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The Effect of a Creative-Problem Solving Learning Model Based on an Open-Ended Approach Toward High Level of Mathematical Thinking Ability of Students

Pengaruh Model Pembelajaran *Creative - Problem Solving* Berbasis Pendekatan *Open-Ended* Terhadap Kemampuan Berpikir Matematis Tingkat Tinggi Siswa

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Abstract

Twenty-first-century learning focuses on developing students' mathematical thinking skills. This study examines the impact of the Creative Problem Solving (CPS) model using an Open-Ended approach to creative thinking, mathematical communication, and adversity quotient. The research employs a quasi-experimental design with a pretest-posttest non-equivalent control group at a junior high school in Bukittinggi, Indonesia. Instruments used include tests for creative thinking skills, mathematical communication, and a questionnaire for adversity quotient. Analysis was conducted using Hotelling's T2 and univariate tests, revealing that the CPS model positively influences all three abilities.

Keywords*: Adversity Quotient; Creative Problem Solving; Creative Thinking Skills; Mathematical Communication Skills.*

Abstrak

Pembelajaran abad kedua puluh satu fokus pada pengembangan kemampuan berpikir matematis siswa. Penelitian ini mengkaji pengaruh model Creative Problem Solving (CPS) dengan pendekatan Open-Ended terhadap kemampuan berpikir kreatif, komunikasi matematis, dan adversity quotient. Penelitian ini menggunakan desain quasi eksperimen pretest-posttest non-equivalent control group di SMP di Bukittinggi, Indonesia, instrumen yang digunakan meliputi tes kemampuan berpikir kreatif, tes komunikasi matematis, dan angket adversity quotient. Analisis dilakukan menggunakan Hotelling's T2 dan uji univariat, dengan hasil yang menunjukkan bahwa model CPS berpengaruh positif terhadap ketiga kemampuan tersebut.

Kata Kunci*: Adversity Quotient; Creative Problem Solving; Kemampuan Berpikir Kreatif; Kemampuan Komunikasi Matematis.*

Introduction

Education has a huge role in the formation of the character of a nation's society, mental growth, and the ability to run individual and social life. Along with the development of the times, the advancement of Science and technology, the challenges of education in the future will be more severe and competition is also getting tougher. To face these challenges, education graduates are needed who are not only skilled in one field, but also creative in developing the competencies they master. This can be realized through any subject in school, including mathematics. Mathematics has contributed a lot to the development of Science and technology [1]. To achieve student mastery of Mathematics must be done by building an active learning system, creative and innovative that can enable students in the learning process [2].

Meanwhile, based on observations made by the learning process that occurs in one of the junior high schools in Bukittinggi has not supported the improvement of high-level mathematical thinking skills of students. This is also shown by the results of the pretest conducted on the mathematical ability of students who are still at a low level. 21st century learning is expected to improve students' thinking skills. Students' thinking skills need to be improved, especially at high levels of thinking skills [3]. Among the high-level thinking skills of students that need to be developed in the 21st century are creative thinking skills and communication skills [4]. Creative thinking will provide various solutions to the problems faced [5].

Creative thinking in mathematics is a combination of logical thinking and divergent thinking based on intuition but in consciousness with attention to aspects of flexibility, fluency, elaboration, and novelty [6]. The ability to think creatively in mathematics by paying attention to these aspects can be

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associated with mathematical communication skills. By thinking creatively students become flexible in stating something. So this needs to be supported by the ability of students to communicate to express mathematical ideas through writing, language, and various other visual forms in the form of images and graphics[7]. Mathematical communication skills means being able to explain mathematical concepts rationally by proposing reasons in solving mathematical problems[8].

Educational activities to develop students' creative thinking and mathematical communication skills. But in the process it is not uncommon to make students easily despair and cry, so other efforts are made so that students are able to learn in the face of the difficulties they face. The strength that a person has in facing and facing difficulties with the intelligence that they have so that they face challenges to be solved with the adversity quotient (AQ) [9]. The Adversity quotient is divided into 3 types: (1) quitters type is the type that is easy to give up, tend to be passive and lack of motivation in solving problems; (2) campers type is a group easily satisfied with the success that has been achieved; (3) climber type is a group that is willing to face all obstacles, and has a high motivation to achieve everything dreamed of [10]. Students who have a high level of adversity quotient tend to be able to use creative thinking skills and mathematical communication skills better, and more achieve the ability indicators set [11] [12].

