AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 12, No. 1, 2023, 23-35

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

DEVELOPING MATHEMATICAL CREATIVE THINKING (CT) ABILITY STUDENTS THROUGH THE TREFFINGER LEARNING MODEL (LM)

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Received 12 June 2022; Received in revised form 28 February 2023; Accepted 02 March 2023

Abstract

The low ability of CT is a problem that occurs in class VIII students of SMPN 1 Kendari. One reason is the application of inappropriate LM. Treffinger's LM is learning by inviting students to think creatively in solving problems based on the facts around them to come up with various ideas and choose solutions. The purpose of this study was to develop the mathematical CT skills of junior high school students. Class VIII SMPN 1 Kendari as a population consists of 9 classes. Class VIII3 and VIII6 were determined by random sampling technique as an experimental class of 26 students and a control class of 25 students. The finding in this study is that students' mathematical CT skills taught by the Treffinger LM are better than in the guided discovery model. Treffinger's LM is superior in developing CT skills. In addition, Treffinger's LM excels in developing aspects of fluency, flexibility, and elaboration of mathematical CT skills. In contrast, the guided discovery LM excels only in developing aspects of originality.

Keywords: guided discovery, mathematical creative thinking, treffinger learning model.

Abstrak

Rendahnya kemampuan CT merupakan masalah yang terjadi pada siswa kelas VIII SMPN 1 Kendari. Salah satu penyebabnya adalah penerapan model pembelajaran yang tidak sesuai. Model pembelajaran Treffinger adalah pembelajaran dengan mengajak siswa berpikir kreatif dalam memecahkan masalah berdasarkan fakta-fakta di sekitar mereka untuk memunculkan berbagai ide dan memilih solusi. Tujuan penelitian ini adalah untuk mengembangkan keterampilan CT matematis siswa SMP. Kelas VIII SMPN 1 Kendari sebagai populasi terdiri dari 9 kelas. Kelas VIII3 dan VIII6 ditentukan dengan teknik random sampling sebagai kelas eksperimen sebanyak 26 siswa dan kelas kontrol sebanyak 25 siswa. Temuan dalam penelitian ini adalah kemampuan CT matematis siswa yang diajar dengan model pembelajaran Treffinger lebih baik dibandingkan dengan model penemuan terbimbing. Model pembelajaran Treffinger lebih unggul dalam mengembangkan keterampilan CT. Selain itu, model pembelajaran Treffinger unggul dalam mengembangkan aspek kefasihan, keluwesan, dan elaborasi keterampilan CT matematis. Sebaliknya, model pembelajaran penemuan terbimbing hanya unggul dalam mengembangkan aspek orisinalitas.

***Kata kunci**: berpikir kreatif matematis, model pembelajaran treffinger, penemuan terbimbing.*

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

INTRODUCTION

Creativity is needed in every aspect of human life (Lian et al., 2018). To be able to compete in the world of work and personal life, students must have problem-solving skills and must be able to think creatively (Suarta et al., 2017). Therefore, CT skills must be developed in mathematics learning activities (Yayuk et al., 2020). Creativity is the result of CT skills (Guilford, 2017), oriented to mathematical activities widely developed in schools, such as solving and proposing problems closely related to creativity, namely flexibility, fluency, originality, and elaboration (Gralewski, 2016). Creativity is a deep problem-solving process regardless of the complexity of classroom learning by providing opportunities for students to solve non-routine, complex, and structured problems (Beghetto, 2018; Lithner, 2017).

CT is lateral, cross-field, and divergent thinking with characteristics of subtlety, fluency, flexibility, elaboration, redefinition, and novelty (Guilford, 2017). CT is a process of constructing ideas based on fluency, flexibility, elaboration, originality (Yaniawati et al., 2020), and sensitivity to scientific, industrial, and life situations with creative design, investigation, and problem development original (Chen & Chen, 2021). CT is an organized thought process that can be learned by paying attention to intuition, sparking imagination, revealing new possibilities, opening amazing perspectives, and generating unexpected ideas. (de Bruin & Harris, 2017).

