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The Influence of Mathematical Creative Thinking Ability on Students' Self-Regulated Learning Through a Scientific Approach

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Abstract

The purpose of this study was to improve the ability of creative thinking, to see the picture of self-regulated learning, and to analyze the effect of creative thinking ability on self-regulated learning through the implementation of the Scientific approach. This research method is a mixed method of insertion type. The research instrument used was a creative thinking ability test, observation, self-regulated learning scale, and interviews. The population in this study were students in a private high school in Bandung with a sample of 2 classes. The increase in creative thinking skills was analyzed by normalized gain scores, the description of self-regulated learning was analyzed by Post Hoc Tests, while the effect of creative thinking skills on self-regulated learning was used regression analysis. The results showed that the increase in the creative thinking ability of students who received the Scientific approach was better than the students who received conventional learning, there was no difference in the self-regulated learning of students who received learning using the Scientific approach and conventional models, and there was no difference the effect of creative thinking ability on self-regulated learning in learning with scientific approaches, and conventional ones.

Abstrak

Tujuan penelitian ini adalah untuk meningkatkan kemampuan berfikir kreatif, melihat gambaran kemandirian belajar, dan menganalisis pengaruh kemampuan berfikir kreatif terhadap kemandirian belajar melalui implementasi pendekatan scientific. Penelitian ini menggunakan metode campuran tipe penyisipan. Instrumen penelitian yang digunakan adalah tes kemampuan berpikir kreatif, observasi, skala kemandirian belajar, dan wawancara. Populasi dalam penelitian ini adalah peserta didik di salah satu SMA swasta Bandung dengan sampel sebanyak 2 kelas. Peningkatan kemampuan berpikir kreatif dianalisis dengan skor gain ternormalisasi, gambaran kemandirian belajar dianalisis dengan Tes Post Hoc, sedangkan pengaruh kemampuan berpikir kreatif terhadap kemandirian belajar digunakan analisis regresi. Hasil penelitian menunjukkan bahwa peningkatan kemampuan berfikir kreatif peserta didik yang memperoleh pendekatan Scientific lebih baik daripada peserta didik yang memperoleh pembelajaran konvensional, tidak terdapat perbedaan kemandirian belajar peserta didik yang memperoleh pembelajaran dengan pendekatan Scientific maupun konvensional, serta tidak terdapat pengaruh kemampuan berfikir kreatif terhadap kemandirian belajar pada pembelajaran dengan pendekatan Scientific, maupun konvensional.

Keywords: Independent Learning; Mathematical Abilities; Mix Method; Problem Based Learning.

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INTRODUCTION

Mathematics is a universal science that underlies the development of modern technology. Mathematics subjects need to be given to all students to equip them with the ability to think logically, analytically, systematically, critically, creatively, and collaboratively. These competencies are needed so that students can have the ability to obtain, manage, and utilize information to survive in conditions that are always changing, uncertain, and competitive so that they can be successful and useful in participating in society (Kasri, 2018).

According to NRC (Rosyid & Puadi, 2016), in the present and the future, in the era of communication and advanced technology, smart workers are needed rather than hard workers. It takes workers who are ready to be able to digest new ideas, able to adapt to change, able to handle uncertainty, able to find order, and able to solve unusual problems. Therefore, the students' need for mathematics today and in the future is more for the ability to think and reason.

The ability to think is needed by every individual to be able to survive in global competition. Facing challenges in the era of technological development, students' mathematical creative thinking skills are needed, therefore learning mathematics is expected to make students think creatively. Creativity in mathematics has termed the ability to think creatively mathematically (Artikasari & Saefudin, 2017).

The ability to think creatively is one of the higher-order thinking skills. Creative thinking skills are important to develop because students with creative thinking skills are more likely to succeed in learning mathematics because they can develop their knowledge and ability to create various creative ways of solving problems (P. Yaniawati et al., 2020).

In addition, according to Facione (Kholisoh, 2019) "creative thinking is one type of thinking that directs the acquisition of new insights, new approaches, new perspectives, or new ways of understanding things. Creative thinking can occur when triggered by challenging tasks or problems."

