first, and the second answer answers the second question.

4.1 Identification of creative mathematics teaching to secondary school students through the "zoom" mobile e-learning applications without implementing self-regulated learning

Based on the first question, the first result shows that the initial creativity of students from the experimental group and the control group without the implementation of self-regulated learning is not significantly different. The identification of students' initial creativity is shown in Table 7.

Table 7. Independent T-test for Identification of students' initial creativity

		t-test for Equality of Means		
		T	***Df***	***Sig. (2-tailed)***
Students' Creativity	Equal variances assumed	-.348	51	.729
	Equal variances not assumed	-.348	50.969	.729

Table 7 shows that $T_{statistic}$ = -.348 with probability (sig.) = .729 > .05 (α=5%). Because the probability (sig.) is .729 > .05 (α=5%), it can be interpreted that there is no significant difference between the students' creativity in the experimental group and the group before the implementation of self-regulated learning.

Based on Table 8, the statistics description of the experimental group shows that the number of participants (N) = 26, mean = 61.8846; std deviation = 1.58308; Std. Error Mean = .31047. Meanwhile, the statistics description of the control group shows that the number of participants (N) = 27, mean = 62,0370; std deviation = 1.60484; Std. Error Mean = .30885. The mean creativity of students from the control group is greater than that of the experimental group (62.0370 > 61.8846), so the creativity of students from the control group is slightly superior to the experimental group. However, the difference is tiny, and the mean is still below the passing grade (mean < 75). Thus, creative mathematics teaching to secondary school students through the "zoom" mobile e-learning applications without the implementation of self-regulated learning is still low, with the mean creativity being less than the minimum mean.

Table 8. Statistics description of pre-test

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Students' Creativity	Experiment Group	26	61.8846	1.58308	.31047
	Control Group	27	62.0370	1.60484	.30885

4.2 Identification of creative mathematics teaching to secondary school students through the "zoom" mobile e-learning applications after implementing self-regulated learning

Based on the second question, the second result shows that the creativity of students from the experimental and control groups is significantly different. As previously explained, the experimental group applied a self-regulated learning strategy while the control group applied the convention strategy. In general, the identification of creativity from both groups is shown in Table 9.

Table 9. T-test independent for creativity from the experimental and control groups

		T-test for Equality of Means		
		T	***Df***	***Sig. (2-tailed)***
Students' Creativity	Equal variances assumed	32.122	51	.000
	Equal variances not assumed	32.198	50.641	.000

Table 9 shows that $T_{statistic}$ = 32,122 with probability (sig.) = 0.000 < .05 (α=5%). Because the probability (sig.) = 0.000 < .05 (α=5%), it can be interpreted that there is a significant difference between the students' creativity from the experimental group and the control group.

Based on Table 10, the statistics description of the experimental group shows that the number of participants (N) = 26, mean = 82.4231; std deviation = 1.41910; Std. Error Mean = .27831. Meanwhile, the statistics description of the control group shows that the number of participants (N) = 27, mean = 69.0370; std deviation = 1.60484; Std. Error Mean = .30885. The mean creativity of students from the experimental group is greater than the control group (82.4231 > 69.370), so the creativity of students from the experimental group is slightly superior to the control group. The creativity of students from the control group still shows a mean < 75, while the mean creativity of students from the experimental group is > 75. Thus, this shows that the application of self-regulated learning provides success for creative mathematics teaching through the "zoom" mobile e-learning applications compared to conventional learning strategy.

Table 10. Statistics description of post-test

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Students' Creativity	Experiment Group	26	82.4231	1.41910	.27831
	Control Group	27	69.0370	1.60484	.30885

5 Discussion

The first study's results show that creative mathematics teaching through the "zoom" mobile e-learning applications without the implementation of self-regulated learning provides low creativity in secondary school students, with the mean creativity less than the minimum mean (mean < 75), due to the limitations of students to control their performance independently and difficulty in thinking new views or ideas. This follows the opinion of Dou et al. (2021), namely, the limitations to exploring different views and providing optimal options to develop their thinking innovatively and independently can affect weakening self-creativity [53]. Creativity refers to high cognitive resources and discovering new and innovative ideas [33]. Thus, increasing creativity requires other supporting factors [35], for example, implying a certain learning strategy to control performance, regulate their thinking, and self-evaluate to acquire new ideas creatively. Learning strategies that involve cognitive development thought development, motivation, emotion, and self-evaluation are self-regulated learning strategies [21].

