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The effect of creative problem-solving learning model using geometry transformation book based on Al-Qur'an on students' van Hiele thinking level and learning outcome

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Abstract. This study aimed at analyzing the differences between Creative Problem Solving and conventional learning model to students' van Hiele geometric thinking level and learning outcome. This study used quasi-experimental design, and this paper focused on the implementation phase of design research. Research subjects were determined by random sampling technique, i.e., an experimental class of 12 students and a control class of 11 students. The Geometry Transformation book was developed based on Al-Quran and includes a discussion on the relationship between geometry concepts and Al-Qur'an. The results of this study showed that the level of geometric thinking ability of 33.33% of the students in the experiment class is at level 4, while only 9.09% of the control class is at the same level. The ANAKOVA test showed that there was a significant difference ($P = 0.041 < \alpha = 0.0050$) in cognitive learning result between the experimental class (63.08) and the control class (59.27).

1. Introduction

The development of education and teaching is closely related to the progress of Science, Technology, and Arts. Furthermore, from the Islamic perspective, the survival of humankind depends on how human beings develop their scholarship in receiving education and teaching as life regulators. The presence of the ASEAN Economic Community (AEC) with its free market system constitutes a form of the impact of the progress in the fields of science and technology on economics. On the other hand, the development of science and technology can negatively impact and even endanger human life and dignity. Currently, ethics and modesty are often forgotten by society [1] and this can be a threat to the next generation. Thus, university as a higher education institution is tasked with organizing education and teaching based on cognitive abilities. [2]. The Department of Mathematics Education of Muhammadiyah University of Surabaya has developed a learning process using Al-Quran-based Geometry Transformation. Therefore, the role of religion as a guide of life becomes the main lesson to be taught based on Islamic aqidah.

CPS model is a variation of learning by problem-solving through systematic techniques in organizing creative ideas so that the learning can take place engagingly, thus generating motivation and encouraging students to construct their knowledge [3]. In this case, the basic skills students need in CPS learning are the abilities to (1) declare the sequence of problem-solving steps; (2) find possible problem-solving strategies; (3) evaluate critically; (4) choose an optimal solution option; and (5) develop a plan for implementing problem-solving strategies. The goals of CPS instruction are: (1) students are able to state the sequence of problem-solving steps in CPS; (2) students are able to find possibilities of CPS strategy; (3) students are able to evaluate and select those possibilities in relation

to the existing criteria; (4) students are able to choose an optimal solution option; (5) students are able to develop a plan in implementing CPS strategy; and (6) students are able to articulate how CPS can be used in various fields or situations. Furthermore, as a combination of Von Oech and Osborn procedures, CPS steps in mathematics learning are namely (1) problem orientation; (2) finding facts; (3) finding problems; (4) finding ideas; (5) finding solutions; (6) finding acceptance [5]. CPS learning model emphasizes understanding a concept and the importance of direct experience involved in the learning process in building meaningful experiences on the students. Meaningful learning process means that the learning can make the students understand and realize that a mathematics concept has meaning and usefulness [6]. Therefore, CPS learning is designed based on Al-Quran by connecting mathematical concepts with the Qur'an, especially in Transformation Geometry topic. The learning design using Al-Qur'an approach connects mathematics and Qur'an, especially in geometry. The relationship between geometric concept and the Qur'an is included in a textbook that serves as an additional reference book for students. Each chapter of the textbook will be extracted from the essence or outline of the problems associated with Islamic values to build meaningfulness in the process of Islamic geometry learning.

Geometry is learned with a concept that can be used to motivate and attract students' attention and stimulate their imagination. Activities in geometry can be used to introduce new ideas by starting with something tangible, an experience that manipulates to produce new insights [7]. The geometrical ability can be measured using van Hiele theory of five thinking levels. van Hiele geometry thinking levels are (1) level 0 (visualization); when students are on shape recognition level; (2) level 1 (analysis); when students' thinking ability develops by describing a shape using their language according to the previous level, (3) level 2 (abstraction); when students use a language to know the difference of each shape according to the previous level; (4) Level 3 (informal deduction), when students' deductive thinking has begun to develop and deductive reasoning as a way to build geometric structures in an axiomatic system has been understood; (5) Level 4 (formal deduction), when students can work in various axiomatic deduction structures [8]. The improvements of geometric thinking ability in each van Hiele level is used by a lecturer to help students improve their geometric thinking ability as indicated in students' learning outcome.