Based on the results of a preliminary study conducted on class X students in a private high school in Bandung, it shows that the results of students' mathematical creative thinking abilities are classified as very low. When students are asked to work on story problems that have many ways of solving them, most of them can only use the same way to solve them.

For example, when students are asked to solve problems in story problems by determine the values of x and y from two linear equations of two variables, they answer by eliminating the two equations, then substituting the results obtained into one of the equations to obtain the values of x and y. Even though this is not the only way, there are several other ways that can be used to determine the values of x and y, another way is changing one form of the equation and then substituting it into another equation.

This response shows that some students are still weak in utilizing their mathematical creative thinking skills. Students find it difficult to express mathematical ideas contained in story problems into mathematical symbols/models, so students only perform calculations without understanding their meaning.

Mathematics learning has a lot to do with problem-solving processes that do not always depend on standard formulas. Difficult math problems require creative thinking skills that can connect ability with creativity to create innovations in

solving problems in various ways (Fisher et al., 2019).

Student creativity can be developed if it is trained through exploration, inquiry, discovery, and problem-solving (Anjarwati, 2017) . A specific problem-solving model for teaching science was proposed by Pizzini, Shepardson, and Abell (Ningsih, 2015) on the premise that to make a problem meaningful to students, it is necessary to identify and define them themselves, and students learn to solve problems and concepts. knowledge through real experience.

Therefore, the government changes the curriculum so that learning becomes more meaningful, and students can learn to solve problems and scientific concepts through a real experience called the 2013 curriculum, in which there is a *Scientific approach. A scientific* approach is learning that encourages students to be better able to observe, ask questions, try/collect data, associate/reason, and communicate (Fadilah, 2014).

As a strengthening of the *Scientific approach*, it is necessary to apply the *Project Based Learning, Problem Based Learning, and Discovery Learning methods.* Each learning method has its learning syntax that can be selected according to the competencies, materials, and available time allocation. *Project-Based Learning* is a learning method that uses project assignments as learning media, *Problem Based Learning* is a learning method that uses problems as learning media, while *Discovery Learning* is a learning method that uses investigation to get a final result in learning (Herawati et al., 2021).

In this research, the approach used is *Problem Based Learning*. Through problem-solving-based learning models, students are accustomed to learning from actual and factual problems in everyday life, and students are also accustomed to study groups and discussions, and learn to study problems, seek relevant information, compile information obtained, review alternative solutions. existing ones, propose alternative solutions, and develop resolution actions. So that students can understand theory in depth through empirical practical learning experiences (Malmia et al., 2019).

PBL can also effectively develop relevant skills such as communication, collaboration, interdisciplinary, innovation, and responsibility. (Hikmasari et al., 2020). Other studies such as (Kurniyawati et al., 2019) show that PBL is more effective than conventional learning in terms of students' mathematical self-regulated learning.

Self-regulated learning is very important for students to have. The learning process, students who have self-regulated learning can build learning goals, try to monitor, regulate, and control cognition, motivation, and behavior, to control the goals that have been determined (P. Yaniawati et al., 2021) . The indicators contained in the assessment of self-regulated learning expressed by Sumarmo (Wahyuni & Nurhayati, 2019) include: (1) learning initiatives; (2) diagnose learning needs; (3) setting learning targets and objectives; (4) monitor, regulate and control; (5) view adversity as a challenge; (6) utilize and seek relevant sources; (7) selecting and implementing learning strategies; (8) evaluate the process and learning outcomes; and (9) self-efficacy (self-concept).

Based on the above, researchers are interested in studying problems related to mathematical creative thinking skills through scientific approach learning and its impact on students' learning independence in the form of research.

