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Mathematics Creative Thinking Skills in Creative Problem Solving Based on Cognitive Style

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Abstract

The purpose of this study was to describe students' mathematical creative thinking skills based on field independent and field dependent cognitive styles. The research uses mixed research methods with a concurrent embedded strategy. The population in this study were class VIII students of SMP Negeri 1 Sengah Temila in the academic year 2020/2021. The sample selection used cluster random sampling technique and obtained class VIII A as the experiment class and class VIII C as the control class. The final data analysis of the quantitative research used the right-hand average difference test and the normalized gain test. Final data analysis of qualitative research with data triangulation. The results showed that field independent students met the aspects of mathematical creative thinking skills. Field independent students are very interested in the new concepts learned, understand the given structure, good analytical skills and can work independently. Then the field dependent students also meet the aspects of mathematical creative thinking skills. Field dependent students are quite interested in the new concept being studied, do not understand the given structure, use an experiential approach to solving problems, and tend to require guidance and direction to solve problems.

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INTRODUCTION

Mathematics as logical thinking is expected to develop creative thinking skills. As stated by Paul & Elder, (2019) that creative thinking is quality and productive thinking that is important in life. According to Hadar & Tirosh (2019) creative thinking is the ability to generate new ideas or solutions in the problem-solving process. Meanwhile, according to Pehkonen (Siswono, 2010) creative thinking is a combination of divergent thinking and goal-oriented logic. Divergent thinking is a thought process of flexibility, fluency, and novelty. Divergent thinking process will produce many ideas, some of which are problem solving solutions. Furthermore, through logical and rational thinking, the right solution can be produced.

According to Lince (2016) creative thinking in mathematics is solving mathematical problems in a different way from what the teacher teaches in class and is the result of students' own thinking. According to Bolden et al., (2016) creative thinking skills are needed in mathematics to build new knowledge and ways of thinking. The characteristics of creative thinking according to Munandar (Lince, 2016) include: (1) fluency, namely the ability to trigger ideas, solve problems, and provide answers to problems; (2) flexibility, namely the ability to generate ideas, provide varied answers, and use various settlement strategies; (3) originality, namely being able to produce new and unique expressions with unusual thoughts; and (4) elaboration, namely being able to explain in detail, enrich and develop ideas to become more interesting.

According to vecová, Rumanová, & Pavlovičová (2014) developing creative thinking in mathematics, teachers cannot directly teach students to create new and unique solutions, but teachers can create situations where students can think creatively. Teachers must pay attention to the context and situation of student learning by developing understanding and integrating many ideas and knowledge so that students' learning to think creatively in mathematics is better (Sriwongchai, 2015).

Creative thinking skills in mathematics are often neglected in learning activities. Based on the results of observations made by researchers at SMP Negeri 1 Sengah Temila, it shows that learning mathematics in the classroom does not emphasize the creative thinking process. The activities or tasks given by the teacher require less exploration of mathematical ideas and the solutions to the problems offered are also less varied. Then students are only used to solving problems with existing patterns or procedures without any development and expansion of mathematical ideas. The PBL learning that the teacher provides is still not optimal to train students' mathematical creative thinking skills. Learning that is believed to be able to train creative thinking skills in learning mathematics is creative problem solving (CPS) learning.

According to Hsieh (2018) CPS learning is emphasizes the importance of creativity in the problem-solving process through various alternative solutions in creative, innovative, and effective ways. Meanwhile, according to Tseng et al., (2013) CPS is a process of finding and thinking of various creative ideas to reflect on problem solutions from various perspectives by analyzing and comparing the knowledge obtained. Furthermore, Hu, Xiaohui, & Shieh (2017) argue that CPS learning can train problem-solving creativity to prepare students to face more diverse and complex problems in the future.

The stages of CPS according to Treffinger, Selby, & Isaksen (2008) are: (1) understanding the challenge, a systematic effort to define, build, or focus problem solving efforts; (2) generating ideas, is an effort to create ideas by considering many different and detailed options. This stage focuses on examining, reviewing, grouping, and selecting the right ideas to look for possible creative problem solving; and (3) preparing for action, is the stage to decide and develop a problem-solving plan through developing solutions and building acceptance. Solution development includes analysis, refinement, and development of best options.

