JPII 8 (4) (2019) 529-537

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

THE EFFECT OF CONFLICT-COGNITIVE STRATEGY IN INQUIRY LEARNING TOWARDS PRE-SERVICE TEACHERS' CRITICAL THINKING ABILITY

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DOI: 10.15294/jpii.v8i4.21002

Accepted: July 23rd, 2019. Approved: December 27th, 2019. Published: December 31st, 2019

ABSTRACT

The trend of today's learning goals for educational institutions is to produce pre-service teachers who think critically. Critical thinking is a higher-order thinking domain that can be taught through appropriate learning strategies. This study intended to describe the influences of the conflict-cognitive strategy in the inquiry-based learning model towards pre-service teachers' critical thinking ability. This is pre-experimental research with one group pretest-posttest design. The sample included 18 pre-service physics teachers at Mataram State Islamic University (UIN Mataram). The pre-service-teachers' critical thinking ability was assessed using a critical thinking skill test instrument adapted from the Ennis-Weir Critical Thinking Essay Test. Indicators of critical thinking ability consisted of the ability to analyze, inference, evaluate, and make a decision. The data on critical thinking ability were analyzed descriptively and statistically, where homogeneity, normality, and t-test were performed. Descriptive analysis results indicated that the average score of critical thinking ability in the pretest was -1 in the "less critical" criteria and increased at posttest to 9,89 in the "quite critical" criteria after learning using the conflict-cognitive strategy in the inquiry-based learning model. Statistically, the analysis results revealed that the implementation of the conflict-cognitive strategy in the inquiry-based learning model had a significant effect on pre-service teachers' critical thinking ability. Therefore, the conflict-cognitive strategy in the inquiry-based learning model can be a reference and alternative learning strategy that can be implemented for specific purposes to improve pre-service teachers' critical thinking ability.

Keywords: conflict-cognitive strategy, critical thinking ability, inquiry learning model

INTRODUCTION

Critical thinking is one of the learners' crucial skills in 21st-century learning that must be acquired. In the 21st century, learners have been faced significant changes in all aspects of life, digital literacies, technological advances, multicultural societies, human mobility, global communication, social networking, innovations, creativity, and inclusiveness (Saleh, 2019), and the role of education is to help learners deal with these changes by using their critical thinking (Chalkiadaki, 2018). Critical thinking has become a trend, the main focus of learning, the curriculum authorities in several developed countries which put critical thinking ability in their curriculum as learning goals (Prayogi et al., 2018a), and

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educational standards such as in United States, Canada, Europe, Australia, and New Zealand (Howard, 2018). Since 2013, Indonesia has established critical thinking as a learning goal through the implementation of the 2013 Curriculum. This is in line with the arguments of Prayogi et al. (2018a) that critical thinking must be the focus of learning development in Indonesia since it has the potential to make learners master their life skills, creations, and innovations to solve progressively complex issues in the 21st century. Considering the importance of critical thinking ability, some student assessment programs at the international level include them as one of the assessment domains, for example, the Program for International Student Assessment (PISA) established by the Organization for Economic Co-operation and Development (OECD). The results of the 2015 PISA study showed that Indonesia ranked 69th out of 76 participating countries (Organisation for Economic Co-operation and Development [OECD], 2017). In the same year, the results of Trends in International Mathematics and Science Study (TIMSS) indicated that Indonesia ranked 46th out of 51 participating countries in science achievements (Mullis et al., 2015).

Studies by Wasis (2016) revealed that Indonesian students tend to fail in problem-solving that requires critical thinking ability. This result is undoubtedly a problem of education and learning in Indonesia, and teachers as a determinant factor often become the target of these problems. On the other side, the teachers believe that critical thinking ability is essential to be trained, but the teacher does not know how to teach it (Prayogi et al., 2018a). Improvements in this sector are needed and can be made as early as possible to pre-service teachers, where teaching interventions for critical thinking are trained since in college so that when they become a teacher, they can train them to the students (Warburton, 2008). Motivating the development of critical thinking skills in pre-service teachers is also an essential result of learning in higher education (Tiruneh et al., 2017). Critical thinking ability is one of the learning competencies that must be achieved at the level of higher education in Indonesia, as stated in the Indonesian National Qualification Framework (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 73 the Year 2013).