Learning outcomes can be assessed and measured that are used as evaluations to determine the success of a learning process. There are three domains of learning outcomes to be studied as the indicators of student learning outcomes, namely cognitive, affective, and psychomotor domains. Cognitive domain is measured through tests. Affective domain assessed is the Islamic attitude that supports students' understanding of mathematical concepts. Islamic attitudes students can obtain through CPS learning model on Quran-based books include: (1) Honesty, as seen in the need for absolute and unchangeable consistency of truth based on facts in the process of solving mathematical problems; (2) Patience, as seen when the students cope with a complicated and long mathematical completion process that requires a spirit of unyielding; and (3) Carefulness and thoroughness, which can be seen during the mathematics learning process that demands high level of carefulness and analysis. These three traits are closely related to the values contained in the Qur'an [9].

The CPS learning model can improve the mastery of concepts and skills [10]. In addition, CPS learning model also affects the ability of mathematical problem solving [11]. Therefore, the purpose of this study is to find out the influence of the complementary Quran-based CPS learning model textbook on student's van Hiele thinking levels and learning outcomes in Transformation Geometry course. Therefore, this study aimed at analyzing the differences between Creative Problem-Solving and conventional learning models in students' van Hiele geometric thinking levels and learning outcome.

2. Method

This research used quasi-experimental research method which was applied to two groups: experimental group (E), treated with Creative Problem-Solving learning model using Geometry Transformation's book based on Al-Quran, and control group (K), treated with conventional learning model. The research design used Pre-test-Post-test Control Group Design; both the experiment and

control groups took a pre-test and a post-test before and after learning. The research involved 23 students who were divided into two classes, and the Department of Mathematics Education of Muhammadiyah University of Surabaya were chosen as the research population. Sample determination was done randomly through cluster sampling, with an experimental group of 12 students and a control group of 11 students. The two instruments used were treatment and measurement. Syllabus treatment instrument was in the form of syllabus, lesson plan, and student worksheet. Measurement instruments used in this study consisted of learning assessment instrument (cognitive, affective, and psychomotor) and van Hiele geometry rating instrument of thinking levels. Content validation by three experts was conducted before the instruments were used. Empirical validity test was conducted on 40 mathematics education students in State Islamic University of Sunan Ampel Surabaya, assisted by a set of validity test using SPSS program. The test showed that 5 out of 6 test questions on cognitive learning outcomes were valid. Only 1 test question was not valid, while the other 5 test questions of geometric ability made based on the indicators of van Hiele's levels of thinking were all valid. The test on the questions dealing with cognitive learning outcome yielded the coefficients of 0.761, while the test on geometry based on van Hiele's thinking levels yielded the coefficients of 0.784. The prerequisite test resulted in homogeneous and normal data. Descriptive and covariance analyses (ANAKOVA) were used in data analysis. Descriptive analysis was used to describe the learning process of students' psychomotor and affective assessment. Covariance analysis was used to test the research hypothesis.

The affective learning outcome of Creative Problem-Solving learning model using Geometry Transformation's book based on Al-Quran was obtained by observing the students' Islamic attitudes during the learning process, which include: (1) Honesty; Mathematics is a science that is closely related to honesty as can be observed in how the students solve math problems. A mathematical problem is a matter of consistent, absolute and unchangeable truth. This is in accordance with the meaning of honesty; saying something with facts. (2) Patience; Learning mathematics teaches students to be patient in dealing with everything in life. Solving difficult mathematical problems requires patience and persistence to arrive at the correct result. (3) Carefulness and thoroughness; learning mathematics trains students to be more careful and thorough in their action to avoid misunderstanding the graphs or miscalculations.