The results of Chang, Lin, & Chen's research (2019) show that through CPS learning students can provide many creative examples and encourage students to generate different ideas. The results of this study indicate that CPS learning can encourage students' creative thinking skills, especially in learning mathematics. This is based on the opinion of Hadar & Tirosh (2019) that creative thinking in mathematics is able to connect several mathematical ideas, identify relationships, and integrate concepts to develop new knowledge and not follow pre-existing patterns. This opinion is also supported by Maftukhin, Dwijanto, & Veronica (2014) that teacher CPS learning does not only provide knowledge to students, but also facilitates students to build their own knowledge so that students have a better understanding of mathematics.

Learning activities in the classroom also involve students with various characteristics, one of which is cognitive style. According to Sujito et al., (2019) cognitive style is the intellectual ability of students to receive, interact, respond to the learning environment, and process information. According to Prayekti (2018), cognitive style refers to individual cognitive processes in relation to understanding, knowledge, perception, thinking, imagination, and problem solving. The introduction of cognitive styles benefits both teachers and students. According to Margunayasa et al., (2019) the introduction of cognitive styles will help teachers teach according to students' abilities and for students will help them utilize the best ways they learn to improve learning.

According to Shi (2011) cognitive style has a significant influence on learning. Students who know their cognitive style well, enable them to take advantage of the best ways of learning and help expand learning and work potential that benefits students. So teachers need to pay attention to students' cognitive styles in learning, and use learning that is consistent with most students' cognitive styles.

Cognitive style according to Witkin (in Ubuz & Aydınyer, 2019) is divided into two types, namely field independent and field dependent. Someone who has a field independent type of cognitive style responds to tasks in a way that tends to be based on his inner requirements, is more analytical, and chooses a stimulus based on the situation/information he gets so that it is not easily influenced by external perceptions Meanwhile, someone with a field dependent type of cognitive style sees the requirements of his environment in response to a task and has difficulty distinguishing stimuli through the surrounding situation/information so that they are easily influenced by external perceptions.

Based on the description above, it is found that the ability to think creatively is needed by students to face more diverse and complex problems in the future. However, the ability to think creatively is not considered and emphasized in mathematics learning activities. Therefore, through CPS learning with a guided inquiry approach, researchers will try to develop students' creative thinking skills in learning mathematics, considering the field independent and field dependent cognitive styles. The purpose of this study was to describe the ability to think mathematically creatively in CPS learning based on field independent and field dependent cognitive styles.

METHODS

This study uses a combined research method of quantitative and qualitative research (mixed methods) with a concurrent embedded strategy, namely a research method that combines quantitative and qualitative research methods in an unbalanced manner. Quantitative research uses experimental research with a quasi-experimental design of nonrandomized control group, pretest – posttest design. This study used two classes, namely one experimental class and one control class.

The population in this study was class VIII students at SMP N 1 Sengah Temila for the academic year 2020/2021 which consisted of 4 classes, with class VIII A as the experimental class and VIII B as the control class. The quantitative data collection technique used the mathematical creative thinking ability test (TKBKM) method, while the qualitative data collection technique used the GEFT (Group Embedded Figure Test) instrument and interviews.

The feasibility analysis of the test instrument includes validity, reliability, level of difficulty, and discriminatory power. Analysis of quantitative research data includes initial data analysis and final data analysis as a prerequisite test of the hypothesis. The initial data analysis used pretest data, while the final data analysis used posttest data. Initial data analysis includes normality test, homogeneity test, and average similarity test. The final data analysis includes normality test and homogeneity test. The normality test used the Kolmogrov Smirnov test, the normality test used the Levene statistic test, and the average similarity test used the independent sample t test, each at a significant level of 5% using the SPSS program.

After fulfilling the prerequisite test, then the research hypothesis can be tested. Hypothesis 1 test uses the right-side average difference test to test the comparison of mathematical creative thinking skills between CPS learning and PBL learning. Hypothesis 2 test uses the normalized gain test (g) then followed by the average difference test using the independent sample t test assisted by the SPSS program, to test the comparison of increasing mathematical creative thinking skills between CPS learning and PBL learning.

