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Improving Collaborative Critical Thinking Skills of Physics Education Students through Implementation of CinQASE Learning Model

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Abstract. The CinQASE Learning Model is a collaborative-based learning that is designed to improve students' collaborative critical thinking skills. The CinQASE Learning Model has a syntax consisting of (1) Problem Presentation, (2) Individual Work, (3) Team Work in Collaboration, (4) Class Discussion, and (5) Evaluation and feedback. The purpose of this research is to improve the collaborative critical thinking skill of physics education students through implementing CinQASE learning model. This research used one group pre-test and post-test design toward 56 physics education students of Halu Oleo University at academic year 2017/2018. The collaborative critical thinking skills of physics education students were measured by using Direct Assessment of Collaborative Critical Thinking (DACCT) with following indicators: questioning, analyzing, synthesizing, and evaluating. Data analysis technique used Paired t-test, n-gain and ANOVA test. The results showed that: (1) Average post-test score was 79.35 (2) the improvement on collaborative critical thinking skill of physics education students was at $\alpha = 5\%$, (3) Average n-gain score of collaborative critical thinking skills was 0.62 ; and (4) No difference of n-gain on collaborative critical thinking skills in all groups; and (5) Students responded in good category toward the implementation of CinQASE learning model. Therefore the CinQASE learning model has proven to be effective to improve students' collaborative critical thinking skills.

1. Introduction

College education has an important role in the industrial revolution 4.0. Especially colleges that produce educator candidates who are expected to provide prospective educators who have expertise that supports them to become successful individuals in the world of work and social life. To succeed in today's world, students need such skills that support them, such as critical thinking and problem solving, creativity and innovation, communication and collaboration [1-8]. The development of students' critical thinking skills is considered as one of the most important goals of education [3, 9-10]. Critical thinking is a process of thinking to determine what is done and what is believed [11]. Several studies have been conducted by applying various models, learning, strategies, methods, and approaches in research to improve critical thinking skills [12-23]. However, the development of critical thinking skills has been emphasized at the individual level. In fostering collaborative critical thinking skills, it is pointed to three things; they are constructivism, situationism, and collaboration. It further develops that educator candidates must have collaborative critical thinking skills. Collaboration encourages the development of critical thinking through discussion, clarification, ideas, and evaluation

of other people's ideas [24]. There is persuasive evidence that collaborative teams reach higher levels of critical thinking and store information longer, than students who secretly work as individuals [25]. The collaborative team serves as a mediating tool to develop individual critical thinking skills. Collaborative learning provides an opportunity for learners to engage in discussion, take responsibility for their own learning, thereby helps individuals become critical thinkers [26].

The preliminary study results indicated that collaborative critical thinking skills activity in UHO Faculty of Teacher Training and Education Physics education students (Kendari, Indonesia) is still low. This is because the lectures often involve the individual critical thinking skills. Lecturers need to facilitate the learning process that embodies the collaborative work that makes natural science students in Teacher Training Institution (TTI) become able to develop their thinking results. Based on recent literature studies through the searching of international databases in the field of education, critical thinking skills at the group or team level that are commonly called as collaborative critical thinking, are still not widely researched, whereas collaborative thinking skills are a vital skill that physics education students must master in TTI as well as physics teachers in supporting their increasing competence within the TPACK framework.

There are several team-based learning models that can improve critical thinking skills. However, the implementation of explicit team-based learning models has not been able to improve the collaborative critical thinking skills. The Cooperative Learning (CL) model has not yet been explicitly shown to be capable to engage in collaborative critical thinking skills [27]. Furthermore, Team Based Learning (TBL) shows a significant improvement in critical thinking skills but it is less efficient and practical because the time required for each phase is not possible to be completed in a single meeting [28]. Based on team-based learning models that have been described previously they can implicitly train critical thinking skills but they have not yet clearly improved collaborative critical thinking skills. Therefore, in this study it is discussed the use of Collaborative in Questioning, Analysing, Synthesizing and Evaluating (CinQASE) model which has been developed and proven to be valid to improve students' collaborative critical thinking skills [29]. The results of this study are expected to be empirical evidence in the disseminate process of the CinQASE learning models' effectiveness to improve the collaborative critical thinking skills of physics education students.