METHOD

The research method used in this study is the mixed-type insertion method (Embedded Design) which was revealed by Craswell (Indrawan & Yaniawati, 2017). This method was chosen because researchers focused more on quantitative research, namely increasing mathematical creative thinking skills and their effect on student self-regulated learning, but to strengthen the results of the study, qualitative data was inserted in the form of a description of student self-regulated learning after obtaining learning with a scientific approach. The research design used was a quasi-experimental design which was carried out without a probability sampling technique process according to the opinion of Jack R, Frankel, Norman E. Wallen, and Craswell (Indrawan & Yaniawati, 2017).

Table 1. Quasi-Experiment Design

Group	Pre-Test	Treatment (independent variable)	Final Test
Experiment	Y	X_1	Y
Control	Y	$-$	Y

Information:
Y: Pre-test = Final test;
X_1: a scientific approach

The population in this study were students of class X in a private high school in Bandung, while the research sample was students of class X IIS A, and X IIS E, totaling 74 people. The sample selection was done purposively, two classes were selected which were equivalent in academic ability. The first class received learning with a scientific approach, and the second class received learning with a conventional learning (control class).

The instruments used in this research are test and non-test. The mathematical creative thinking ability test was conducted to determine the significant change in creative thinking ability after the experimental group students received a scientific approach. The form of the test used is a description type consisting of 5 questions. Before being used, the test questions were tested first, including validity, reliability, discriminatory power (DP), and difficulty index (IK). The following is a recapitulation of the test results of the mathematical representation ability instrument.

The non-test instruments used include (1) observation, carried out to directly observe the characteristics of the implementation of the scientific approach learning process, (2) interviews, used to obtain student opinions about learning with a scientific approach which is not obtained through direct observation in the classroom, (3) a questionnaire, is used to measure the level of student self-regulated learning.

Qualitative data obtained through observer sheets and interviews were then processed descriptively and the results were analyzed through essay writing reports that concluded the criteria, characteristics and processes that occur in learning.

Meanwhile, the quantitative data obtained in the form of pre-test and post-test data were then analyzed with a normalized gain score to describe the increase in creative thinking skills. Learning independence questionnaires were analyzed using Post Hoc Tests to obtain a description of the learning independence of students, while the effect of creative thinking skills on learning independence was analyzed using regression analysis.

RESULTS AND DISCUSSION

Research result

Mathematical Creative Thinking Ability Pretest Data Analysis

The results of the pretest data were analyzed to determine the students' mathematical creative thinking abilities before conducting the research. The first stage is a descriptive analysis of the data as follows.

Table 2 Descriptive Statistics Mathematical Creative Thinking Ability Pretest Data

	Scientific Experiment Class Pretest	Control Class Pretest
N	29	38
mean	5.59	5.37
Minimum	3	0
Maximum	11	13
Sum	162	204

The results show that the initial ability of the *Scientific experimental class* is better than the control class. To find out whether there is a difference in the average of the data groups of students, it is calculated using the Post Hoc Test. The result is that there is no significant difference between the *Scientific experimental* class and the control class.

Post-test Data Analysis of Mathematical Creative Thinking Ability

The results of the post-test data were analyzed to determine the students' mathematical creative thinking abilities after the research was carried out. The first stage is a descriptive analysis of the data as follows.

Table 3 Descriptive Statistics Mathematical Creative Thinking Sbility Posttest Data

	Scientific Experiment Class Posttest	Control Class Posttest
N	29	38
mean	10.45	8.50
Minimum	7	0
Maximum	18	19
Sum	303	323

The results show that the mean of the three classes is different. The scientific experimental class is 1.95 superior to the control class. This means that the final ability of the experimental class is better than the control class. To find out whether there is a difference in the average of the data groups of students, it is calculated by using the *Post Hoc Test*. The result is that there is no significant difference between the control class and the experimental class *Scientific.*

Normalized Gain Analysis Mathematical Creative Thinking Ability

The results of the normalized gain data were analyzed to determine the quality of increasing students' mathematical creative thinking abilities using *Scientific* and conventional learning models. The initial stage is a descriptive analysis of the data as follows.