Quantitative data analysis was used to describe the characteristics of students' mathematical creative thinking abilities based on cognitive style. Quantitative data analysis used posttest, GEFT and interview results. Subjects in quantitative research are 2 students in the experimental class whose mathematical creative thinking abilities will be observed based on cognitive style. Students who were selected as quantitative research subjects were subject E-12 with a field independent cognitive style and subject E-29 with a field dependent cognitive style. The steps of quantitative data analysis include data reduction, data presentation, and drawing conclusions. Then the data triangulation was carried out by comparing the posttest data and the interview results of the research subjects to determine whether the data was valid or not.

RESULTS AND DISCUSSIONS

The data from the posttest results for the experiment and control class can be seen in Table 1 below. The data will be used to test hypothesis 1.

Table 1. Posttest Results

Criteria	Class	
	Experiment	Control
Total students	31	30
Highest score	100	85
Lowest score	55	40
Average value	76.13	63.67

Based on Table 1 above, the data obtained that the average TKBKM value for the experimental class is 76.13 and control class is 63.67. So descriptively it can be concluded that the students' mathematical creative thinking ability in the experimental class is better than the control class. These results are then analyzed further through statistical tests using the right-hand average test. The results can be seen in Table 1.2 below.

Table 2. Hypothesis 1 Test Result

s	n_1	$\overline{x_1}$	n_2	$\overline{x_2}$	t_{test}	t_{table}
11,033	31	76,13	30	63,67	4,410	1,671

Based on Table 2 above, the data values of $\boldsymbol{t_{test}}$ = 4.410 and $\boldsymbol{t_{table}}$ = = 1.671 are obtained. Because $\boldsymbol{t_{test}} > \boldsymbol{t_{table}}$ tehen $\boldsymbol{H_0}$ is rejected. This means that statistically the mathematical creative thinking ability in the experimental class is more than the control class. Thus, it can be concluded that the mathematical creative thinking ability in CPS learning is better than PBL learning.

The results of the normality gain (g) of the experimental class and the control class can be seen in Table 3 below. The data will be used to test hypothesis 2.

Table 3. Value of the Gain (g) Normality

Class	Pretest	Posttest	Gain Index	Description
Experiment	53.23	76.13	0.49	Medium
Control	50.17	63.67	0.27	Low

Based on Table 3 above, the data obtained the average of Normality Gain (g) for the experiment class is 0.49 in the medium category, then the average of normality gain (g) in the control class is 0.27 in the low category. So descriptively it can be concluded that the average increase in students' mathematical creative thinking skills in the experiment class is more than the control class. The results were then analyzed further statistically by means of an average difference test using an independent sample t test. The results of the average difference test of the Normality Gain value (g) can be seen in Table 1.4 below.

Table 4. Hypothesis 2 Test Result

SIG.	DECISION
0,000	H_0 REJECTED

Based on Table 4 above, the data value of sig. = 0.000 is obtained. Therefor the value of sig. < 0.05 then $\boldsymbol{H_0}$ is rejected, meaning that the average increase in students' mathematical creative thinking skills in the experimental class is more than the control class. So, it can be concluded that the increase in students' mathematical creative thinking skills in CPS learning is higher than PBL learning.

Based on the description above, it can be concluded that the students' mathematical creative thinking ability in CPS learning is better than PBL learning. This can be seen from the average value of students' mathematical creative thinking skills in CPS learning of 76.13 while the control class is 63.67. Then the increase in students' mathematical creative thinking skills in CPS learning is higher than PBL learning, which is 0.49 in CPS learning and 0.27 in PBL learning.

Furthermore, quantitative data analysis will be carried out to describe students' mathematical creative thinking abilities based on cognitive style. The following is a discussion of mathematical creative thinking skills based on cognitive style on aspects of fluency, flexibility, originality, and elaboration of subjects E-12 and subject E-29.