Learning is the process of forming and improving learners' ability to think (Wrenn & Wrenn, 2009). Experts have long explored the tendencies of individual thinking and related them to the learning outcomes obtained in two ways of thinking, namely convergent and divergent. Convergent thinking refers to critical thinking patterns, while divergent thinking is associated with creative thinking (Webb et al., 2017). Referring to Facione (2011), critical thinking is a thorough description of some characteristics that include interpretation, analysis, evaluation, inference, explanation, and self-regulation process. One of the famous contributors to the tradition of critical thinking is Robert Ennis. Ennis (2011; 2013) argued that critical thinking, as reflective and reasonable thought, focuses on determining what to believe or do. Moroever, Lai (2011) has reviewed several works of literature and expert opinions on critical thinking and come up with a conclusion that it could be observed in three main approaches in its definition; philosophical, cognitive psychological, and educational approach. Critical thinking in a philosophical approach places more emphasis on the quality and characteristics of a critical thinker. According to the cognitive psychology approach, critical thinking highlights real action and behavior that can be demonstrated by a critical thinker. So, in its definition, there is a list of critical thinking skills. Finally, as an educational approach, critical thinking emphasizes a higher-level thinking process or what is referred to as "higher-order thinking skills."

Teaching science today relies on optimizing physics learning in the classroom. Physics is one branch of science that seeks to describe how nature works and involves the study of universal law and behavior as well as the relationships between various natural phenomena (Argaw et al., 2016), which requires critical thinking (Prayogi et al., 2018a). Improving the pre-service teachers' critical thinking ability, especially pre-service physics teachers, is a crucial expected learning outcome. This is essential to be done because some learners remain to have low critical thinking ability (Brookfield, 2017). Previous studies by Qing et al. (2010) found that critical thinking ability of pre-service science teachers was still in the low category. Critical thinking ability is an essential thinking ability and must be taught (Patrick et al., 2014), but many lecturers do not get how to teach it effectively (Brownlee et al., 2009; McPeck, 2016). The low critical thinking ability of pre-service teachers is thought to have something to do with the implemented teaching process (Wlodkowski & Ginsberg, 2017). The conventional or traditional teaching model applied such as lecturing (Anggoro et al., 2019) cannot facilitate the development of learners' critical thinking ability (Hammond et al., 2015) because students

learn through the preaching and explanation of teachers that cause undeveloped learners' cognitive skills and weak reasoning skills (Hong & Chai, 2017). Therefore, for improving the quality and facilitate the development of critical thinking of pre-service teachers, it is mandatory to find out alternative solutions to it.

Enhancing critical thinking ability needs a holistic approach, including a set of appropriate and goal-oriented learning that allows pre-service teachers to manipulate their cognitive skills (Thompson, 2011; Verawati et al., 2018). In this context, the holistic approach in question is the use of learning strategies and approaches that can fully contribute to creating students' critical thinking. Facione et al. (2017) described a holistic approach as an approach that allows an extensive interaction between learning components for training critical thinking. The components referred to are instructors with students, between students, and the main thing is the implementation of the learning approach itself. Dewey (in Zahid & Khanam, 2019) implied that a teaching approach emphasizing experience requires reflective thinking to be able to develop students' critical thinking ability. In contemporary terms, doing hands-on is insufficient. Dewey assumed that minds-on experiences and activities are needed. Various instructional approaches, such as problem-solving, exploration, inquiry, and asking for high-level questions, can develop pre-service teachers' critical thinking ability (Redmond, 2014). Prayogi & Asy'ari (2013) previously conducted research and found that pre-service teachers' critical thinking ability could be developed and improved through experimental activities in the laboratory to solve problems.