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2. Experimental Method

2.1 General background of Research

The main purpose of this research is to analyse the improvement of collaborative critical thinking skills of physics education students through the implementation of CinQASE learning model. This research was conducted in physics education department at Halu Oleo University (Kendari, Indonesia), academic year 2017/2018 who takes basic physics course. The improvement physics education students' collaborative critical thinking skills through the implementation of the CinQASE learning model is determined based on: (1) Post-test scores of physics education students' collaborative critical thinking skills that must be at least in medium category, (2) A statistic increase in score between pre-test and post-test of physics education students' collaborative critical thinking skills, (3) The n-gain of physics education students' collaborative critical thinking skills must be at least on low improvement criteria, (4) The consistency of n-gain average score of physics education students' collaborative critical thinking skills in three experimental groups, and (5) the responses of physics education that must be at least in enough category.

2.2 Sample of Research

The sample in this research was 56 students of physics education at Halu Oleo University (Kendari, Indonesia), academic year 2017/2018 who takes basic physics course. All physics education students were divided into 3 groups namely class A (19 students), class B (19 students), and class C (18 students). Each group took the basic physics course at academic year 2017/2018.

2.3 Instrument and Procedures

The collaborative critical thinking skills of physics education students were measured by using a Direct Assessment of Collaborative Critical Thinking (DACCT) with indicators of valid and reliable

questioning, analysing, synthesizing, and evaluating [29-31]. Meanwhile, the student response data was obtained by using a student response questionnaire that was given after the entire learning process was completed. The questionnaire response aims to determine the student's response to the instruments and learning process by applying CinQASE learning model. The physics course that was used in this research was chosen to be the one that was suitable with the characteristic of CinQASE learning model; basic physics. This study used one group pre-test and post-test design, O1 X O2 [32]. The learning began by giving pre-test (O1). Every physics education student was required to complete DACCT. After the pre-test, the lecturers applied CinQASE learning model and instruments in each group (X). The implementation of the CinQASE learning model had been conducted for seven meetings on the basic physics course. The physics learning by using the CinQASE Learning model has syntax that consists of 5 phases, they are: (1) Problem Presentation, (2) Individual Work, (3) Teamwork in Collaboration, (4) Class Discussion, and (5) Evaluation and feedback. The learning instruments consisted of: syllabus, lecture plan, student work sheet, student textbook, DACCT, and response questionnaire (valid and reliable) [29]. Each phase of the CinQASE learning model collaborative critical thinking skills in basic physics courses included: questioning, analysing, synthesizing, and evaluating. The implementation of CinQASE learning model ended by post-test (O2) by using DACCT. Each student was required to complete the DACCT on a post-test and filled out a student response questionnaire.

2.4 Data Analysis

The improvement of students' collaborative critical thinking skills was analysed by using the N-Gain equation [33]. The result of N-gain calculation was then converted by criteria: High > 0.70; Medium 0.3 - 0.70; Low <0.30. The inferential statistical tests used Paired t-test (analysis of statistical improvement) and n-gain consistency analysis of all physics education students after the implementation of CinQASE learning model that is used ANOVA test. The analysis of student response questionnaire used Guttman scale, that was for students who answered Yes, they got one score (1) and students who answered No, they got zero (0). The percentage of student responses was converted to the following criteria: 81% - 100% = Very Good; 61% - 80% = Good; 41% - 60% = Good enough; 2% - 40% = Less Good; 0% - 20% = Not Good [29].

3. Result and Discussion

The results are presented in Table 1, Table 2, and Table 3 which is described as follows:

Table 1. The learning outcomes of physics education students' collaborative critical thinking skills.

