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Improving science process skills of junior high school students through the implementation of collaborative creativity learning (CCL) model in physics learning

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Abstract. The collaborative creativity learning (CCL) model is a collaborative-based scientific creativity learning to improve scientific creativity, science process skills, and collaborative skills of the junior high school students. The purpose of this research is to improve science process skills of junior high school in physics learning through the implementation of CCL model. This research used one group pre-test and post-test design toward 144 students of State Junior High School 2 Jember and State Junior High School 3 Jember (Jember, Indonesia) academic year 2017/2018. The student's science process skills were measured by using Science Process Skills Instrument (SPSI) with indicators of formulating problems, formulating the hypothesis, identifying variables, formulating the operational definition of variables, designing the data table, carrying out the experiment, analysing the data, formulating the conclusions. The data analysis technique used the Wilcoxon test, n-gain, and Mann-Whitney U test. The results show that: (1) The average post-test score was in the medium category, (2) There is improvement of student's science process skills at $\alpha = 5\%$, (3) N-gain average score of student's science process skills was in medium category, and (4) There is no difference (consistent) n-gain on student's science process skills in all groups. Therefore the CCL model has proven to be effective to improve the science process skills of junior high school in physics learning. The implication of this research is that CCL model can be used as a solution to improve science process skills of junior high school in physics learning.

1. Introduction

Physics cannot stand firmly without the process of scientific investigation. This scientific inquiry develops in terms of science process skills (SPS) the basis of science [1-5]. SPS are very important for junior high school students because students will not be able to do physics learning properly without the mastery of good process skills. This is the basis for the importance why SPS of students should be trained and improved by teachers through innovative learning models. The indicators of SPS in this study include: formulating problems, formulating hypotheses, identifying variables, formulating the operational definition of variables, creating table of experiment data, conducting experiments,



analysing data, and making conclusions based on the results of literature study and preliminary study by researchers, the indicators are still low and need to be improved by students in physics subject.

The facts of the study by PISA (Program for International Student Assessment) and TIMSS (Trends International in Mathematics Science Study) show that between 2012 and 2015 science performance among 15 year old students increased by 21 points [6-8]. However, the students have not been able to use any information and have not been able to demonstrate scientific reasoning and reasoning ability. This is reinforced by preliminary study about: (1) The low skill of science process by junior high school students in physics learning; (2) The limitations of teachers to develop models and instruments of physics learning that are specifically designed to improve the SPS of junior high school students [9-11]. In order to improve the students' academic creativity in physics learning, the appropriate learning models are needed; one of them is Collaborative Creativity Learning (CCL) model as an alternative solution to improve the SPS of junior high school students in physics learning [9-11].

The collaborative creativity learning (CCL) model is a collaborative-based scientific creativity learning to improve scientific creativity, SPS, and collaborative skills of students [9-11]. The CCL model has the characteristics to train the SPS through scientific research activities based on scientific creativity. These are in conjunction with the social constructivist theory of Vygotsky [12-14]. The CCL model has proved to be feasible (valid, practical, and effective) to improve the science creativity, SPS, and collaborative skill of junior high school students in science learning [9-11]. The CCL model has five syntaxes: (1) Problem Identification; (2) Exploration of creativity ideas; (3) Collaborative Creativity; (4) Elaboration of creativity ideas; (5) Evaluation of the Scientific Creativity Process and Results. The purpose of this research is to improve the SPS of junior high school in physics learning through the implementation of the CCL model. The focus of this research is a follow-up study based on the [9] recommendation to see the effectiveness of CCL Model by doing generalization. The results of this study are expected to be empirical evidence in the process of the CCL Model effectiveness to improve the SPS of junior high school students in physics learning.

2. Experimental Method

2.1 General Background of Research

The objective is to analyse the improvement of the students' SPS through the implementation of CCL Model. The improvement of students' SPS is determined based on: (1) Significant increase (statistically) on score between pre-test and post-test of SPS of students, (2) Post-test of students' SPS in medium category, (3) The average n-gain of students' SPS is determined at least on low improvement criteria, and (4) The consistency of the average n-gain score of students' SPS in all groups.

2.2 Sample of Research

The sample were 144 junior high school students in Jember (Jember, Indonesia) in 2016 by using purposive sampling technic; which consisted of four group: group-1 (students of class VIIIA State Junior High School 3 Jember), group-2 (students of class VIIIB State Junior High School 3 Jember), group-3 (students of class VIIIA State Junior High School 2 Jember), and group-4 (students of class VIIIB State Junior High School 2 Jember).