Table 4 Descriptive Statistics Normalized Gain Mathematical Creative Thinking Ability

	Scientific Experiment Gain	Gain Control
N	29	38
mean	0.1403	0.0901
Minimum	-0.10	-0.14
Maximum	0.37	0.28
Sum	4.068599	3.424196

The table above shows that the average normalized gain of the *the Scientific*

experimental class and the control class has a difference of 0.0502. The average gain of the experimental class (0.2092) was higher than the control class. To see whether the difference is significant or not, the *Kruskal Wallis* test is then carried out.

Table 5 Kruskal Wallis Test Results Gain Score Based on The Learning Model

Test Statistics [a,b]

	Mark
Chi-Square	8080
df	2
asymp. Sig.	.018

a. Kruskal Wallis Test

b. Grouping Variables: class

The results show the value of *Asymp. Sig.* 0.018 < 0.05. The results of the statistical test accepted Ha, meaning that there was a significant difference in the average normalized gain value from the *Scientific experimental* class and the control class.

Analysis of Student Self-regulated learning Questionnaire

The description of the self-regulated learning scores of the experimental class and control class students is as follows.

Table 6 Descriptive Statistics of Students' Self-regulated Learning Questionnaire Results

	Scientific Experiment Class	Control Class
N	33	35
mean	0.0007	0.0483
Minimum	-0.84	-0.33
Maximum	0.30	0.74

Results show that the control class is 0.0476 superior to the *Scientific* experimental class. It means, self-regulated control class students performed better than the *Scientific* experimental class. To find out whether there is a difference in the average of the data groups of students, it is calculated by using the *Post Hoc Test*. The result is that there is no significant difference between the *Scientific experimental* class and the control class.

Analysis of the Influence of Mathematical Creative Thinking Ability on Self-regulated Learning of Students

To analyze the effect of mathematical creative thinking ability on students' self-regulated learning, regression analysis was used.

Table 7 Regression Coefficient on Learning by Approach *Scientific*

Model	Unstandardized Coefficients		Sig.
	B	Std. Error	
1 (Constant)	.140	.019	.000
gain SRL	-.050	.068	.467

a. Dependent Variable: creative gain

The results show that the significance value of the regression coefficient is 0.000 less than $\alpha = 0.05$but there is one regression coefficient value which is 0.467 meaning Ho is accepted, meaning that there is no significant effect between creative thinking ability and self-regulated learning of students in learning the *Scientific approach.*

Table 8 Regression Coefficient on Conventional Learning

Model	Unstandardized Coefficients		Sig.
	B	Std. Error	
1 (Constant)	.096	.016	.000
gain SRL	-156	.077	.052

a. Dependent Variable: creative gain

The results show that the significance value of the regression coefficient is 0.000 less than $\alpha = 0.05$but there is one regression coefficient value which is 0.052 meaning Ho is accepted. That is, there is

no significant effect between creative thinking ability and self-regulated learning of students in conventional learning.

Discussion

Students' Mathematical Creative Thinking Ability

Analysis of the research results showed that there was a significant difference in the average gain value of students' creative thinking abilities from the *Scientific experimental* class and the control class. This means that the creative thinking ability of students who receive the *Scientific approach* has increased and is higher than students who have received conventional learning.

Thus, the *Scientific approach* can be used to improve students' creative thinking skills. This is in line with the results of previous research (Elizabeth & Sigahitong, 2018; Septian & Rizkindi, 2017; Soeviatulfitri & Kashardi, 2020; Tan et al., 2020) which states that the *Scientific approach* with Problem Based Learning model provides better creative thinking skills than conventional learning models. and in general, the attitude of students towards learning mathematics using the *Scientific approach* with Problem Based Learning model is positive.

Another aspect that plays a role in increasing mathematical critical thinking skills is the use of teaching materials. Teaching materials are an important part of the problem-based learning model. The teaching materials used in this research are power points that contain realistic problems. The use of this PowerPoint also affects increasing students' mathematical creative thinking skills. This is in line with the results of research (Mahendrawan et al., 2022; Nurmala et al., 2021) which states that the use of Problem Based Learning worksheets as teaching materials is more effective in terms of mathematical creative thinking skills compared to conventional approaches.