In order for the learning process in the classroom to build the development of creative thinking skills, mathematical communication skills, and student adversity quotient, it is necessary for the teacher's efforts to facilitate by implementing appropriate learning models. One of the learning models that are closely related to creative thinking skills and mathematical communication skills is the Creative Problem-Solving (*CPS*) learning model

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[13] [14]. The CPS learning Model emphasizes analytical thinking by making the creative aspect the differentiator. Students are required to be active, practice thinking, and apply knowledge and skills to everyday life [15] [16]. There are three main steps in the CPS learning model: understanding the challenge includes the stages of constructing opportunities, exploring data, and framing problems; generating ideas; and preparing for action includes the stages of developing solutions and acceptance-finding.

A learning model can be combined with a learning approach that can also help facilitate the learning process that can develop student skills. One of the learning approaches that can be used to measure creative thinking skills and mathematical communication skills, as well as see the level of student adversity quotient is an open-ended approach. Open-ended learning is learning that begins by presenting an open-ended problem, after which learning is continued with the use of many correct answers that aim to provide experience for students to discover something new [17]. The creative problem-solving learning model has the potential to be combined with an open-ended approach can develop high-level thinking skills of students by providing flexibility for students to explore the problem in depth [18]. However, it is not known empirically the effect of the learning process by applying the creative problem-solving learning model based on an open-ended approach to the ability to think creatively, mathematical communication, and adversity quotient of students. Therefore, the researcher considers the need to carry out research on learning creative problem-solving learning model based on an open-ended approach to measure its effect on creative thinking skills, mathematical communication skills, and adversity quotient of students.

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Methods

This study is a quantitative research with quasi-experimental method) using Pretest-Posttest Non-equivalent Control Group Design. This study aims to determine the effect of creative problem-solving learning model with an open-ended approach to the ability to think creatively, mathematical communication skills, and adversity quotient of students. This study was conducted on two groups of students, namely the experimental group and the control group. Grouping of students in the experimental group and control group in this study was not done randomly, due to the difficulty of regrouping students who have been grouped in their respective classes by the school.

The pretest - potstest non-equivalent control group design is presented in Table 1.

Table 1. Research Design

Group	*Pretest*	Treatment	*Posttest*
Experiment	O_1	Xe	O_3
Control	O_2	X_k	O_4

O_1 : *Pretest experimental class*
O_2 : *Pretest control class*
X_e : Learning with *CPS* learning model based on open-ended
X_k : Learning with *CPS* models
O_3 : Posttest experimental class
O_4 : Posttest control class

Data collection techniques using test and non-test techniques. Students were given a pretest in the form of description questions to measure creative thinking skills and mathematical communication skills, as well as an adversity quotient questionnaire to see students' initial abilities. Then the students were given the treatment of learning CPS model based on open-ended approach in the experimental class and learning CPS model in the control class.

Data collection instruments are creative thinking skills, mathematical communication skills, and adversity quotient questionnaire. The indicators of creative thinking ability measured in this study are fluency, fluency, originality, and elaboration. Meanwhile, indicators of mathematical communication skills measured are: using symbols, notation, and mathematical structures in making mathematical modeling according to the problem (KM1); communicate mathematical thinking clearly and logically (KM2); (3) express mathematical ideas using written, oral, and able to describe virtually (KM3); (4) draw conclusions based on solutions obtained

from solving problems (KM4). Furthermore, the measured adversity quotient indicators are control, ownership, reach, and endurance.

The research instruments were tested for validity and reliability estimation first. Validity is the validity of the content and construct validity. The validity of the content is an assessment given by expert judgment. Content validity includes: face validity which contains grammar, writing format, item legibility, the existence of answer keys, table layout, tables, figures, graphs, and diagrams; and logical validity which contains the suitability of competency standards, basic competencies, and indicators of competency achievement as measured by instruments designed.

Construct validity relates to the extent to which the instrument measures the theoretical construct to be measured. Construct validity test is done after the content validity process which is then followed by trials on test subjects. Construct validity test was conducted on test instruments and non-test instruments, namely questions that measure students 'creative thinking skills, students' mathematical communication skills, and students ' adversity quotient questionnaires. The Data obtained from the test results and non-test instruments were analyzed using IBM SPSS Statistics 22 software with Factor Analysis. Factor analysis was done by looking at the results of the Kaiser Meyer Olkin test (KMO) Measure of Sampling. If the KMO value is more than 0.5 and the significance level is less than 0.05, the factor analysis can be continued using Confirmatory Factor Analysis (CFA). Based on the analysis that has been done, it is obtained that the indicators used are valid and able to measure the variables of creative thinking ability, mathematical communication, and adversity quotient.