2.3 Instrument and Procedures

The students' SPS in physics learning are measured by using the SPS Instrument (SPSI), which has been declared valid and reliable [9]. The SPSI is structured based on the measurable SPS indicators, they are: formulating the problem, formulating the hypothesis, identifying the variables, formulating the operational definitions of variables, creating the tables of experimental data, conducting the experiments, analysing the data, and making conclusions [9]. Physics lesson subjects that were used in this study were selected to be in accordance with CCL Model characteristics, it was motion and simple plane. This study used one group pre-test and post-test design, O1 X O2 [15-17]. The learning began by giving pre-test (O1). Every junior high school student was working on SPSI. After the pre-test, the

teacher applied CCL Model and physics learning instruments in each group (X). The implementation of CCL Model has been conducted for seven meetings on physics subject. The physics learning by using CCL Model has five syntax, they are: (1) Problem Identification,(2) Exploration of creativity ideas,(3) Collaborative Creativity,(4) Elaboration of creativity ideas,(5) Evaluation of the Scientific Creativity Process and Results. The learning instruments of physics consist of: Syllabus, Lesson Plan (RPP), Student book (BAM), and Student worksheet (LKS) (valid and reliable) [9]. Each phase of the CCL Model by design trains the SPS indicators on the subject of physics. After the CCL model implementation, students did post-test (O2) by using SPSI. Each student was required to complete SPSI on post-test.

2.4 Data Analysis

The improvement of students' SPS through the implementation of the CCL model was analysed based on the pre-test, post-test, and n-gain. The students' SPS was further analysed by using inferential statistics with the help of IBM SPSS software. The score of students' SPS were based on indicator: formulating problem, formulating hypothesis, identifying variable, formulating operational definition of variable, making table of experiment data, conducting experiment, analysing data, and making conclusion. N-gain was determined by using equations by Hake [18-20]. Inferential statistical tests used Wilcoxon test (analysis of statistical improvement) and n-gain consistency analysis of all students after the application of CCL model used Mann-Whitney U t-test.

3. Result and Discussion

The results are presented in Table 1, Table 2, and Table 3 which will be described as follows.

Table 1. The average score of pre-test, post-test and n-gain of students' SPS.

Group	Junior high school students' SPS											
	Motion						Simple Plane					
	Pre-test		Post-test		N-gain		Pre-test		Post-test		N-gain	
1 (Class VIIIA)	1.13	L	2.30	M	.41	M	1.06	L	2.50	M	.49	M
2 (Class VIIIC)	.72	L	2.54	M	.55	M	1.17	L	2.40	M	.43	M
3 (Class VIIIA)	1.15	L	2.33	M	.41	M	1.13	L	2.33	M	.42	M
4 (Class VIIIB)	1.17	L	2.33	M	.41	M	1.16	L	2.44	M	.45	M

Note: L (Low), M (Medium)

Table 1 describes the average score of the SPS. In all groups the average pre-test score is .72-1.17 (low category) in the chapter of motion and simple plane. This is because students are not familiar and rarely taught by teachers to implement the SPS in physics lessons. The findings are in accordance with the results of preliminary studies conducted by researchers that implementation of students' SPS are still relatively low. This finding is also reinforced by the results of the study [9] that students still have difficulties in SPS and scientific creativity. In contrast to the post-test score after the implementation of the CCL Model in all groups, it was 2.30; 2.54; 2.33; and 2.33 (chapters of motion) are all in the medium category and 2.50; 2.40; 2.33; and 2.44 (simple plane chapter) are all in the medium category and this is presented in Table 1. Table 1 shows that the n-gain of junior high school students' SPS in all groups was .41; .55; .41, and .41 (motion chapter) in the medium category and .49; .43; .42; and .45 (simple plane chapter) and in the medium category. The results of this study prove that the implementation of the CCL Model was proved to be effective in improving students' SPS in physics learning. This is because the developed CCL Model meets validity (content and construct), practicality, and effectiveness to enhance scientific creativity, collaborative affective, and SPS of junior high students in physics learning [9]. This is supported by the results of the study [21-33] that the models, media, methods, instruments that are eligible will be able to improve and achieve learning objectives.

Table 2. Average score of junior high school students' SPS indicators.