Some previous researchers (such as Fine & Desmond, 2015; Fitriani et al., 2018; Muliadi et al., 2019; Prayogi et al., 2018b), recommended inquiry activities as the foundation of teaching to promote the needs of the 21st-century learning skills including critical thinking ability. Activities in the inquiry process that support critical thinking are hypothesizing and testing hypotheses, exploration, analysis, inference, and generalization. Through inquiry learning, pre-service teachers can actively build their knowledge so that the expected learning outcome can be achieved (Samarapungavan et al., 2008). Further, Arends (2012) popularized inquiry teaching with the term "inquiry-based lesson." The inquiry-based lesson is the operationalization of inquiry teaching in the classroom with six phases of teaching. They are (1) preparing to learn and run the inquiry process; (2) present the problem situation; (3) encouraging the learners to formulate the hypothesis; (4) collecting data to test the hypothesis; (5) formulating explanations and/or conclusions; and (6) reflecting the learning process. Activities in scientific inquiry serve as precursors in training learners' critical thinking ability; so, the inquiry must be conducted in teaching for training students' critical thinking.

Prayogi et al. (2018a) recently developed a learning model to train critical thinking ability, namely the Critical-Inquiry based Learning model in which inquiry is the basis of the model, and one of the essential attributions in its learning activities is the presentation of conflict-cognitive strategies. Conflict-cognitive is a perceptual state in which learners understand the difference between his cognitive structure and his environment (external information) or amongst different components (for example, conception, beliefs, substructure, and upon) of cognitive structures (Kang et al., 2010).

Conflict-cognitive happens when learners' mental balance is interrupted by experiences that are not in line with their current understanding (Foster, 2011). According to Prayogi et al. (2018b), conflicts occurring in the cognitive structure of learners are the central part of inquiry learning. There is a fact that before the implementation of inquiry learning, learners have a prior knowledge or information of the concept of the material being taught, so that generally in the learning process there will be conflicts between prior knowledge and their inquiry process called conflict-cognitive because of changes in conceptions (Prayogi et al., 2018b). When the irrelevant information is connected with a response, reliance on automatic processing might facilitate the task if this response is desirable. Although, when the irrelevant, automatically processed information is associated with an inappropriate response, the resulting conflict between appropriate and inappropriate responses might be challenging to overcome. This is where intervention the importance of critical thinking, and critical thinking of learner has been growing by conflict-cognitive learning strategies (Akmam et al., 2018). However, according to Piaget (in Anggoro et al., 2019), the main point when conflict-cognitive strategies are conditioned in learning is the occurrence of unadapted responses in which participants are not aware of the existence of conflict so that it affects the desired learning outcomes. As a result, students' understanding tends to rely on intuition and tactile experiences (Vicovaro, 2014). This is also a challenge in implementing the inquiry model. Therefore, it is necessary to do 'in deep

exploration' to scrutinize the effects of conflict-cognitive strategies in the inquiry-based learning model toward pre-service teachers' critical thinking ability.

METHODS

This is pre-experimental research that aimed to examine the effects of conflict-cognitive strategies in the inquiry-based learning model toward pre-service teachers' critical thinking ability. The one group pretest-posttest design was used in this study (Fraenkel et al., 2012).

Table 1. The Research Design

Group	Pretest	Treatment	Posttest
N	O_1	X	O_2

Anotation: N = Group (number of sample); O1 = Pre-test; X = Treatment (learning with conflict-cognitive strategy in inquiry-based learning model); O2 = Post-test.

This study used one sample group, and 18 pre-service physics teachers were involved at Mataram State Islamic University (UIN). The sample was selected purposively with the provisions of those who were studying in the first year of education and taking fundamental physics courses. The sample consisted of eight males and ten females. The number of meetings in this study was six times, where the first meeting was for the pre-test, the next four meetings were for treatment, and the last meeting was for the posttest. The learning process is carried out four times over two weeks (two meetings each week). The treatment referred to in this study is learning with a conflict-cognitive strategy in the inquiry-based learning model on fluid mechanics topics. Indicators of critical thinking ability in this study refer to the indicators used by Prayogi et al. (2018a), namely analysis, inference, evaluation, and decision making. The four indicators are used because they have accommodated aspects of learning needs at the higher education in Indonesia, according to the statement in the Indonesian National Qualification Framework at the 6th qualification level. Besides, the four indicators are the leading indicators of critical thinking, according to experts, such as Ennis (2011, 2013), Facione (2011), Elder and Paul (2010).