In addition, group discussion activities and class discussions also play a role in increasing creative thinking skills. Discussion activities are the basis of *Scientific approach* with PBL learning theory, as stated in (RP Yaniawati et al., 2019) that Problem Based Learning is a learning and teaching approach with the following characteristics: (1) using problems as a starting point for learning, (2) small group collaboration, and (3) flexible tutoring. This allows students to interact with each other, ask questions, express opinions, respond to the opinions of other students, and explain the results of their work in front of the class. This can spur students to be more active in exploring their potential to find answers to what is being asked so that they can improve their creative thinking skills.

Self-regulated learning of Students

Based on descriptive statistics, the results showed that the self-regulated learning of students in the *Scientific experimental* class was better than the control class. However, the results of the analysis of the data show that there is no significant difference in the average score of the students' self-regulated learning. This means that there is no difference in the self-regulated learning of students who receive learning using the *Scientific approach*and conventional learning.

This finding is similar to findings in other studies (Budiyanto et al., 2014; Mulyana & Sumarmo, 2015; Rohaeti et al., 2014) which stated that there was no difference in self-regulated learning between students in both learning, namely problem-based learning and conventional learning. The results of the study (Ramadhania et al., 2019) also stated that the

self-regulated learning of students whose learning using the *Scientific approach* with Problem Based Learning model was not better than the self-regulated learning of students who received conventional learning. In addition, research (Temel, 2013) reveals that problem-based learning (*Scientific approach)* and traditional teaching methods do not have a significant effect on the self-regulated learning of prospective teachers.

Self-regulated learning is a process of careful design and self-monitoring of cognitive and affective processes in completing academic tasks, self-regulated learning is also an individual's awareness to think, use strategies and continuous motivation, and evaluate learning outcomes. Judging from this understanding, self-regulated learning is a process that requires habituation and a strong will because many are based on the internal factors of everyone, so it is not easy to be able to change them.

However, the development of attitudes that lead to self-regulated learning such as the courage to ask questions and express opinions, and enthusiasm in participating in learning has already been seen, both in the *Scientific experimental* class group and the control class group.

The Influence of Mathematical creative thinking ability on Self-regulated learning of Students

From the results of the analysis of regression calculations, it was found that there was no significant effect between the results of mathematical creative thinking abilities and students' self-regulated learning. So, it can be concluded that there is no influence of mathematical creative thinking ability on the self-regulated learning of students.

This finding is in line with the results of research (Marsinia & Rahmi, 2018; Ramadhania et al., 2019) which states that there is no relationship between students' creative thinking abilities and student self-regulated learning. The results of another study (Lestari et al., 2019) stated that there was no interaction between the Open-Ended learning approach and student self-regulated learning on students' mathematical creative thinking abilities.

However, this finding is different from the results of research (Akhdiyat & Hidayat, 2018) which states that the mathematical creative thinking ability of high school students is positively influenced by mathematics self-regulated learning by 87.5%, while 12.5% is influenced by factors other than students' mathematical self-regulated learning. Similar results were also expressed by (Astuti et al., 2020; Mauludin & Nurjaman, 2018; Nurcholifah et al., 2021; Runisah & Ismunandar, 2020) which stated that student self-regulated learning in problem-based learning (*Scientific approach)* affected creative thinking skills in mathematics.

The findings above indicate that the existence of the association between mathematical ability and affective aspects of mathematics learning outcomes is inconsistent (Budiyanto et al., 2014).

CONCLUSION

Based on the results of the research and discussion above, it can be concluded that there is no influence of mathematical creative thinking ability on students' self-regulated in learning with a *scientific approach*. This is because there is no difference in self-regulated learning between students who receive learning using *scientific approach* or conventional learning.

Suggestions that can be given based on the results of this study are in the use of the *Scientific approach* educators are expected to have broad insight so that

they can create self-regulated learning situations and be able to come up with ideas/ideas in providing mathematical problems that have various solutions so that students can try several strategies in their learning experience.

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