Students' Initial	Class											
	A				B				C			
	O1	O2	<g>	5	O1	O2	<g>	C	O1	O2	<g>	14
M1	37.00	69.00	0.51	M	45.00	79.00	0.62	M	53.00	80.00	0.57	M
M2	49.00	78.00	0.57	M	57.00	89.00	0.74	H	37.00	69.00	0.51	M
M3	51.00	76.00	0.51	M	54.00	72.00	0.39	M	41.00	75.00	0.58	M
M4	45.00	70.00	0.45	M	41.00	87.00	0.78	H	37.00	69.00	0.51	M
M5	53.00	77.00	0.51	M	37.00	95.00	0.92	H	36.00	73.00	0.58	M
M6	41.00	67.00	0.44	M	30.00	70.00	0.57	M	53.00	90.00	0.79	H
M7	40.00	70.00	0.50	M	45.00	86.00	0.75	H	65.00	90.00	0.71	H
M8	45.00	80.00	0.64	M	29.00	77.00	0.68	M	47.00	81.00	0.64	M
M9	41.00	79.00	0.65	M	53.00	78.00	0.53	M	37.00	80.00	0.68	M
M10	65.00	92.00	0.77	H	45.00	83.00	0.69	M	45.00	77.00	0.58	M
M11	41.00	67.00	0.44	M	53.00	79.00	0.55	M	45.00	82.00	0.67	M
M12	45.00	90.00	0.82	H	45.00	69.00	0.44	M	57.00	90.00	0.77	H
M13	49.00	78.00	0.57	M	35.00	73.00	0.58	M	45.00	86.00	0.75	H
M14	37.00	70.00	0.52	M	35.00	74.00	0.60	M	51.00	85.00	0.69	M
M15	43.00	75.00	0.56	M	43.00	86.00	0.75	H	57.00	89.00	0.74	H
M16	39.00	81.00	0.69	M	49.00	66.00	0.33	M	45.00	79.00	0.62	M
M17	61.00	92.00	0.79	H	51.00	73.00	0.45	M	41.00	72.00	0.53	M

Students' Initial	Class											
M18	53.00	91.00	0.81	H	45.00	78.00	0.60	M	53.00	92.00	0.83	H
M19	45.00	87.00	0.76	H	37.00	80.00	0.68	M				
M18	46.32	78.37	0.61	M	43.6	78.63	0.61	M	46.94	81.06	0.65	M

Note: O1 (Pre-test); O2 (Post-test); C (Category); <g> (n-gain); L (Low); M (Moderate); H (High)

Table 1 shows the learning outcomes of physics education students' collaborative critical thinking skills on physics learning. In all groups, the average pre-test score is still low and did not pass. This is because the students are still unfamiliar with collaborative critical thinking skills in physics. The findings are in accordance with the results of preliminary studies that the collaborative critical thinking skills of physics education students are still relatively low [29]. The opposite condition occurs in the post-test results where after the implementation of the CinQASE learning model, no students get a low score. The average value of collaborative critical thinking skills in class A, class B, and Class C are 78.37, 78.63, and 81.06 respectively. Table 1 also informs the positive results of the CinQASE learning model implementation that the n-gain of collaborative critical thinking skills in class A, class B, and class C are 0.61, 0.61, and 0.65 respectively and are in the medium category. The results of this study show that the implementation of the CinQASE learning model is proved to be effective to improve the collaborative critical thinking skills of physics education students. This is because the developed CinQASE learning model meets the validity, practicality and effectiveness to improve the collaborative critical thinking skills of physics education students [29]. This is supported by the results of the study [2-8, 34-47] that the model, method, media, approach, teaching and learning that can meet validity, practicality and effectiveness will be able to improve and achieve the learning objectives.

Table 2. Average score of physics education students' collaborative critical thinking skills indicator.