The pre-service teachers' critical thinking ability was measured using a critical thinking ability test instrument in the form of essay questions adjusted to indicators of critical thinking. The questions presented are closely related to the real-world context in everyday life. One of the examples of a critical thinking ability test instrument that measures the aspect of the analysis is presented as follows.

Five densities of matters dipped in a tub of water are:

A: 0,85 g/cm3
B: 0,95 g/cm3
C: 1,05 g/cm3
D: 1,15 g/cm3
E: 1,25 g/cm3

The density of water is 1,0 g/cm^3. The diagram in the figure shows the six possible positions of the five matters if put in a tub of water. Analyze the state of matters by selecting positions from 1-6 for the five matters, give your reasons.

Before being implemented, the test instrument was examined for validity, reliability, and sensitivity. The validity was measured using validation sheets based on Likert scales consisting of five scoring scales for each item declarations, from very valid to invalid (Bahtiar& Prayogi, 2012). The reliability was calculated with the equation of agreement percentage by Emmer and Millet (in Borich, 1994). The results of the validity and reliability test by experts show that the test instrument is valid and reliable to be implemented. The sensitivity test was done to determine whether the test items (questions) can measure the effects of learning that has been carried out. The sensitivity of the test item is expressed by the sensitivity index, referring to the Gronlund theory (1982). Question items are stated to be sensitive if they are positive in the sensitivity index range from 0 to +1. The sensitivity test results show that all test items are sensitive, with an average sensitivity score (sensitivity index) of 0,36. The average sensitivity index for each indicator of critical thinking consists of analysis (0,32), inference (0,45), evaluation (0,25), and decision making (0,43).

The data of pre-service teachers' critical thinking ability were analyzed following critical thinking rubrics. The critical thinking rubric used in this study is in the form of a multilevel scale, which is a statement followed by a scaling scale in line with predetermined criteria. The critical thinking ability score using scale 5 refers to the Ennis-Weir Critical Thinking Essay Test (EWCTET) scoring technique, where the highest score is +3, and the lowest is -1. The item test number of questions is 8 (eight) questions following the indicator of critical thinking (each indicator consists of 2 items) so that the maximum score is +24, and the minimum score is -8. The criteria of

critical thinking ability, which was adapted from Prayogi et al. (2018a), is provided in Table 2 as follows.

Table 2. Critical Thinking Ability Criteria of Pre-Service Teachers' Using Five Scale

Range	Criteria
X > 17,6	Very Critical
11,2 < X ≤ 17,6	Critical
4,8< X ≤ 11,2	Quite Critical
-1,6 < X ≤ 4,8	Less Critical
X ≤ -1,6	Not Critical

Annotation: X = empirical score of critical thinking

Increasing the score of critical thinking ability was analyzed using the N-gain equation according to Hake's theory (1999) with the criteria as in Table 3.

Table 3. Criteria of Score Change (*N-gain*)

Range	Criteria
> 0,70	High
0,30 – 0,70	Moderate
< 0,30	Low

Statistical analysis (inferential statistics) was carried out to analyze the test data of pre-service teachers' critical thinking ability. The test is the t-test that aims to examine the effects of conflict-cognitive strategies in scientific inquiry activities on students' critical thinking abilities. The formulation of statistical hypotheses in the t-test, namely H_0: μ1 = μ2 (there is no effect of conflict-cognitive strategy in inquiry learning towards pre-service teachers' critical thinking ability), and H_1: μ1 ≠ μ2 (there is an effect of conflict-cognitive strategy in inquiry learning towards pre-service teachers' critical thinking ability). H_0 is rejected if the score of the t-test is less than the significance level 0.05. H_1 is accepted if the score of the t-test was higher than alpha testing (0.05).

