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The Advantage And Impact Of CIRC-Typed And Problem-Based Cooperative Learning Models On Students' Mathematical Argument

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ABSTRACT
Mathematics learning in undergraduate education level mostly used group discussion and problem-based approach. Hence, every undergraduate student should have good argumentation skill. However, they often felt difficult to construct and propose their mathematical arguments. Therefore, this study applied cooperative learning model which type referred to Cooperative Integrated Reading and Composition (CIRC) and Problem-Based Learning (PBL). This study aimed to describe whether or not the difference of students' argumentation skills between those using CIRC and those using PBL:, in addition to showing the cause of such difference. It was an experimental research with randomized control group pretest and posttest design. Two classes were used as experiment classes, and another one class was used as control class. One experiment class applied CIRC and another one applied problem-based learning method, while the control class applied conventional learning. 90 students participated as the sample of this study. The instrument was test of mathematical argumentation skill. The result found that (1) the students' mathematical argumentation skills were not significantly different between those using CIRC and those using Problem-Based Learning method; (2) the students' mathematical argumentation skills were not significantly different between those using CIRC and those using conventional method; (3) the students' mathematical argumentation skills were significantly different between those using PBL and those using conventional method. Hence, CIRC and PBL brought effects to students' mathematical argumentation skills.

Keywords: *CIRC, PBL, Mathematical Argument.*

INTRODUCTION

Mathematics learning in undergraduate education level mostly uses problem-based approach. Undergraduate students are given and asked to solve particular problems. [1] mentioned two kinds of problems which referred to *to find* and *to prove* problems. Solving *to prove* problems is critical for students, since proof is the core of mathematical thinking [2–5]. When solving such problem, students may define mathematical symbols and logic statements, as well as correlating definitions to theorem.

When solving *to-prove* problems, the problem solver requires supports in the form of arguments [6–15]. Mathematical argumentation skill is a capability to propose data, arguments, and theoretical supports, capability of writing and talking becomes one alternative to define solution of a problem. The capability of proposing an argument along with adequate data and theoretical supports for a mathematical problem, both verbal and writing, is an important part of mathematical argumentation skill that every student should have. Arguments supported by appropriate data and theoretical review may bring correct understanding about mathematical concepts. Arguments may explain why a statement is either

considered right or wrong. Arguments may also change people's interpretation on concepts, and this alteration happens when they change their understanding about a number of concepts and conceptual framework they previously use, reset or reconstruct the framework to accommodate new perspectives.

However, students often feel difficult to construct and propose mathematical arguments [16–18]. It is because their teachers have less pedagogical competence to develop students' argumentation in class. Teachers' measures may develop students' argumentation skills as they can encourage their students to describe, write, and justify their arguments during class discussion [19–23]. Students' arguments depend on their class culture, task attributes, and kinds of reasoning their teachers try to emphasize.

Many researchers in some developed countries have focused on identifying the cause and solution of students' less mathematical argumentation skill. They used various theories of education, learning models, and approaches that developed the insights of argumentation. They are such as [24] who studied about the patterns of arguments and dimension of high school students in critical discussion; [25] who implement a class activity to develop high school students' arguments and proofs under teacher's guidance; [26] who analyzed the process of students' interaction in learning mathematics, their arguments and participations; [27] who explored the concepts of argumentation, reasoning, and proof; [14] who described students' capability in constructing deductive arguments through inductive ones, the kinds of mathematical arguments that students used in argumentation [15], and the process of students' thinking in constructing arguments [28].

To develop students' mathematical argumentation skills, this current study applied a cooperative learning which type referred to *Cooperative Integrated Reading and Composition* (CIRC). This approach could be implemented in undergraduate education level as the competence of reading and writing mathematics has tight relation with students' argumentation skills [29]. CIRC-typed cooperative learning model consists of three phases that include concept recognition, exploration-application, and publication. In concept recognition, students are given a material through an interpretative reading text. It is a text that requires students to make conclusion from the content of the text, either explicit or implicit. They are also drilled to reveal the ideas of the text with their own words, either in verbal or writing.