3. Results and discussion

In this study, students' learning outcomes are in the form of cognitive, affective, and psychomotor learning outcomes. The cognitive learning outcomes were measured through a written test. Description of the cognitive test learning outcomes is shown in Table 1. Table 1 indicates that the mean values of the control class pretests are greater than those of the experimental class, while the mean score of post-test of the experimental class is greater than that of the control class. The mean value of cognitive learning outcome of experimental class (63.08) is higher than that of the control class (59.27). This implies that the treatment given to the experiment class was able to produce greater post-test value than the untreated control class. The result of the analysis of the influence of CPS learning model based on Al-Qur'an approach to the cognitive learning outcomes showed that there are significant differences in post-test values of cognitive learning outcomes between experimental and control classes ($p = 0.000 < \alpha = 0.050$). Furthermore, there is a difference of post-test value in terms of cognitive learning outcomes between experimental class and control class as indicated by the significant pre-test data value ($p = 0.041 < \alpha = 0.050$)

Table 1. The average value of cognitive learning outcome.

	Pretest	Post-test		
	Mean	Mean	Std. Deviation	N
Experiment	52.6	63.08	1.17	12
Control	56.0	59.27	1.22	11
Total	108.6	122.36	2.39	23

Psychomotor and affective learning outcomes were obtained through observation during the learning process. Psychomotor assessment includes assessment of work performance by observing students' activities in completing Student Worksheet. The assessment aspects include (1) Completeness, (2) Accuracy of calculation and (3) Accuracy of writing formulas and units. Description of the average value of psychomotor learning outcome can be seen in Table 2.

Table 2. The average value of psychomotor learning outcome.

	Psychomotor learning outcome			Average
	Completeness	Accuracy of calculation	The accuracy of writing formulas	
Experiment	87.5	78.90	83.00	83
Control	81.0	75.40	78.00	78
Average	84.3	77.15	80.50	81

Affective learning outcome was obtained by observing the students' Islamic attitudes during the learning process, which include: (1) Honesty, (2) Patience, and (3) Carefulness and thoroughness. The overall description of the affective learning outcome can be seen in Table 3. Based on Table 3, general the average value of affective learning outcome of the experimental class is higher than that of the control class.

Table 3. The average value of affective learning outcome.

	Affective learning outcome			Average
	Honesty	Patience	Careful and thorough	
Experiment	82.3	81.80	85.80	83
Control	81.0	77.10	73.50	77
Average	81.7	79.45	79.65	80

The data on students' geometric ability can be measured using 5 description questions. The data on the van Hiele thinking rate is determined by categorizing each item. Category 1 is at level 0, category 2 at level 1, category 3 at level 2, category 4 at level 3, and category 5 at level 4. The description of van Hiele's levels of thinking can be seen in Table 4. Table 4 shows that the average pretest value of van Hiele thinking levels in the control class is greater than that of the experimental class, while the average of the experiment class post-test is greater than that of the control class.

Table 4. Geometry ability based on van Hiele's thinking level.

	Pretest	Post-test		
	Mean	Mean	Std. Deviation	N
Experiment	51.9	65.83	16.33	12
Control	53.5	59.91	10.89	11
Total	105.5	125.74	27.22	23

The van Hiele's geometric levels of thinking can be seen in Table 5. Table 5 shows that after learning Transformation using CPS model Qur'an-based textbook, the students were no longer at level 0-2. After the post-test, the percentage of Year 3 students in the control class was 90.91%, as compared to 66.67% in the experimental class. This suggests that the van Hiele's thinking level of most students in the control class had not reached a formal deduction stage; they still had difficulties in geometric axiomatic system reasoning. However, while 33.33% of the students in the experimental class were at level 4, only 9.09% of those in the control class was at level 4. This means that the CPS model of learning can develop students' creativity in solving the problem.

Table 5. Van Hiele's Geometry thinking level.

No Test	Van Hiele's level	Pre-test				Post-test			
		Experiment		Control		Experiment		Control	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	0	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0	0
3	2	7	58.33	6	54.55	0	0	0	0
4	3	5	41.67	5	45.45	8	66.67	10	90.91
5	4	0	0	0	0	4	33.33	1	9.09
Total		12	100	11	100	12	100	11	100

The prerequisite analysis test was performed before the research hypothesis test. The prerequisite analysis test included normality and homogeneity tests. The normality test used the Simonov Kolmogorov method to determine whether the data used was normally distributed or not. The decision-making basis of this test was calculated by using the p-value. The significance level of test results greater than the alpha of 5% indicated that the data used was in normal distribution. The Kolmogorov-Smirnov test value (p-value) on cognitive value and van Hiele levels of thinking in the experimental class and control class were more than 0.05, meaning that each data was normally distributed. The homogeneity test was conducted by using the Levene method in order to determine whether the data used had the same variation among treatments or not. The basis for the decision making of this test was determined by using the p-value. The significance value of the test results greater than the alpha of 5% indicated that the data used had the same range among treatments. The significance value (p-value) in the determination of cognitive value and the value of van Hiele thinking is more than 0.05, meaning that the type between the experimental class and the control class is the same or homogenous.