RESULTS AND DISCUSSION

The critical thinking ability test was given to pre-service teachers as the pre-test and post-test. The test was held to evaluate the improvement of pre-service teachers' critical thinking ability after learning using the conflict-cognitive strategy in the inquiry-based learning model. The result descriptions of the pre-service teachers' critical thinking ability test are presented in Table 4. The measurement results of pre-service teachers' critical thinking ability indicated that the critical thinking average score in the pretest was -1 and belonged to the "less critical" criteria (less critical, if: -1.6 <X ≤ 4.8) and posttest was 9.89 and categorized as "quite critical" (quite critical, if: 4.8 <X ≤ 11.2), with an N-gain of 0,44 which included in the "moderate" criteria. The pretest results revealed that 9 pre-service teachers were classified as 'less critical', 9 others were categorized as 'not critical', 6 pre-service teachers were identified as 'critical,' and 12 pre-service teachers were classified as 'quite critical.' No pre-service teacher was rated as 'very critical,' 'less critical,' and 'not critical.' Pre-service teachers' critical thinking ability is in the less critical criteria in all aspects (indicators) in the pretest. The implementation of conflict-cognitive strategy in the inquiry-based learning model in the learning process has an influence on improving critical thinking ability in each aspect. Though the final results of pre-service teachers' critical thinking ability in UIN-Mataram were quite good, there was still an improvement of critical thinking ability in all aspects (indicators). Increasing pre-service teachers' critical thinking ability at UIN-Mataram measured by N-gain showed the highest increase in the inference indicator, followed by indicators of evaluation, decision making, and analysis.

Table 4. The Results of Pre-Service Teachers' Critical Thinking Ability on Pretest and Posttest whichwere Analyzed Descriptively According to Intervals, Criteria, Mean Score, and Score Change (N-Gain)

Interval	Criteria	Pretest		Posttest		N-gain	Criteria
		Freq.	Mean	Freq.	Mean		
X > 17.6	VC	0	-1 (less critical)	0	9.89 (quite critical)	0.44	Moderate
11.2 < X ≤ 17.6	C	0		6			
4.8 < X ≤ 11.2	QC	0		12			
-1.6 < X ≤ 4.8	LC	9		0			
X ≤ -1.6	NC	9		0			
N		18		18			

Annotation: VC (very critical), C (critical), QC (quite critical), LC (less critical), NC (not critical)

The data of critical thinking ability were also statistically tested using the t-test, homogeneity, and normality test. The results of the homogeneity and normality test are shown in Table 5, while the results of the t-test are presented in Table 6.

Table 5. The Result of Homogeneity Using Levene's Test and Normality Using Kolmogorov-Smirnov's Test

Variance	N	Homogeneity		Normality	
		Levene's Test Score	Sig.	Kolmogorov-Smirnov's Test Score	Sig.
Pretest-posttest	18	0.716	0.403	0.096	0.200

The homogeneity test used the Levene test, while the normality test used Kolmogorov-Smirnov's test. The homogeneity and normality of the data test showed that the data variants are homogeneous (Levene's test score = 0.716) and normally distributed (Kolmogorov-Smirnov's test = 0.096) with a significance value of 0.403 and 0.200, both of which were greater than alpha testing.

Table 6. The Result of T-Test (Pair T-Test) among Pretest and Posttest Score of Critical Thinking Ability on the Learning Using Conflict-Cognitive Strategy in the Inquiry-Based Learning Model

Variance	N	Homogeneity		Normality	
		Levene's Test Score	Sig.	Kolmogorov-Smirnov's Test Score	Sig.
Pretest-posttest	18	0.716	0.403	0.096	0.200

The results of this study dealing with pre-service teachers' critical thinking ability using the t-test unveiled that the significance value of the test (0.000) was smaller than alpha testing (0.05). It means that H_0 (there was no effect of conflict-cognitive strategy in inquiry learning towards pre-service teachers' critical thinking ability) was rejected and H_1 (there was an effect of conflict-cognitive strategy in inquiry learning towards pre-service teachers' critical thinking ability) was accepted. The elaboration of the results in this study presented that the implementation of the conflict-cognitive strategy in the inquiry-based learning model had a significant effect on pre-service teachers' critical thinking ability.

The results are inseparable from the vital role of conflict-cognitive strategy in the inquiry-based learning model. The conflict-cognitive strategy is a catalyst for cognitive development in the learning process for training critical thinking (Lai, 2011). The conflict-cognitive strategy presents a more meaningful learning process (Nilsson & Castro, 2013). Then, it becomes a stimulant for learners to understand higher concepts in learning material (Baddock & Bucat, 2008). The conflict-cognitive strategy interventions in the inquiry-based learning model in this study were in 3 learning sequences, namely establishing sets and conveying learning objectives, presenting or demonstrating contradictory information (anomalous data) to generate motivation in learning, and finally presenting an advance organizer as a follow-up to the anomalous data presented. The participating pre-service teachers' showed attention to establishing sets conducted by lecturers as well as on delivering learning objectives and gave responses related to contradictory information (anomalous data) presented by lecturers in learning and showed interest in advancing organizers explained by the lecturer as a follow-up of anomalous data.