Groups	Scores	Junior High School Students' Science Process Skills															
		I		II		III		IV		V		VI		VII		VIII	
Motion																	
1 (Class VIII A)	O1	1.20	L	1.20	L	1.30	L	.60	L	1.40	L	1.10	L	1.10	L	1.10	L
	O2	2.50	M	2.20	M	2.50	M	1.90	M	2.40	M	2.30	M	2.30	M	2.30	M
	<g>	.46	M	.36	M	.44	M	.38	M	.38	M	.41	M	.41	M	.41	M
2 (Class VIII C)	O1	1.20	L	.70	M	1.20	M	.60	L	1.20	L	1.10	L	1.10	L	1.10	L
	O2	3.63	H	2.20	M	2.50	M	2.00	M	2.40	M	2.40	M	2.40	M	2.40	M
	<g>	.87	M	.45	M	.46	M	.41	M	.43	M	.45	M	.45	M	.45	M
3 (Class VIII A)	O1	1.20	L	1.30	L	1.30	L	.60	L	1.40	L	1.10	L	1.10	L	1.10	L
	O2	2.50	M	2.20	M	2.50	M	1.90	M	2.40	M	2.30	M	2.30	M	2.30	M
	<g>	.46	M	.33	M	.44	M	.38	M	.38	M	.41	M	.41	M	.41	M
4 (Class VIII B)	O1	1.20	L	1.30	L	1.10	L	.80	L	1.40	L	1.20	L	1.20	L	1.20	L
	O2	2.50	M	2.50	M	2.30	M	1.80	M	2.40	M	2.50	M	2.50	M	2.50	M
	<g>	.46	M	.44	M	.41	M	.31	M	.38	M	.46	M	.46	M	.46	M
Simple Plane																	
1 (Class VIII A)	O1	1.20	L	1.20	L	1.30	L	.60	L	1.10	L	1.00	L	1.10	L	1.10	L
	O2	2.50	M	2.20	M	2.40	M	1.40	M	2.40	M	2.40	M	2.30	M	2.30	M
	<g>	.46	M	.36	M	.41	M	.24	M	.45	M	.47	M	.41	M	.41	M
2 (Class VIII C)	O1	1.10	L	1.20	L	1.30	L	1.10	L	1.50	L	.80	L	1.10	L	1.10	L
	O2	2.50	M	2.20	M	2.40	M	2.00	M	2.50	M	2.40	M	2.40	M	2.40	M
	<g>	.48	M	.36	M	.41	M	.31	M	.40	M	.50	M	.45	M	.45	M
3 (Class VIII A)	O1	1.20	L	1.20	L	1.30	L	.70	L	1.60	L	.80	L	1.10	L	1.10	L
	O2	2.50	M	2.20	M	2.40	M	1.90	M	2.40	M	2.40	M	2.30	M	2.30	M
	<g>	.46	M	.36	M	.41	M	.36	M	.33	M	.50	M	.41	M	.41	M
4 (Class VIII B)	O1	1.40	L	1.10	L	1.30	L	1.10	L	1.50	L	.60	L	1.20	L	1.20	L
	O2	2.60	M	2.40	M	2.50	M	2.00	M	2.40	M	2.30	M	2.50	M	2.50	M
	<g>	.46	M	.45	M	.44	M	.31	M	.36	M	.50	M	.46	M	.46	M

Note: I (Formulating problems), II (Formulating hypothesis), III (Identifying variables), IV (Formulating the operational definition of variables), V (Making the table of experiment data), VI (Conducting experiment), VII (Analysing data), VIII (Making conclusion), L (Low), M (Medium)

Table 2 shows that all indicators of students' SPS in the pre-test are in the low category (motion and simple plane chapters), whereas after the implementation of physics learning with the CCL Model, all indicators of the students' SPS have improved. The general n-gain of SPS is generally in medium category with score above .31. The positive result is because the implementation of physics learning with CCL Model by design has improved the SPS indicators through five phase of the CCL Model that are: (1) Problem Identification; (2) Exploration of creativity ideas; (3) Collaborative Creativity; (4) Elaboration of creativity ideas; (5) Evaluation of the Scientific Creativity Process and Results [9]. The results of the normality and homogeneity test of variance showed that the pre-test, post-test, and n-gain scores of students' SPS in the physics lessons were homogeneous and not normally distributed. Therefore, the impact of CCL Model implementation to improve the students' SPS in physics learning for the whole group used Wilcoxon test and the consistency test used Mann-Whitney U test. The results of the Wilcoxon test and the Mann-Whitney U test are presented in Table 3.