Collaborative critical thinking skills indicator	Class											
	A				B				C			
	O1	O2	<g>	C	O1	O2	<g>	C	O1	O2	<g>	C
Questioning	2.15	2.84	0.81	H	2.32	2.68	0.53	M	2.17	2.67	0.60	M
Analysing	1.73	2.63	0.71	H	1.42	2.37	0.60	M	1.67	2.61	0.71	H
Synthesizing	1.57	2.42	0.59	M	1.22	2.42	0.67	M	1.28	2.44	0.67	M
Evaluating	1.21	2.4	0.66	M	1.37	2.58	0.74	H	1.17	2.56	0.76	H

Note: O1 (Pre-test); O2 (Post-test); C (Category); <g> (n-gain); L (Low); M (Moderate); H (High)

Table 2 shows that all collaborative critical thinking skills indicator of physics education students in the pre-test are in the low category and still need to be improved. Positive results indicate an increase in collaborative critical thinking skills of physics education students, which is shown in table 2 that all indicators of collaborative critical thinking skills are in high category. This is shown through an n-gain score analysis where the n-gain value for each indicator increases. The highest increase can be seen in indicators of questioning, analysing, synthesizing, and evaluating with a range of n-gain scores from 0.53 - 0.81.

It shows that during the learning process, students have enhanced their collaborative critical thinking skills through scientific experimentation activities to build and discover facts to support their argument in collaboration. The process of collaborative critical thinking starts from the initial knowledge, verifies, and modifies can be trained by using the step technique: (1) create a story, (2) test conflict, (3) evaluate the story, and (4) develop a contingency plan. This training strategy has been validated in several samples. In collaborative critical thinking, individual decision-makers should often make choices in dynamic complex situations. This arrangement is often with incomplete, conflicting, informative, and ambiguous information. Collaboration is processes where someone looks at different aspects of a problem, explores differences and seeks solutions that transcend the limitations of his/her own knowledge of what is possible. During collaboration, a person with complementary skills interacts to create a shared understanding of a situation in a whole compared than someone who has achieved individually [48]. Effective collaboration requires special skills in terms of negotiating and listening

actively. Collaborative critical thinking can be regarded as one of the factors that affect the team's ability to collaborate. The indicators of collaborative critical thinking skills in this study are adapted from indicators that have been developed with questioning, analysing, synthesizing, and evaluating components [31]. Theoretically, it is argued that a person who is accustomed to work in groups continuously will have a negative impact if he/she is required to work individually.

The results of the normality and homogeneity test of variance suggest that the pre-test, post-test, and n-gain of collaborative critical thinking skills are homogeneous and normally distributed for the whole group. Therefore, the impact of implementing the CinQASE learning model to improve collaborative critical thinking skills in the courses for the whole group used Paired t-test while the consistency test used ANOVA test. The paired t-test and ANOVA test results are presented in Table 3.

Table 3. The result of Paired t-test and ANOVA test of student's collaborative critical thinking skills.

Paired t-test, $\alpha = 5\%$						ANOVA test, $\alpha = 5\%$				
Class	N	Mean	t	df	p		Sum of Squares	df	Mean Square	Sig.
A	19	-3.20	-21.89	18	.000	Between groups	.023	2	.012	.495
B	19	-3.50	-13.99	18	.000	Within groups	.870	53	.016	
C	18	-3.41	-32.46	17	.000	Total	.894	55		

Table 3 shows that the mean of collaborative critical thinking skills for classes A, B, and C are -3.20, -3.50, -3.41 and have degrees of freedom (df) 18, 18, and 17, t arithmetic -21.89, -13.99, and -32.46 respectively. This result is significant because $p < 5\%$. The result of the calculation has a negative sign which means that there is difference in the pre-test and the post-test (improvement) of physics education students' collaborative critical thinking skill after the implementation of CinQASE learning model in all classes. Table 3 shows that F arithmetic gives $F_{\text{arithmetic}} < F_{\text{table}}$ with significance level $P = .495 > 5\%$. The results show that the implementation The CinQASE learning model can significantly improve the collaborative critical thinking skills of physics education students for all groups.