Preparing pre-service teachers to learn and deliver learning objectives at the beginning of classroom learning is increasingly important. According to Arends (2012), excellent teachers begin their lessons by explaining goals, establishing learning sets, and getting student attention. Teachers' behaviors at the beginning of learning influence the willingness, motivation, and formation of learners' beliefs about what they will learn (Anggoro et al., 2019). Besides, presenting contradictory information or anomalous data or discrepant event at the beginning of learning is often essential to encourage student interest and ensure the emergence of fundamental knowledge (Ambrose & Lovett, 2014).

Presenting anomalous data assists students to reflect more on their ideas to explain the phenomena being studied (Vosniadou, 2014; Toth, 2016). Providing explanations following ideas or phenomena is one of the main factors that encourage and train students to be able to

think critically. It is in line with Prayogi et al. (2018a), who stated that it is crucial to start the learning process in scientific inquiry activities by presenting anomalous data because it can train to the reason (critical thinking) and become the main instrument to motivate pre-service teachers' in the learning process. Meanwhile, after presenting anomalous data, the learning process was followed up with an advanced organizer as a bridge to facilitate them with the initial action of learning with the inquiry process itself.

The peculiarity of the advance organizer lies in how contradictory information can be formulated into problems that later become the focus of the investigation activities. Theoretical studies showed that advance organizers are a form of cognitive thinking stimulation in learning that could encourage motivation, and also the information conveyed at the beginning of learning is more meaningful (Shihusa& Keraro, 2009). Advance organizers in the form of presenting information that bridges new learning materials and related ideas that exist (Omondi et al., 2018). Advance organizers could be used by pre-service teachers to organize and interpret the information they can apply for further learning (Safdar et al., 2014). Also, advanced organizers encourage the use of critical thinking ability, such as analyzing abstract concepts and deepening understanding, also, expanding the relationship amongst ideas.

The results of this study are similar to previous research findings that the presentation of contradictory information enables the learner to reach pure scientific conceptions (Hadjiachilleoset al., 2013). The conflict-cognitive strategy is effective in improving learner performance (Ab-Rahim et al., 2015). Learner build mental schemes in the learning process through learning interactions and reasoning (critical thinking), both learning resources for more effective learning processes for desired goals (Tytler et al., 2009; Waldrip et al., 2010), and in this study, the goal has been achieved, where conflict-cognitive strategies effectively improve critical thinking ability.

CONCLUSION

The findings of this study showed that the implementation of the conflict-cognitive strategy in the inquiry-based learning model had a significant effect on pre-service teachers' critical thinking ability. Descriptively, pre-service-teachers' critical thinking ability increased from 'less critical' to 'quite critical' after the implementation of conflict-cognitive strategy in the inquiry-based learning model. Statistically, testing hypotheses related to the focus of research showed that there was an improvement of pre-service teachers' critical thinking ability between the pretest score and the posttest score after the implementation of conflict-cognitive strategy in the inquiry-based learning model. Based on these results, the conflict-cognitive strategy in the inquiry-based learning model can be a reference and alternative learning strategies that can be implemented for specific purposes to improve pre-service teachers' critical thinking ability.

The researcher team suggested that future research explore these research findings further dealing with the results of critical thinking ability that is purely described as the impact of implementing conflict-cognitive strategies or inquiry learning in general. It is hoped that the contribution of strategy in the inquiry-based learning model becomes clearer. Besides, critical thinking dispositions that are not explained in this study are essential to be explored further to evaluate their impact with the implementation of conflict-cognitive strategies.

ACKNOWLEDGEMENTS

Authors would like to thank the contributing parties who funded the research process, gave research permission, became the research subject, and other people which could not be mentioned one by one. The results of this study are expected to provide benefits and spirit for the advancement of education, especially in Indonesia.

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