The second study's results indicate that the implementation of self-regulated learning provides success for creative mathematics teaching through the "zoom" mobile e-learning applications compared to conventional strategies because students can regulate their cognition to think of new ideas in an undirected and original way. This follows the opinion of Xie et al. (2021), that the contribution of intentional regulation of cognitive modes and spontaneous thinking in an undirected way can increase creativity [14]. In addition, higher students' cognitive, behavioral, and thought processes can be assisted by implying self-regulated learning [28]. Research by Raković et al. (2022) also state that self-regulated learning can anticipate learning difficulties, adapt, control learning performance, and improve academic achievement and students' thinking levels [29]. Case study research by Porter and Peters-Burton (2021) shows that most teachers design SRL strategies by linking the self-reflection phase to students' SRL to improve students' higher-order thinking skills [23]. Learning strategies that lead to self-regulation can increase adaptive abilities and flexible actions that produce more original ideas [18].

This study found that the creativity means of students from the control group increased after they applied conventional strategies. However, the increase is tiny compared to the implementation of self-regulated learning. Thus, researchers predict that self-regulation is the primary key for a person to develop cognitive and creative thoughts that are wild in solving complex problems. This follows the opinion of Leo et al. (2019), that self-regulated learning can manage confusion and think of various problem-solving strategies to solve complex problems [54]. The results showed that students applied their self-regulation skills to make cube nets in various creative ways. The results of this student's creativity show the success of student learning [55].

Based on the contradictions in the introduction, the concrete thinking patterns of students at the secondary school level can be improved and developed into extraordinary self-creativity with the help of self-regulated learning. The results of this study contribute to new knowledge for educators and the general public to use self-regulated learning in every lesson plan to succeed in creative mathematics teaching for secondary school students or other students with concrete thinking patterns. This research is original and has never been studied by other researchers; therefore, this research is essential to be researched.

6 Limitation

Research shows that the implementation of self-regulated learning provides success for creative mathematics teaching through the "zoom" mobile e-learning applications to secondary school students in Malang, Indonesia. The success of creative teaching is seen from the mean of student creativity. However, this research has limitations. First, the research has not examined in depth the contribution percentage of self-regulated learning to creative mathematics teaching. The percentage of this contribution will develop this research on using other supporting factors that allow integration with self-regulated learning to increase the success of creative mathematics teaching through the "zoom" mobile e-learning applications. Second, the scope of this research is relatively tiny; namely, the participants are limited to students at the level of secondary school education, the sub-material of geometry in the field of mathematics, and the research participant is limited in the city of Malang, Indonesia.

7 Recommendations for future research

This study provides recommendations for future research. First, further research can identify in depth the contribution percentage of self-regulated learning to creative mathematics teaching so that the determination of other supporting factors that have the potential to make a greater contribution to increasing student creativity can be a recommendation for researchers for future research development. Second, implementing self-regulated learning strategies in creative learning can be carried out on students with varying levels of education, namely elementary school students or students with concrete thinking patterns. The selection of other materials can also be applied in implementing a self-regulated learning strategy to improve creative learning. In addition, the effectiveness of the successful implementation of self-regulated learning strategies in creating creative mathematics learning can be strengthened by expanding the research participant, not just in one city.

8 Conclusions

This study shows that the application of self-regulated learning provides success for creative mathematics teaching through the "zoom" mobile e-learning applications for secondary school students in Malang, Indonesia. The researcher suspects that participants can be extended to students with concrete thinking patterns. So, this research can be developed for future research. In addition, implementing Self-regulated Learning (SRL) can increase students' motivation and behavior to solve mathematical problems creatively. This study provides information on the effectiveness of implementing SRL in creative mathematics teaching and improving students' creative thinking. Thus, this research is essential for educators because educators can consider the use of implementing SRL strategies for creative mathematics teaching.

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