Mathematical CT is the ability to solve problems and develop logical and deductive thinking (Ndiung et al., 2019). In addition, mathematical creativity is combining ideas, techniques, or approaches in new ways (Suherman & Vidákovich, 2022), thereby generating and building arguments and competencies that students need (Lucas et al., 2013).

Several studies have been conducted to develop mathematical CT skills, including Ratnaningsih (2017), and Maskur et al. (2020) with the PBL model; Hendriana & Hendriana & Fadhillah (2019) with problem-solving; Septian et al. (2020) with android based GeoGebra; Ibrahim & Widodo (2020) with open issues; Sari & Hidayat (2019) with double loop problem-solving learning.

Based on the results of observations by conducting a pre-test on class VIII students of SMPN 1 Kendari it was found that the mathematical CT ability was relatively low. The LM used to develop CT skills at SMP Negeri 1 Kendari is guided discovery. Guided discovery is a learning approach in which the teacher presents examples of a particular topic and guides students to understand the topic (Eggen & Kauchak, 2012; Salam, et al., 2020). The guided discovery model is intentionally designed to increase student activity, and is process-oriented, finding identity, and information needed to achieve learning goals (Salam, Misu, et al., 2020; Yuliani & Suragih, 2015). However, in this study, the Treffinger LM will be applied to develop CT skills.

The Treffinger LM aims to generate creativity, which involves cognitive and affective abilities by demonstrating the interdependence between the two in encouraging students to think. (Huda M, 2016; Nizham et al., 2017). Treffinger's LM consists of 3 stages, Treffinger et al., (2003), namely: Phase I includes divergent thinking skills and creative

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

techniques as basic tools. The development of fluency, flexibility, originality, and elaboration in thinking is a divergent function in the introduction. The affective part of stage, includes the willingness to answer, see experiences, willingness to accept, face problems and challenges, curiosity, courage to take risks, awareness, and self-confidence. Phase I activities carried out were (1) the teacher gave open questions, (2) the teacher guided students to carry out discussions to convey their ideas or ideas and provide results for each group.

Stage II provides opportunities for students to apply the skills they have learned in Stage I in practical situations. The introduction in stage II includes application, analysis, synthesis, and evaluation. The affective aspects in stage II include feelings and multiple conflicts, directing attention to problems, using imagination, thinking, and relaxation (relaxation), and being creative or creating. Phase II learning activities in this study were (1) the teacher guided and directed students to learn by giving analog examples, and (2) the teacher asked students to make examples in everyday life.

Stage III, working with real problems, namely applying skills in the first two stages by using their abilities so that they are meaningful in life. Stage III learning activities are: (1) the teacher gives problems in everyday life; (2) the teacher guides students to create problems and solve them independently; (3) the teacher guides students to make conclusions.

Based on the description above, the hypotheses that will be tested in this study are (1) CT skills increase after being taught the Treffinger LM, (2) CT skills increase after being taught the guided discovery LM, (3) students' mathematical CT skills which use the Treffinger LM is higher than guided discovery, and (4) the quality of improving students' mathematical CT skills using the Treffinger LM is better than guided discovery.

RESEARCH METHODS

This experimental study used a Pretest-Posttest Control Group Design with a population of class VIII students at SMP Negeri 1 Kendari, Kendari City, Southeast Sulawesi Province, which consisted of 9 parallel classes. Class VIII3 and VIII6 as the experimental class consisted of 26 students and the control class consisted of 25 students using a random sampling technique. The Treffinger LM and guided discovery were applied to the experimental class and the control class. The research design can be seen in Figure 1, with **EC** is Experiment Class, **CC** is Control Class, **T1** is Treatment 1 (applying Treffinger LM), **T2** is Treatment 2 (applying guided discovery LM), **O1** is Pre-test of experiment class students, **O3** is Pre-test of control class students, **O2** is Post-test of experiment class student, and **O4** is post-test of control class student (Sugiyono, 2017).

EC	O1	T1	O2
CC	O3	T2	O4

The instrument used to collect pre-test and post-test data is a CT ability test consisting of 4 essay questions. The test is structured based on 4 aspects of mathematical CT skills, namely flexibility, fluency, originality, and elaboration. Test the validity and reliability using the Aiken and Alpha Cronbach tests.