The reliability of the instrument was analyzed using empirical test data of creative thinking ability, mathematical communication ability, and advertsity quotient questionnaire aimed at estimating the reliability of the instrument by looking at the cronbach's Alpha value. The instrument used in this study is said to be reliable if the estimated value of reliability obtained is more than or equal to 0.60. Based on the results of analysis using IBM SPSS Statistics 22 rocks obtained the value of the reliability coefficient (Cronbach's Alpha) on the creative thinking ability test instrument, mathematical communication skills, and adversity quotient questionnaire more than 0.60 so that the research instrument is said to be reliable.

Data analysis techniques performed in this study in the form of descriptive and inferential analysis. Descriptive analysis aims to describe the data while inferential analysis aims to test research hypotheses obtained with the help of IBM SPSS Statistics 22. Before the hypothesis test, outlier detection aims to see the presence or absence of extreme values in the research data, test the assumption of normality, and homogeneity first.

Multivariate normality test was carried out using the Mardia Test assisted by the R program. Meanwhile, normality test was conducted on each dependent variable in experimental class and control class using kolmogorov-smirnov test conducted on each dependent variable in experimental class and control class with significance level $\alpha = 0.050$. If the data is not normally distributed then the non-parametric test is Mann Whitney test. If the data is normally distributed then proceed with the homogeneity test. Homogeneity test conducted is homogeneity test variance and variance Matrix test using Levene Statistic and box's M Test.

Hypothesis test applied in this study using multivariate hypothesis test using Hotelling's T^2 test, while the hypothesis test of the influence of learning models on each dependent variable using an independent sample t-test. Then calculated the effect size is given by using the Partial Eta Square formula for multivariate hypothesis and Cohen'sd formula for the hypothesis of influence on each dependent variable.

Result and Discussion

Based on the results of the study, the following is presented a descriptive analysis of the results of pretest and post-test creative thinking skills in Table 2

Table 2. Descriptive Analysis Results

	Creative Thinking Skills				Mathematics Communication Skills				*Adversity Quotient*			
	Experiment Class		Control Class		Experiment Class		Control Class		Experiment Class		Control Class	
	Pre.	Post.	Pre.	Post.	Pre.	Post.	Pre.	Post.	Pre.	Post	Pre.	Post
Min.	0	0	0	0	0	16.67	0	8.33	53.00	61.00	55.00	59.00
Max.	16.67	66.67	25	66.67	66.67	100	25.00	83.33	88.00	93.00	93.00	94.00
$\bar{x}$	7.28	41.94	7.22	17.78	31.95	55.56	7.78	45.00	69.93	75.20	74.00	74.57
SD	8.17	18.37	8.11	17.33	24.77	18.22	8.73	20.01	9.51	7.68	8.04	8.05

Based on the results of descriptive analysis, it can be seen that there is a difference in the average value of the experimental class and control class before treatment and after treatment which shows the influence of CPS model based on open-ended approach to the ability to think creatively, mathematical communication skills, and adversity quotient of students.

Before performing the inferential hypothesis test, outlier detection, multivariate and univariate normality test, and covariance and variance homogeneity are performed to determine whether the data obtained are from data with normal distribution and have the same variance.

Univariate outlier detection using *Mahalanobis* distance boxplot and chi-square. Based on the detection of outliers against univariate data, detected outliers in the posttest data creative thinking skills of the control

class on the 1st data. However, the researchers did not remove outliers because outliers are not seen to have a biased effect on subsequent analysis. Meanwhile, multivariate data counter detection compares *Mahalanobis* distance value with chi-square. Based on the results of the detection of multivariate outliers, that the research data does not contain multivariate outliers because the value of the distance *Mahalanobis* pretest and posttest data of each research subject is less than the critical value ($\chi^2_{0,01(3)} = 11.3449$).

Calculation of multivariate normality test using R Program. The test statistic used for multivariate normality assumption is Mardia test. Multivariate normality test results are presented in Table 3.