The phase of exploration-application gives chances for students to reveal the result of their interpretation and definition they have made in the first phase. They develop new insights collectively in a group and under minimum guidance from their teacher. It may evoke self- cognitive conflict, and thus, they try to make a test and have discussion to explain their observation.

In the phase of publication, students communicate the ideas of the text, the solutions of the given problem, prove and re-demonstrate the discussed material. They are trained to be ready for any criticism or suggestion, or even having argumentation to one another.

In addition to CIRC, this current study also applied Problem-Based Learning model to develop students' mathematical argumentation skills. It is expected that this model may encourage students to have critical thinking, analyze complex and actual problems, work cooperatively in small groups, and have effective as well as accurate communication skills, both verbal and writing, in order to develop their mathematical argumentation skills [30]. Students' mathematical argumentation skills will be much better if they participate in problem-based learning, particularly those related to unstructured problems which interpretations and alternative solutions need argumentation. They are required to remember any information, definition, and theorem through which they may get involved in argumentation. The circumstance of having problem-based learning commonly presents claims or alternative solutions that students should encounter through argumentation. With this model of learning, students are expected to be critical and creative [5] [31] in order to construct mathematical argumentation.

METHOD

This study was an experimental research with *randomized control group pretest posttest* design. It had three groups; two as experiment groups, and another one as control group. The firs experiment group used CIRC-typed cooperative learning model, and the second one used Problem-Based Learning. Furthermore, the control group used conventional learning method. the design of this study was presented in Table 1, as follow.

Table 1 Illustration of research design

Group	*Pretest*	Treatment	Posttest
E_1	T_1	X_1	T_2
E_2	T_1	X_2	T_2
K	T_1	-	T_2

Note :

E_1 : Group that used CIRC-typed cooperative learning model

E_2 : Group that used Problem-Based Learning model

K : Group that used conventional learning

method.

X_1 : CIRC-typed cooperative learning model

X_2 : Problem-Based Learning model

T_1 : Score of students' mathematical argumentation before having any treatment.

T_2 : Score of students' mathematical argumentation after having a treatment.

This study was conducted in STKIP PGRI Jombang. The population of this study was all of 2019s undergraduate students of this university. There were three classes in 2019s.This study used simple random sampling to select the sample, which referred to students in class. It was selected through lottery due to some factors such as no approval from university to raffle the students one by one, the limitation of time, and noise which might disturb the other students. The researcher gave three paper rolls and took lottery to find the sample of this study. It was agreed that the first taking would be the 1st experiment class, the second would be the 2nd experiment class, and the last taking would be the control class. Next, the students were randomly classified into three groups as the sample of this study. Two of them played as the first and the second experiment class respectively, while another one played as the control group which used a conventional learning method.

The instrument of this current study was in the form of test. Those three groups would have the same test. It was used for data collection related to students' mathematical argumentation skills. The components of students mathematical argumentation skill were as follow.

1. The attributes of mathematical argumentations such as data, claim, backing, warrant, and conclusion;
2. The quality of students' mathematical arguments, which should use deductive argument correctly/

The data of students' mathematical argumentation skills was then analyzed quantitatively by giving scores to each of the components. The guidelines of scoring for the data of this study were as follow.

- Score 2, if students revealed the components correctly
- Score 1, if students revealed the components in wrong way.
- Score 0, if students did not reveal any of the components.

The result of students' mathematical argumentation among those three groups was compared (the difference among them would be tested). Before testing their mathematical argumentations, a test of data normality and homogeneity was previously conducted. To see the difference of mathematical argumentation among the students who used CIRC-typed cooperative learning, problem-based learning, and conventional method respectively, a test of one-way variance (i.e., *one way anova*) was conducted. In addition, the hypotheses of this study were as follow.

H_0 : No difference is found the result of mathematical argumentation among studnets who used CIRC-typed cooperative learning, problem-based learning, and conventional method

H_1 : Difference is found in the result of mathematical argumentation among studnets who used CIRC-typed cooperative learning, problem-based learning, and conventional method.

In case that H_0 was not supported, further anova test using *tukey* technique would be conducted to see which learning model was significantly different from the others. The hypotheses were as follow.