Write down some possible algebraic forms that if operated the result is $(5xy - 2y)$

Figure 1. Test of Fluency Aspect

Subject E-12 based on the results of the fluency aspect test was able to design an algebraic form that fits the problem as many as 5 possible answers correctly, consisting of addition, subtraction, and multiplication operations. So that the subject of E-12 can provide more than one idea, the calculation process and the results are correct. Then based on the results of the interview, it was found that the subject of E-12 was very interested in the new concepts he was learning so that it stimulated him to look for many possible answers which were the answers to the problems. Thus, subject E-12 fulfills the fluency aspect.

Subject E-29 based on the results of the fluency aspect test can also design possible algebraic forms according to the problems above. However, subject E-29 can only write 2 possible algebraic forms correctly and 1 incorrectly, using addition and subtraction operations. So that subject E-29 can give more than one relevant idea but the answer is still wrong. Then based on the results of the interview, it was found that the subject of E-29 was quite interested in the new concepts he was learning but the results were still not optimal. Thus, subject E-29 meets the fluency aspect.

Determine the area of the plane below using several different ways

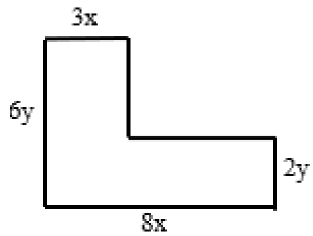

Figure 2. Test of Flexibility Aspect

Subject E-12 based on the results of the flexibility aspect test can provide answers in 3 different ways and the results are correct, using the formula for the area of a rectangle and a trapezoid. Subject E-12 divides the figure above into two parts, each of which consists of a rectangle and a trapezoid. So that the subject of E-12 can give answers in more than one way (various) the calculation process and the results are correct. Then based on the results of the interview, subject E-12 can understand the given structure and is able to design different flat-shaped models to determine the combined area. E-12 subjects also have a high desire to work independently in completing their tasks. Thus, the subject of E-12 fulfills the flexibility aspect.

Subject E-29 based on the results of the flexibility aspect test can give the correct answer using 2 different ways using the formula for the area of a rectangle. Subject E-29 divides the shape above into 2 parts, each of which consists of a rectangular shape. So that the subject of E-12 can give answers in more than one way (various) the calculation process and the results are correct. Then based on the results of the interview, subject E-29 quite understands the given structure, but is still not in depth. The subject of E-29 has not been able to design a trapezoidal flat shape model to determine the combined area. Then Subject E-29 still looks less independent who needs help and reinforcement to complete his task. Thus, the subject of E-29 fulfills the flexibility aspect.

The sum of two numbers is 17. Then 3 times the number the first is 1 more than 2 times the second number. Determine the two

Figure 3. Test of Originality Aspect

Subject E-12 based on the results of the originality aspect test can determine the two numbers that are asked correctly using algebraic concepts using their own way. Subject E-12 uses the concept of algebra, namely by writing the algebraic form then using the equation of the algebraic form to determine the number in question. So that the subject of E-12 can provide answers in their own way, the calculation process, and the results are correct. Then based on the results of the interview, subject E-12 was able to explain well the completion steps he wrote. E-12 subjects can work in their own situations using the algebraic concepts they have learned. Thus, the subject of E-12 meets the originality aspect.

Subject E-29 based on the results of the originality aspect test can also determine the two numbers asked in their own way. subject E-29 writes down an algebraic form that fits the problem then with the algebraic equation it is possible to determine the number in question using his own way. So that the subject of E-29 can provide answers in his own way, the calculation process, and the results are correct. Then based on the results of the interview, subject E-29 was also able to explain well the completion steps he wrote down. Subject E-29 uses an experience approach in solving it. The experience is obtained from the results of previous studies. Thus, the subject of E-29 meets the originality aspect.

John's father is 5 times older than John and John is 2 times older than her sister Mery. In another two years' time, the sum of their ages is 58 years. How old is John now?

Figure 4. Test of Elaboration Aspect

Subject E-12 based on the results of the elaboration aspect test can determine John's age correctly. Subject E-12 wrote in detail the completion steps used using algebraic concepts. Subject E-12 wrote down each algebraic form for John's father Mery and John in two years. Then make an algebraic equation for the sum of their ages 58 years and determine John's age correctly. So that the subject of E-12 can provide correct and detailed answers. Then based on the results of the interview, subject E-12 was able to explain well and in detail the steps of completion he wrote, starting from compiling algebraic forms, making algebraic equations, and determining algebraic values. E-12 subjects have good analytical accuracy and skills and can solve complex problems with their own frame of mind. Thus, subject E-12 fulfills the elaboration aspect.