This is because the CinQASE learning model has been developed by design to improve students' collaborative critical thinking skills with the following phases. (1) Activity in phase 1 (Problem presentation), (a) Lecturer motivates students to engage in team collaboratively in problem solving, (b) Lecturer gives scaffolding in the form of questions to grow up student's curiosity, (c) Lecturer provide a social environment that supports lectures by grouping students heterogeneously into groups of 6-8 collaborative people; (d) Lecturers present authentic real-life situation problems that allow various solutions to be solved; and (e) Lecturers deliver objectives of the lesson related to problems that will be solved individually and collaboratively. (2) Activity in Phase 2: Individual Work includes (a) Lecturer directs students to work individually in their group to analyse the given problems, (b) Students collect information according to the given problems from their experience individually, which will be communicated to the work team in collaboration. (3) Activities in Phase 3: Collaborative Critical Thinking Team Work includes (a) Lecturers direct students to work in pairs in collaborative groups, (b) Lecturers distribute worksheet (LKM) to each partner in the collaborative group as a guide in solving the problem (d) Students work together in a paired collaborative group and work on the provided worksheet, (e) Each pair in the collaborative group discusses the collaboration of the collaborative group, (c) the lecturer distributes the worksheet in each collaborative group to analyse the results of experiment or investigation on problems to be solved collaboratively, (f) lecturers develop social structures that encourage the emergence of appropriate behaviour to collaborate among students, (g) lecturers provoke interaction between students with the physical and social environment in analysing the problem solving. (4) Phase 4' Activities: Classroom Discussions include (a) Lecturers organize tasks to be presented by each collaborative group, (b) Each collaborative group presents its work according to the task, the lecturer facilitates other groups to discuss the results of the exposure group (c) Lecturers facilitate the growth of collaborative work

between groups of students in the classroom. (5) Activities in Phase 5: Evaluation & Feedback include (a) Lecturers help students to reflect or evaluate the process and results of investigation or collaborative problem solving, (b) Lecturer guides students to draw conclusions based on work result at team work collaboration stage and class discussions, (c) Lecturers provide feedback. The results are reinforced by theoretical and empirical support that the CinQASE learning model is based on motivational theory, social constructivist theory, positive dependency theory, and cognitive psychology-theory [29,49-51].

The result of students' response analysis that was collected is concluded that the overall percentage of students' response after the implementation of CinQASE learning model was above 70%. It shows that students responded very well to the developed learning model. The responses also show that the developed and implemented collaborative critical thinking skills test instrument in the six-session learning activities can assist students in understanding the material and improve collaborative critical thinking skills during the learning activities. Therefore, the CinQASE learning model proved to be effective to improve collaborative critical thinking skills of physics education students.

4. Conclusion

The CinQASE Learning Model is a collaborative-based learning that is specifically designed to improve students' collaborative critical thinking skills. The CinQASE Learning Model has syntax that consists of 5 phases, they are: (1) Problem Presentation, (2) Individual Work, (3) Team Work in Collaboration, (4) Class Discussion, and (5) Evaluation and feedback. The result of the research proves that: (1) Average post-test value was 79.35 (high category), (2) There is improvement of physics education students' collaborative critical thinking skills at $\alpha = 5\%$, (3) N-gain average score of physics education students' collaborative critical thinking skills was 0.62 (medium category); and (4) No difference (consistent) n-gain of collaborative critical thinking skills of physics education students in all groups; and (5) Students responded well to the implementation of the CinQASE learning model. Another finding based on the results of interviews shows that the CinQASE learning model has a nurture effect to improve the collaborative skills and argumentation. Therefore the CinQASE learning model has proven to be effective to improve collaborative critical thinking skill of physics education students. The implication of this research is that CinQASE learning model can be used as alternative solution to improve collaborative critical thinking skill of physics education students in Indonesia. Further research can be done by implementing the CinQASE learning model to improve the collaborative critical thinking skills of education and pure science students.

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