1. H_0 : No difference is found in the result of mathematical argumentation between students who used CIRC and those who used problem-based learning model.
   H_1 : Difference is found in the result of mathematical argumentation between students who used CIRC and those who used problem-based learning model.
2. H_0 : No difference is found in the result of mathematical argumentation between students who used CIRC and those who used conventional model.
   H_1 : Difference is found in the result of mathematical argumentation between students who used CIRC and those who used conventional model.
3. H_0 : No difference is found in the result of mathematical argumentation between students who used problem-based learning model and those who used conventional one.
   H_1 : Difference is found in the result of mathematical argumentation between students who used problem-based learning model and those who used conventional one.

RESULT AND DISCUSSION

Table 2 presented the result of this current study related to the collected data of mathematical argumentation by the students of STKIP PGRI Jombang.

Table 2 Data of students' mathematical argumentation

No	Group E1		Group E2		Group K	
	Pre test	*Post Test*	*Pre Test*	*Post test*	*Pre test*	*Post test*
1	65	95	70	85	75	80
2	70	85	65	85	65	80
3	60	80	60	95	65	80
4	60	90	65	85	65	85
5	70	95	70	90	75	80
6	65	85	70	95	70	85

7	60	85	60	85	65	80
8	65	80	60	90	60	80
9	70	80	70	85	65	85
10	60	85	65	90	70	85
11	60	85	60	85	70	80
12	70	95	75	85	65	85
13	65	85	70	90	60	80
14	60	85	75	90	65	85
15	60	85	65	85	70	90

Before testing the difference of the collected data, a test of data normality and homogeneity should be previously conducted. Table 3 presented the result of those tests, as follow.

Table 3. The Result of data normality test on students' mathematical argumentation

Group	Test	Sig. Score
E_1	*Pretest*	0,160
	Posttest	0,069
E_2	*Pretest*	0,556
	Posttest	0,083
K	*Pretest*	0,225
	Posttest	0,075

The result of data normality test on students' understanding of mathematical concept as presented on Table 2 showed that the sig. score for each group was > 0.05. it indicated that the data of each group was normally distributed.

Table 4. The result of data homogeneity test on students' mathematical argumentation

Test	**Sig. Score**
Pretest	0,619
Posttest	0,366

The result of data homogeneity test on students' mathematical argumentation as presented in Table 4 showed that the sig. score of each group was > 0.05, indicating that students' mathematical argumentation, both pretest and posttest, had homogeneous variance.

The result of data analysis related to students' mathematical argumentation as presented in Table 5 showed that the sig. score of each group was < 0.05. Hence, H_0 was not supported. It concluded that difference in the mean score of mathematical argumentation was found among the students who used CIRC-typed cooperative learning, problem-based learning, and conventional method. As H_0 was not supported, further test should be conducted to see the difference among the groups, and it referred to *Post Hoc Test*.

Table 5. Anova output

Students' mathematical argumentation

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	223.333	2	111.667	6.637	.003
Within Groups	706.667	42	16.825		
Total	930.000	44			

Table 6. Post hoc tests multiple comparisons output

Students' mathematical argumentation

Tukey HSD

(I) LEARNING MODEL	(J) LEARNING MODEL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
CIRC	Problem-based	-1.66667	1.49779	.512	-5.3055	1.9722
	Conventional	3.66667*	1.49779	.048	.0278	7.3055
Problem-based	CIRC	1.66667	1.49779	.512	-1.9722	5.3055
	Conventional	5.33333*	1.49779	.003	1.6945	8.9722
Conventional	CIRC	-3.66667*	1.49779	.048	-7.3055	-.0278
	Problem-based	-5.33333*	1.49779	.003	-8.9722	-1.6945

*. The mean difference is significant at the 0.05 level.

Table 7. Homogeneous subsets

Students' mathematical argumentation

Tukey HSD[a]

LEARNING MODEL	N	Subset for alpha = 0.05	
		1	2
Conventional	15	82.6667	
CIRC	15		86.3333
Problem-based learning	15		88.0000
Sig.		1.000	.512

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 15.000.