Table 3. Multivariate Normality Test Results

Data	Group	Mardia Test
Before Treatment	Experiment	$\hat{\gamma}_{1,p} = 3.942$
		p-value Mardia Skewness = .949
		$\hat{\gamma}_{2,p} = -1.825$
		p-value Mardia Kurtosis = .068
	Control	$\hat{\gamma}_{1,p} = 13.644$
		p-value Mardia Skewness = .189
		$\hat{\gamma}_{2,p} = -1.393$
		p-value Mardia Kurtosis = .163
After Treatment	Experiment	$\hat{\gamma}_{1,p} = 0{,}623$
		p-value Mardia Skewness = .116
		$\hat{\gamma}_{2,p} = .050$
		p-value Mardia Kurtosis = .960
	Control	$\hat{\gamma}_{1,p} = 11.546$
		p-value Mardia Skewness = .317
		$\hat{\gamma}_{2,p} = -0.2988$
		p-value Mardia Kurtosis = .765

Based on Table 3. it can be seen that the p-value of Mardia Skewness and Mardia Kurtosis of each group is more than α (.05), so it can be concluded that overall H_0 is accepted, which means that each class has multivariate normal distribution.

The following Table 4. presents the results of the univariate normality test post-test data creative thinking skills, mathematical communication skills, and adversity quotient.

Table 4. Univariate Normality Test Results

	Creative Thinking Skills		Mathematics Communication Skills		*Adversity Quotient*	
	Experiment	Control	Experiment	Control	Experiment	Control
p-value	.318	.132	.557	.618	.759	.927

Based on Table 4, it can be seen that the p-value of both classes in each creative thinking ability, mathematical communication ability, and adversity quotient is more than .05, so it can be concluded on the ability to think creatively, mathematical communication, and adversity quotient both groups come from a normally distributed population.

Furthermore, covariance and variance homogeneity tests were conducted. Calculation of covariance matrix homogeneity using the help of IBM SPSS Statistics 22 by looking at the Test box's M. The following are presented in Table 5 results of covariance matrix homogeneity test before and after treatment.

Table 5. Covariance Matrix Homogeneity Test Results

	Box's M	F	*p-value*	Description
Before Treatment	12.130	1.908	.076	Homogen
After Treatment	2.475	.389	.886	Homogen

Based on Table 5, it can be seen that the p-value for the homogeneity test before treatment is .076 and after the treatment is .886 where the value is greater than 0.05, this means that the covariance matrix of pretest and posttest data is homogeneous so that the data of creative thinking ability, mathematical communication ability, and adversity quotient of students have the same level.

Table 6. Univariate homogeneity test results Pretest and Posttest

	Dependent Variable	*Levene Statistic*	*p-value*	Description
Pretest	Creative Thinking Skills	.581	.449	Homogen
	Mathematics Communication Skills	1.741	.192	Homogen
	Adversity Quotient	1.843	.180	Homogen
Posttest	Creative Thinking Skills	.142	.708	Homogen
	Mathematics Communication Skills	.663	.419	Homogen
	Adversity Quotient	.017	.898	Homogen

Based on Table 6 shows the p-value of the test results homogeneity of creative thinking skills, mathematical communication skills, and adversity quotient of students before treatment and after treatment of more than .05, so that the assumption of homogeneity of variance is met.

After the assumption of normality and homogeneity test pre-test and post-test data, then the next hypothesis test. Hypothesis test conducted consists of multivariate and univariate hypothesis test. Multivariate test calculation pre-test and post-test data using the help of IBM SPSS Statistics 22 with statistical test Hotelling's T^2 presented in Table 7.

Table 7. Multivariate Test Results Pretest Data

	Pretest			*Postest*		
	T^2	F	*p-value*	T^2	F	*p-value*
Hotelling's T^2	.079	12.492	.995	.527	9.840	.000

Based on Table 7, it can be seen that the p-value of multivariate hypothesis test (.995) is more than .05. These results identified that at the significance level of 0.05 showed no difference in the average pre-test value of the experimental class and the control class, so it was concluded that the ability of students in both groups is relatively the same. Meanwhile, the significance value of multivariate test results post-test data (.000) is less than .05. These results identify that at the significance level of .05 indicates there is a difference in the average value of experimental and control class post-test, so H_0 means there is an effect of the application of *CPS* learning model based on an open-ended approach to the ability to think creatively, mathematical communication skills, and adversity quotient students. The value of effect size (partial eta squared) obtained is .345.

Univariate hypothesis test on the ability to think creatively, mathematical communication, and adversity quotient conducted with the help of IBM SPSS Statistics 22 using independent sample t-test.