Descriptive and inferential statistics were used to process the pre-test and post-test data. The normality

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

test used was the Shapiro-Wilk test, and the data homogeneity test using the Levene test, t-test, and Mann-Whitney test were used to test the hypothesis.

To determine the quality of students' CT skill improvement in each class, normalized gain (N-gain) is used. Using N-Gain eliminates high-effect factors and guesswork to avoid biased conclusions. (Heckler, 2004).

This study was conducted in three stages: (a) giving a pre-test to both classes, (b) implementing learning for 6 meetings, and (c) giving a post-test.

RESULTS AND DISCUSSION

The first research' result is students' CT math abilities are described in Table 1.

Table 1. Data descriptive results

	N	Min	Max	Mean	Std. Dev.
O1	26	19.12	73.53	51.698	14.775
O2	26	19.12	98.53	68.610	19.620
N-Gain Eksperimen	26	0	0.94	0.403	0.288
O3	25	20.59	73.53	51.527	14.924
O4	25	22.06	77.94	56.986	16.533
N-Gain Kontrol	25	0.02	0.4	0.124	0.133

From table 1 it can be explained that the pretest value of the experimental class before being given treatment (O1) spread from 19.12 to 73.53 with an average of 51.698 and Std. Dev. 14,775. After being given treatment, the posttest (O2) value of the experimental class spread from 19.12 to 98.53, the average was 68.610, and Std. Dev. 19,620. This shows an increase in students' creative thinking skills after being taught the Treffinger LM. The pretest value in the control class before being given treatment (O3) ranged from 20.59 to 73.53 with an average of 51.527 and Std. Dev. 14,924. The post-test scores for the control class after being given treatment (O4) spread from 22.06 to 77.94, with an average of 56.986 and a standard deviation of 16.533. The mean experimental N-Gain was 0.403 and the Std. Dev. is 0.288. The mean N-Gain Control is 0.124 and the standard deviation is 0.133. These results also show that in the control class students' mathematical creative thinking abilities also increase, but the increase occurs in the experimental class is higher than in the control class.

The results of normality calculations using Shapiro-Wilk are described in Table 2.

Table 2. Normality test

	Statistic	Df	Sig.
O2	.938	26	.119
O1	.949	26	.217
N-Gain experiment	.920	26	.045
O4	.922	25	.057
O3	.937	25	.127
N-Gain Control	.688	25	.000

The results in Table 2, obtained the value of Sig. for variables O1, O2, O3, and O4 more than 0.05. This shows that the data variables O1, O2, O3, and O4 are normally distributed. The N-gain data for the experimental and control classes were not normally distributed because of the value of Sig. smaller than 0.05. Then, the results of the calculation of the homogeneity of the O3 vs O4 and O1 vs O2 variables are described in Table 3.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

Table 3. The results of the calculation of the homogeneity of variance

	Levene Statistic	df1	df2	Sig.
O3 vs O4	.309	1	48	.581
O1 vs O2	1.324	1	50	.255

The results in Table 3 show that the O3 vs O4 variable is homogeneous as indicated by the value of Sig.=0.581 which is greater than 0.05. Likewise, O1 vs O2 data is homogeneous, with sig. = 0.255 is greater than 0.05.

Hypothesis of this research are students' CT ability increases after being taught with the Treffinger LM (**Hypothesis 1**) and students' CT ability increases after being taught with the Guided discovery LM (**Hypothesis 2**). Hypothesis 1 and hypothesis 2 were tested using paired t-tests. The results of testing using SPSS are obtained in Table 4.

Table 4. Paired sample test

	Mean	t	df	Sig. (2-tailed)
O2 vs O1	16.91	8.58	25	0.00
O4 vs O3	5.46	4.65	24	0.00

Table 4 row O2 vs O1 obtained Sig. = 0.00 less than = 0.05. This shows that hypothesis 1 is accepted, that is, students' CT abilities after being taught with the Treffinger model have increased. Visually, the increase in students' CT skills can be explained in Figure 1.