Table 3. Recapitulation of inferential statistical test results of science process skills.

Inferential test (two-tailed)	School	Class	Data of Science Process Skills	Asymp Sig. ($\alpha = 5\%$)
Wilcoxon Matched Pairs (Differential test of Pre-test and Post- test)	State Junior High School 2 Jember	Group 1 (VIII A)	Motion Chapter	There is an increase in student's SPS
			Simple plane chapters	There is an increase in student's SPS
	State Junior High	Group 2 (VIII C)	Motion Chapter	There is an increase in student's SPS There is an increase in
			Simple plane chapters	student's SPS
	State Junior High	Group 3 (VIII A)	Motion Chapter	There is an increase in

Inferential test (two-tailed)	School	Class	Data of Science Process Skills	Asymp Sig. ($\alpha = 5\%$)
	School 3 Jember		Simple plane chapters	student's SPS There is an increase in student's SPS
		Group 4 (VIIB)	Motion Chapter	There is an increase in student's SPS There is an increase in student's SPS
			Simple plane chapters	There is consistency of N-gain
Mann- Whitney U (N-gain consistency test)	State Junior High School 2 Jember	Group 1 (VIIB)	Motion Chapter	There is consistency of N-gain
		Group 2 (VIIC)	Simple plane chapters	There is consistency of N-gain
		Group 3 (VIIB)	Motion Chapter	There is consistency of N-gain
		Group 4 (VIIB)	Simple plane chapters	There is consistency of N-gain
	State Junior High School 3 Jember	Group 1 (VIIB)	Motion Chapter	There is consistency of N-gain
		Group 2 (VIIC)	Simple plane chapters	There is consistency of N-gain
		Group 3 (VIIB)	Motion Chapter	There is consistency of N-gain
		Group 4 (VIIB)	Simple plane chapters	There is consistency of N-gain

Table 3 shows the student's SPS in physics learning (chapter motion and simple plane) for all groups of each Asymp Sig score. is considered significant, because Asymp Sig. $<.05$. It also indicates that there is an impact that the application of the CCL Model can significantly improve the student's SPS (in motion and simple plane chapters) significantly for all groups. Table 3 also informs that for n-gain (chapter motion and simple plane) the significance value of Asymp Sig. $\geq .05$. This clearly indicates that there is no significant difference in the existence of the junior high student's SPS (in motion and simple plane chapters) from the impact of CCL Model implementation in physics learning for all groups. This is because the CCL model has been developed by design to improve students' science process skills with the following phases. (1) Problem identification aims to conceptualize students to formulate problems in collaborative creativity (CC) group,(2) Exploration of creativity ideas, students in the CC group explore creative ideas to create hypotheses, identify experiment variables, and make operational definitions of experiments,(3) Collaborative Creativity; students begin implementing experiments in CC groups to obtain experiment data, (4) Elaboration of creativity ideas; the results of the experiments were elaborated with students' scientific creativity ideas for the process of data analysis and making conclusions,(5) Evaluation of Scientific Processes and Results, students active in scientific activities with teacher guidance to evaluate process and creativity outcomes to improve students' scientific creativity [9]. The results are reinforced with theoretical and empirical support that the collaborative creativity learning (CCL) model is a collaborative-based scientific creativity learning to improve scientific creativity, SPS, and collaborative skills of the junior high school students [9]. The CCL model has characteristics to train scientific process skill through scientific research based on scientific creativity by design to enhance scientific creativity, collaborative, and SPS based on the process of creativity, motivation theory, social behaviour theory, social constructivist theory, and cognitive psychology theory [9, 12-14]. Therefore the CCL model has been proven to be effective in improving the student's SPS in physics learning. The implication of CCL model can be used as a solution to improve the student's SPS in physics learning.

4. Conclusion

The collaborative creativity learning (CCL) model is a collaborative-based scientific creativity learning to SPS of the junior high school students. The results show that: (1) The average post-test score was in the medium category, (2) There is improvement of student's SPS at $\alpha = 5\%$, (3) N-gain average score of student's SPS was in medium category, and (4) There was consistency n-gain of student's SPS in all groups. Therefore the CCL model has proven to be effective in improving the student's SPS in physics learning. Further research needs to replicate the CCL Model in improving the student's SPS in physics learning at different levels and different materials.

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