Table 6 (i.e., Post Hoc Test Output) was used for identifying which data of students' mathematical argumentations was significantly different. It was analyzed by investigating whether or not the mark * on column *Mean Difference*. This mark * showed a significant difference on the mean score. Table 6 also showed that the mean score of mathematical argumentation by students who used problem-based learning model was significantly different from those using conventional model. The mean score of mathematical argumentation by students with CIRC-typed cooperative learning model was significantly different from those with conventional one. However, no significant difference was found between the students who used CIRC and those using problem-based learning model.

As problem-based learning model drilled students to develop their mathematical argumentation skill, the difference happened. Mathematical argumentation skill was defined by the quantity of drilling by the students. [32] suggested that mathematical argumentation skill was a long process that required experiences and practices over and over again. Besides, the different result of the students' mathematical argumentation skill happened since problem-based learning model allowed them to have strong understanding on basic factual and applicable insights, showed an effective and accurate communication skill both verbal and writing, and let them to work cooperatively in small groups [33].

The difference of argumentation skill was also apparent in CIRC-typed cooperative learning model. It was because this learning model motivated students to do particular activities that might develop the disposition of their critical thinking on mathematics, through which their mathematical argumentation skill could develop [29]. In the phase of concept recognition, the students had chance to do reading for interpreting and constructing the meaning of the given text, as well as writing to make summary and questions. During the process of interpreting and constructing the meaning contained in the given test, a process of correlation to other mathematical ideas and thoughts from sources out of the text, mental translation on mathematical symbols, identification, evaluation, clarification, and explanation also happened. In the phased of exploration-application, a more-critical-reading material was presented through problems or tasks, as this phase aimed to encourage the students' interest, curiosity, and to apply their initial conception in learning activity. The phase of publication drilled the students to communicate any ideas contained in the given text, the solutions of a given problem or task, to prove and re-demonstrate the discussed material.

The output presented in Table 6 was used for identifying which variable had mean difference, while the output in Table 7 was for identifying which variable had less-significant difference. To identify the difference, it considered the column *Subset*. In table 7, in particular to *Subset* 1, it had 1 score from conventional learning model. However, Subset 2 had 2 score from CIRC-typed cooperative learning model and problem-based learning. It indicated that no significant difference in the mean score of mathematical argumentation was found between the students who used CIRC-typed cooperative learning model and those who used problem-based learning model. Hence, it concluded that both CIRC-typed cooperative learning and problem-based learning model affected students' mathematical argumentation skill.

The effect of CIRC-typed cooperative learning and problem-based learning model on students' mathematical argumentation skill occurred since teachers did not dominate their students' learning activity. Otherwise, they gave chances as much as possible to their students to actively participate and develop their concept and arguments, both individual and in group. The students could learn through an active discussion and cooperation. They could find basic principles of solving problems. Additionally, they were drilled to solve actual problems in the form of simulation for instance, and any problems in real life.

Significant difference between those using CIRC-typed cooperative learning and those using conventional model was found due to different treatment on the phases of learning and the process of delivering material [34] [35]. CIRC-typed cooperative learning model was a learning model that allowed students to experience what they were learning in order to strengthen, develop, and implement their academic knowledge and skills in various challenges of life, either in school or out school.

As the result, they could be autonomous in constructing their understanding of mathematical concepts. Furthermore, significant difference between students who used problem-based learning model and those who used conventional one was also found since problem-based learning model assisted students to develop their analysis skills which involved defining and solving problems. Moreover, problem-based learning also developed students' skills in making conclusion in problem-solving.

CONCLUSION

The result of this study showed that mathematical argumentation skill of the students who used CIRC-typed cooperative learning model was not significantly different from those using problem-based learning model. However, significant difference in mathematical argumentation skill was found between the students who used CIRC-typed cooperative learning model and those using conventional learning model. Additionally, significant difference was also found between those using problem-based learning model and those using conventional one. Overall, it concluded that both CIRC-typed cooperative learning model and problem-based learning model affected students' mathematical argumentation skills.

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