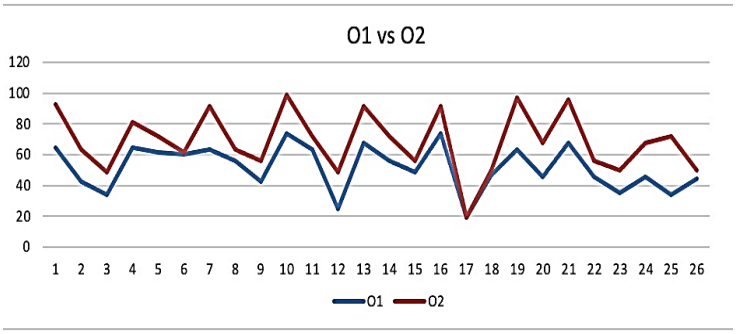

Figure 1. Students' CT ability after applying the Treffinger model.

Table 4 row O4 vs O3 shows the value of Sig. = 0.00 less than 005, then hypothesis 2 is accepted which means CT mathematical skills can be improved through the guided discovery model. Visually, the improvement of students' CT skills after being taught guided discovery can be seen in Figure 2.

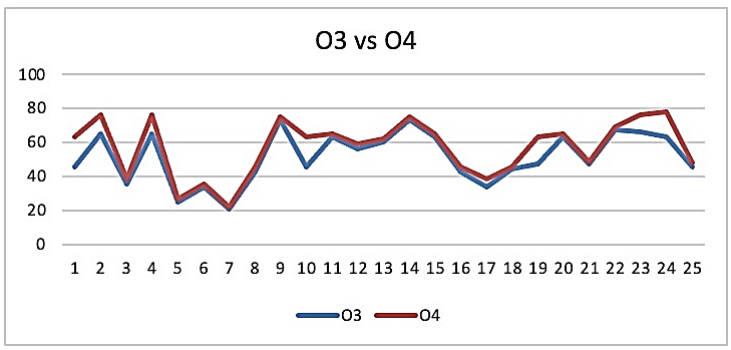

Figure 2. Graph of increasing students' CT skills after learning with guided discovery models.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

The next hypothesis of this research is the mathematical CT ability of students who use the Treffinger LM is higher than the guided discovery (**hypothesis 3**). Hypothesis 3 was tested using an independent sample t-test. The test results are presented in Tables 5 and 6.

Table 5. T-test result from O1-O3

	Levene's Test		**t-test**		
	F	**Sig.**	**t**	**df**	**Sig. (2- tailed)**
Equal variances assumed	.027	.870	.041	49	.97
Equal variances not assumed			.041	48.89	.97

Table 6. T-test result from O2-O4

	Levene's Test		**t-test**		
	F	**Sig.**	**t**	**df**	**Sig. (2- tailed)**
Equal variances assumed	.30	.58	.04	49	.97
Equal variances not assumed			2.29	48.19	.03

Table 5 shows that students' CT skills before being given treatment between the control class and the experimental class have the same variance, which is shown by sig. 0.97 is greater than 0.05. The mathematical CT ability of students using the Treffinger (O2) LM is higher than the Guided discovery (O4) LM as indicated by sig. 0.03 is less than 0.05. In terms of CT skills, the average achievement of each aspect of CT skills can be seen in Table 7.

Table 7. Average achievement of each aspect

Aspects of CT	**Average**	
	Experiment	**Control**
Fluency	80	71.43
Flexibility	71.43	42.36
Originality	57.14	66.67
Elaboration	66.67	46.67

The results in Table 7 show that the average achievement of aspects of fluency, flexibility, and elaboration in the experimental class is higher than in the control class. While on the aspect of originality, the average value of the experimental class is lower than the control class.