Subject E-29 based on the results of the elaboration aspect test obtained inaccurate results. Subject E-29 erred in making an algebraic equation for the sum of the ages of John's father, Mery, and John. However, in the process of completion, the subject of E-29 was able to write down in sufficient detail every step of the settlement used. The subject of E-29 has been able to make an algebraic form that fits the problem, only making a mistake in making the algebraic equation. So that the subject of E-29 can provide answers in sufficient detail, but the results are wrong. Then based on the results of the interview, subject E-29 gave a good response to every question given and was able to explain in sufficient detail the completion steps he wrote. However, the subject of E-29 tends to require guidance in the form of instructions and directions to find answers to these problems. Thus, the subject of E-29 fulfills the elaboration aspect.

The recapitulation of the acquisition of aspects of mathematical creative thinking skills for subjects E-12 and subject E-29 can be seen in Table 5 below.

Table 5. Results of Analysis Mathematical Creative Thinking Skills

	Fluency	Flexibility	Originality	Elaboration
E-12	√	√	√	√
E-29	√	√	√	√

Based on Table 5 above, students' mathematical creative thinking skills in CPS learning meet the aspects of mathematical creative thinking skills which include fluency, flexibility, originality, and elaboration. The application of CPS learning with the stages of exploring challenges, generating ideas, and implementing solutions helps students to deepen and expand their algebraic knowledge. Students can find ideas that are relevant to the problem and provide problem solutions with a variety of answers and unique ways and are able to explain the results in detail. These results are in accordance with the results of research by Fitriyantoro & Prasetyo (2016) that CPS learning allows students to smoothly express their ideas to provide answers, can use different methods, be flexible, be able to show different and unique ideas, and be able to develop thoughts and provide ideas. detailed in his thoughts.

Furthermore, the analysis of mathematical creative thinking skills based on field independent, and field dependent cognitive styles is as follows. Based on the fluency aspect, independent filed students are very interested in the new concepts they are learning so that it stimulates them to look for many possible answers which are answers to problems. Then the field dependent students are also quite interested in the new concepts they are learning but the results are still not optimal.

Based on the flexibility aspect, field independent students can understand the given structure so that they are able to design a solution model and find different ways and strategies to solve problems. Then the field dependent students quite understand the given structure, but they are still not deep.

Based on the originality aspect, field independent and field dependent students both can provide answers in their own way and the results of their own thoughts.

Furthermore, based on the elaboration aspect, field independent students have accuracy and good analytical skills and can solve complex problems with their own frame of mind so that they are able to describe problems and explain them in detail. Then field dependent students can also explain in detail their thoughts but tend to require guidance in the form of instructions and directions to find answers to these problems.

Based on the description above, it can be concluded that field independent students in the mathematical creative thinking process are very interested in new concepts so that they stimulate them to find new methods and strategies to solve problems in their own way independently. Then field independent students also have good analytical skills with good accuracy so that they can describe problem solving solutions in detail. Furthermore, field dependent students in the mathematical creative thinking process are quite interested in the new concepts they are learning but are still not optimal, because they use an experiential approach in solving problems. Then field dependent students understand enough about the given structure but are not deep and good enough in explaining in detail the results of their thoughts and field dependent students tend to need guidance in the form of instructions and directions to find solutions to problems.

CONCLUSION

Based on the description above, it can be concluded that, field independent students in the mathematical creative thinking process are very interested in new concepts so that they stimulate them to find new methods and strategies to solve problems in their own way independently. Then field independent students also have good analytical skills with good accuracy so that they can describe problem solving solutions in detail. Furthermore, field dependent students in the mathematical creative thinking process are quite interested in the new concepts they are learning but are still not optimal, because they use an experiential approach in solving problems. Then field dependent students understand enough about the given structure but are not deep and good enough in explaining in detail the results of their thoughts and field dependent students tend to need guidance in the form of instructions and directions to find solutions to problems.

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