The content of Geometry Transformation's book based on Al-Quran includes the discussion on how geometry concepts and Al-Qur'an are related. The book is the product of design research using questionnaires and small-scale trials validated by experts. As a result of the development of this book, the average results of the validation and testing showed that it was a good fit for use in accordance

with the table eligibility criteria and product revision level. This book is a product designed with average validation results, and the tests are good matches to use in accordance with table eligibility criteria. Also, its product revision level as a whole is valid. The textbook review process was used to produce Quran-based geometry transformation book that conforms to the Islamic context. The quantitative data analysis indicators of the textbook validation and its integration into Qur'an include the integration of materials on transformation geometry with Al-Quran, the integration of Al-Quran with each material on transformation geometry, the suitability of reading letters to Al-Quran with translation, the stance of the Islamic terms, and the conformity of Islamic terms.

The results of this study are in line with the results of several other studies on CPS and the level of thinking of van Hiele geometry. Research conducted by Helie (2010) on the theory of CPS is one form of understanding produced by integrating new theories. Therefore, CPS is a development of process-based creativity theory [12]. The findings of a study by Yingsu and Vincent (2010) are used to view cognitive abilities based on problem-solving. Problem-solving is a cognitive process, so this study is closely related to CPS as a mathematical problem-solving process [13]. Research conducted by Fatih and Murat (2015) shows that van Hiele's ability level can be observed in the activities of the students who are trained in geometry-based activities [14]. Research conducted by Sasha and Margaret (2014) indicated that van Hiele's thinking recalls involving complex reasoning abilities, so it is not easy to conduct a process of inquiry [15].

The implications of this research can be used to improve lecturers' creativity in developing learning models that can provide students with thinking motivation through the degree of problem orientation, finding the facts, finding problems, finding ideas, finding solutions, and finding acceptance. As a result, students will possess geometry skills in solving problems based on van Hiele thinking levels.

4. Conclusion

Based on the results of the research and the data analysis of the hypothesis test results, it can be concluded that: after participating in the geometry learning with CPS model, the level of thinking ability of van Hiele geometry among students increased. 4 out of 12 students (33.33%) in experiment class are currently at level 4 (formal deduction), i.e., they begin to understand the axioms as statements that can be used to prove theorems in geometry formally, and realize how important the precision of the basic principles underlying a proof is, so as to create Islamic traits of honesty, patience, and carefulness. In the control class, however, only 90.91% or 10 out of 11 students are currently at level 3; they cannot fully understand transformation geometry by formal deduction. There are three domains in the assessment of learning outcomes, cognitive, psychomotor, and affective domains. The result of cognitive learning in the experimental class was 63.08 while that of the control class was 59.27. Psychomotor learning result in experiment class was 83 while that in control class was 78. The result of the experimental class' affective learning was 83 while that of control class was 77. Because CPS learning model can be applied with various approaches, it is advisable for other researchers to examine CPS learning model by using technology-based media, so that time constraints in constructing concepts do not become obstacles.

Based on the results of research and hypothesis test results, it can be concluded that there is a difference between van Hiele thinking levels between students taught by using CPS model and those taught using conventional model. There are also differences in learning outcomes between students who learn using CPS learning model and those who learn using conventional model. Although this study shows that the mean value of van Hiele thinking level in the experimental group is higher than that in the control group, the average score is still unsatisfactory, with van Hiele thinking level being 65.83 and cognitive learning outcomes being 63.08. This figure is still below the Minimum Passing Level (MPL). In order to effectively implement CPS learning model, especially in managing time, lecturers are advised to accumulate time in Semester Lesson Plan appropriately. Due to the fact that CPS learning model can be applied using various approaches, it is suggested that other researchers examine CPS learning model using technology-based media, so that time constraints in constructing the concepts do not become obstacles.

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