The last hypothesis is The quality of increasing students' mathematical CT skills by using Treffinger's LM is better than Guided Discovery (**hypothesis 4**). Hypothesis 4 was tested using non-parametric statistics, namely the Mann-Whitney test, taking into account that neither the experimental N-gain data nor the control N-gain data was normally distributed. The test results can be seen in Tables 8 and 9.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

Table 8. Mann-Whitney Test Ranks

Variable	N	Mean Rank	Sum of Ranks
Experimental N-gain	26	33.75	877.50
N-gain control	25	17.94	448.50
Total	51		

Table 9. Test Statistics

Statistics	N_Gain
Mann-Whitney U	123.500
Asymp. Sig. (2-tailed)	.000

The results in table 8a show that the experimental average N-gain is 33.75 higher than the control N-gain average of 17.94. Furthermore, in table 8b the value of Asymp. Sig (2-tailed) = 0.00 less than 0.05. These results indicate that hypothesis 4 is accepted, which means that improving students' CT math skills using the Treffinger LM is better than guided discovery. To clarify the comparison of the improvement of students' CT skills between the experimental class and the control class can be seen in Figure 3.

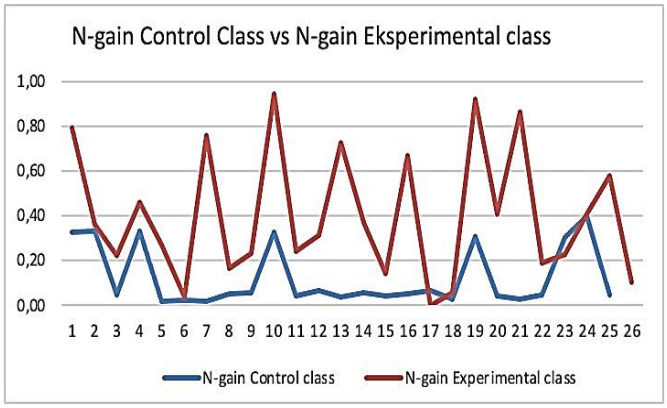

Figure 3. Comparison of the improvement of students' CT skills between the experimental class and the control class.

From these categories, the comparison of the increase in CT skills between the experimental class and the control class is presented in Table 9.

Table 9. Categorization of N-gain.

Category	Experiment Class		Control Class	
	frequency	%	frequency	%
High	6	23,08	0	0
Moderate	8	30,77	7	28
Low	12	46,15	18	72
Sum	26	100	25	100

The results of the analysis of the quality improvement of CT skills are based on table 9 in the control class, no students achieved the category of high-quality improvement, 28% of students achieved moderate improvement, and 72% of students achieved low-quality improvement. While the experimental class that achieved the high-quality improvement category was 23.08% of students, the medium-quality improvement was 30.77% of students, and the low-quality improvement was 46.15% of students.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

In the 2013 curriculum, specifically for primary and secondary education, one of the emphases is on developing critical thinking skills, CT skills, collaboration, and communication. This paper was developed on the development of mathematical CT skills, which was carried out experimentally, and studied descriptively and inferentially. The experiment involved two LM, namely Treffinger which was used in the experimental class, and guided discovery in the control class. Some research results in state that Treffinger's LM and guided discovery can develop mathematical CT skills.

The results of testing hypothesis 1 show an increase in CT skills after being taught with the Treffinger LM. This is because the Treffinger LM is a LM that is specifically designed from basic thinking to more complex thinking, to trigger students' CT skills that involve cognitive and affective abilities (Handayani et al., 2018; Isaksen et al., 2010). In addition, Treffinger's LM leads to the use of critical and CT skills, individually and in groups, to understand challenges and opportunities, create ideas, and develop effective plans to manage change and solve problems (Amanoe & Isnarto, 2021).

The results of testing hypothesis 2 obtained an increase in students' CT skills after being taught with the guided discovery LM. Guided discovery is student-centered learning so that they have the freedom to try, use intuition, and obtain information through group discussions, find solutions, and solve problems based on their activities and observations so that students' ability to analyze increases. (Arya Wulandari et al., 2018; Khasanah et al., 2018).