Table 8. Independent Sample t-Test Results

Dependent Variable	t	df	*p-value*
Creative Thinking	5.240	58	.000
Mathematics Communication	2.316	58	.037
Adversity Quotient	.312	58	.756

Based on the test results of the independent sample t-test the ability to think creatively and mathematical communication, count more than t-table and p-value less than .05. This is it identifies that the learning model with CPS learning model based on an open-ended approach has a better effect than

learning with *CPS* model if it is oriented to creative thinking skills and mathematical communication skills of students. Meanwhile, the test results of independent sample t-test adversity quotient, t_{count} less than t_{table} and the p-value is more than .05. It identifies that learning model with *CPS* learning model based on an open-ended approach has no effect on the adversity quotient. it has no better effect than learning with *CPS* model too if it is oriented to the student's adversity quotient. The amount of influence exerted on each variable is shown by Table 9.

Table 9. Effect Size

Dependent Variable	*Effect Size*	Description
Creative Thinking	1,36	Strong
Mathematics Communication	3,02	Strong
Adversity Quotient	0,08	Weak

In general, the application of *CPS* learning model based on an open-ended approach has an influence on the ability to think creatively, mathematical communication skills, and adversity quotient of students. Analysis of each dependent variable obtained the results that the application of *CPS* learning model based on an open-ended approach has an influence on the ability to think creatively and mathematical communication skills, but has a weak influence on the student's adversity quotiont. Furthermore, learning with *CPS* model based on open-ended approach has a better effect than learning with *CPS* model to improve students' creative thinking and mathematical communication skills.

The experimental class in this study is a *CPS* learning model based on an open-ended approach and in the control class apply *CPS* model. Based on the results of inferential statistical tests in multivariate obtained that there is an effect of the application of *CPS* learning model based on an open-ended approach to the ability to think creatively, mathematical communication skills, and adversity quotient of students. Meanwhile, univariate obtained the results that learning with *CPS* learning model based on an open-ended approach has a better effect than learning with *CPS* model on students ' creative thinking skills and mathematical communication skills of students. However, the *CPS* learning model based on an open-ended approach has a weak influence on the student's adversity quotient. The results of this study in accordance with previous research by Windarti the influence of the CPS model on students' creative thinking skills but in his research obtained the

results that there is an influence of CPS model on the adversity quotient of students [19].

Based on the analysis conducted, the main factor that makes learning mathematics by applying *CPS* learning model based on an open-ended approach has a better effect than learning with *CPS* model is on learning steps that combine each component of the CPS model and open ended approach, especially on generating ideas and preparing for action components that direct students to generate creative ideas, develop solutions that have been obtained, and think openly in solving problems. This is in line with the research of Rolia which states that the learning step of the CPS model makes the classroom dynamic [20]. There are some differences in the implementation of learning design prepared by teachers in each experimental class and control class. As for some of the things that teachers do in the experimental class, namely: (1) in the experimental class that applies *CPS* learning model based on an open-ended approach emphasizes students to solve problems openly; (2) teachers who act as facilitators get used to interacting with students in the form of giving open-ended questions (3) the learning process is also facilitated by the provision of student worksheets (LKS) that have been designed in the form of open problems and the learning process is carried out with group discussions so as to facilitate the interaction of teachers with students (4) The teacher directs students in each group to choose a solution to the problem presented is different from other groups and generate a variety of ideas, using a variety of steps to resolve, and find solutions to various problems.

Meanwhile, the activities carried out by teachers in control classes that apply creative problem-solving models are: (1) the learning process is carried out in groups and facilitated by the provision of worksheets, but the thing that distinguishes the experimental class is the problem presented in the worksheet. In the control class, the problems presented are in the form of closed-ended problems but still pay attention to the creative aspect, namely the teacher directs students to use various alternatives to solve the problem so as to produce the right solution; (2) The teacher acts as a facilitator directing students to solve a problem based on several solutions that have been designed by the teacher; (3) The teacher does not require students to

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choose the solution of the problem presented differently from the rest of the group.

Conclusion

The results of statistical tests showed that the creative problem-solving learning model based on an open-ended approach has an influence on the ability to think creatively, mathematical communication skills, and adversity quotient of students. The limitations of this research include the existence of other variables that influence the research results that cannot be controlled by the researcher, such as the time of research implementation, the student learning environment, and the learning material used in this research is limited to Straight Line Equations, so the conclusions obtained only cover the material. It is hoped that future research can use different materials.

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