The finding of hypothesis 3 is that students' mathematical CT skills using the Treffinger LM are superior to guided discovery. In terms of CT skills, Treffinger's LM excels in indicators of fluency, flexibility, and elaboration. While the guide discovery LM only excels in the originality aspect. The results of the independent t-test showed that the CT ability of students who used the Treffinger LM (O2) was higher than that of guided discovery learning (O4). This is due to the dominant characteristics of Treffinger's LM, which integrates students' cognitive and affective dimensions, finding the direction of completion to be taken in solving problems, by giving students freedom as they wish (Nurzulifa, 2021). Treffinger's learning is better in improving students' mathematical CT skills (Triwibowo et al., 2017). While the guided discovery model, students are not given the freedom to solve problems as they wish. In the guided discovery LM, the teacher provides examples of certain topics and guides students to understand the topic to encourage student involvement and motivation, help gain in-depth understanding and explanation of topics, and train students to find concepts with teacher guidance so that there are no misconceptions (Darmawan & Suparman, 2019). The guided discovery model demands being an expert in asking questions and guiding students' thinking (Putri, 2020).

The finding of hypothesis 4 is that the quality of improving mathematical CT skills of students using the Treffinger LM is better than guided discovery. This finding is indicated by the results of testing using Mann-Whitney obtained the Asymp value. Sig.(2-tailed) 0.00 less than 0.05 and the results of Normalized Gain

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

categorization. The average increase in the quality of the experimental class reached 0.40 (medium category) and the control class increased by 0.12 (low category). This finding is in line with the results of the study that the Treffinger LM made a positive contribution to the development or improvement of students' mathematical CT skills (Maharani & Indrawati, 2018; Pratiwi & Sari, 2022).

The advantages of the Treffinger LM are possible because the Treffinger LM relies on the philosophy of constructivism, where students build their knowledge and understanding, ranging from non-scientific ideas to scientific knowledge (Lambertus et al., 2016). Treffinger's LM performs learning stages starting from basic elements to more complex ones (Isaksen et al., 2010) In addition, the Treffinger LM in its implementation seeks to combine cognitive and affective dimensions, thus enabling students to get ideas in solving problems to produce CT that can be used in solving various mathematical problems they face (Huda, 2013; Nizham et al., 2017; Rahmadhani & Ahmad, 2022; Salam & Misu, 2018).

The development of mathematical CT skills in this study involved 4 aspects, namely fluency, flexibility, originality, and elaboration. From these 4 aspects, the experimental class is better at developing aspects of fluency, flexibility, and elaboration than the control class. While the control class is better at developing aspects of originality than the experimental class. This means that the Treffinger LM is superior to the guided discovery LM in developing aspects of mathematical CT skills. This advantage is obtained because in its implementation the Treffinger LM provides opportunities for students to understand various concepts, increase student activity in learning activities, develop students' thinking skills, develop students' abilities in presenting data, analyzing data, creating ideas, and trying various problem-solving, students implement their new ideas or ideas in dealing with every problem (Maharani & Indrawati, 2018). Meanwhile, according to Silver (1997), problem-solving and problem-posing can improve CT skills through aspects of fluency, flexibility, originality, and elaboration.

The advantages of the Treffinger LM in developing the aspects of fluency, flexibility, and elaboration that were developed are that the Treffinger LM is better in terms of: (1) developing the ability to generate or generate several ideas quickly, answers and questions quickly and accurately completes relationships, build analogies ; (2) develop the ability to use a variety of different solutions and different answers in a problem solving; (3) develop the ability to detail, develop and generate ideas, solve problems with procedures carried out, logistics, explain, and reasons. While the guided discovery LM only excels in developing aspects of originality, and developing aspects of fluency. The initiation that the guided discovery LM is better in developing the ability to generate original, new, and unique ideas, and answers, ideas; and also good at developing the ability to generate or generate several ideas quickly, answers, and questions quickly and accurately, complete relationships and construct analogies.

CONCLUSION AND SUGGESTION

Based on the discussion above, it can be said: (1) The students' mathematical CT ability can be

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v12i1.5432

improved through the guided discovery LM and Treffinger, (2) The students' mathematical CT ability using the Treffinger LM is better than the guided discovery, (3) Treffinger's LM excels in developing aspects of flexibility, fluency, and elaboration, while the guided discovery LM excels only in developing aspects of originality, dan (4) Treffinger's LM is better at developing students' mathematical CT skills compared to guided discovery.

Based on the findings in this study, the average student's creative thinking ability has not yet reached 75, so it is suggested to apply the Treffinger LM by adding scaffolding or other media so that students' creative thinking ability can increase.

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ISSN 2089-8703 (Print)
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