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Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers

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Abstract. Critical thinking has become one of the main competencies of learning at the level of higher education in Indonesia, and teaching interventions that lead to the achieving of these competencies are important to do. One of the learning models developed to promote critical thinking ability is the Inquiry Creative Process (ICP), a learning model. This research aims to describe the effectiveness of the ICP learning model to promote the critical thinking ability of prospective physics teachers. The implementation of the ICP learning model involved prospective physics teachers at four higher education institutions in the province of West Nusa Tenggara - Indonesia, that are the Mataram University (UNRAM), Teacher Training and Education Institut of Mataram (IKIP Mataram), Mataram State Islamic University (UIN Mataram), and the University of Muhammadiyah Mataram (UM Mataram). This study is experimental research, where is for each group performed pretest, implementation of the ICP learning model, and then posttest. The critical thinking ability of prospective physics teachers was measured using a critical thinking ability test instrument. The data of critical thinking ability were analyzed descriptively and statistically, where the homogeneity, normality, t-test, and ANOVA test were conducted. The results showed that the implementation of the Inquiry Creative Process learning model was effective to promote the critical thinking ability of prospective physics teachers. Descriptions of further research results are described in this article.

1. Introduction

Students after graduation must have the ability to think critically, and this has become the general hope of educators, parents, and the general society. Critical thinking is considered important for young people who want to continue further education, compete to get a job, or simply become responsible citizens. For critical thinking to be properly cultivated in schools, we must ensure that teachers have the critical understanding and critical thinking [1], and critical thinking teaching interventions are very appropriate for prospective teachers when they are still educating at the higher education level [2].

Teaching critical thinking to learners especially prospective teachers has attracted attention in recent decades given the role of future teachers as agents of change for the education system in terms of developing learner critical thinking [3]. In higher education institutions that produce prospective teachers, lecturers must teach high-level thinking skills and education before becoming a teacher is the right time for intervention activities that can promote critical thinking [4]. However, teaching to think remains confusing for many teachers [5]. This is due to the lack of clarity of the various methods available to teach critical thinking skills [5, 6]. At the higher education level, Bissell and Lemons [7] show that the average learner does not think critically. Thompson [8] argues that teaching critical thinking requires a holistic approach and must involve a set of appropriate learning models. Therefore, it is necessary to develop a set of specific learning models to improve learner critical thinking skills.

One of the learning models that aimed at how learners to think is the inquiry instruction model [9] and has been developed for specific purposes, for example in this study to improve the critical thinking ability of prospective physics teachers. The inquiry model is integrated with the process of scientific creativity into it, according to Philley [10] critical thinking is a multidimensional cognitive construction, as a result of the creative process. The integration of this study constructed in the learning model is called the Inquiry Creative Process (ICP) learning model. The ICP learning model is a model developed by integrating the attribution of creative processes (scientific creativity) in each syntax of inquiry models. Scientific creativity is creativity in learning science which is attributed to the emphasis on the ability to find the problems (problem finding), creating hypotheses, creatively experiment designing, science creatively problem solving, and creatively product design [11,12,13,14]. The assignment of creativity can expand the reach of creative activities, so the learner can apply, produce, find, compare, connect, imagine, and design creative ideas [15].

Attributions in scientific creativity are then integrated into scientific inquiry activities. The inquiry-based lesson according to Arends [9] consists according to activities; problem identification, formulating hypotheses, planning experiments to test hypotheses, formulating explanations, and reflecting. Inquiry processes need to be integrated and attributed to scientific creativity for the purpose to improve learner critical thinking, as explained by Adams [16] that the creative process or scientific creativity has the potential to exercise critical thinking ability. This integration is also to sharpen the potential to facilitate thinking through inquiry activities.

The ICP model promotes the critical thinking ability of prospective physics teachers. Ennis [17] and Hassard [18] define critical thinking as reasonable and reflective thinking that is focused on deciding what to believe or do. Critical thinking is often called independent thinking, reflective thinking, or evaluative thinking [19]. Critical thinking ability has been seen as a cognitive process, some previous researchers [2, 20, 21, 22] consistently use aspects of analysis, inference, evaluation, and decision making as the main indicators of critical thinking ability. This study aims to implement the ICP learning model and then evaluate its effectiveness in promoting the critical thinking ability of prospective physics teachers.

2. Methods

This study is a type of experimental research that aims to describe the effectiveness of the ICP learning model to promote the critical thinking ability of prospective physics teachers. The implementation of the ICP learning model involved prospective physics teachers (PPT) at four higher education institutions in the province of West Nusa Tenggara-Indonesia, which are the 20 PPT in UNRAM, 9 PPT in IKIP Mataram, 16 PPT in UIN Mataram, and 16 PPT in UM Mataram. The number of PPT involved was 61 people. For each group performed pretest, implementation of the ICP learning model, and then posttest. CT ability of PPT measured using a critical thinking ability test instrument, adapted from the Ennis-Weir Critical Thinking Essay Test with the indicators measured are the ability to analyze, inference, evaluate, and decision making [20]. The data of CT ability were analyzed descriptively and statistically, where the homogeneity, normality, t-test, and ANOVA were conducted. The effectiveness criteria of the ICP learning model if there is an improvement in critical thinking ability after the implementation of the model, and score of CT ability at least "critically" criteria in the posttest. Moreover, the effectiveness criteria according to the hypothesis tested in this study are: a) there is an increase in CT ability of PPT between the pretest score and the posttest score after implementation the ICP learning model in all group, and b) there is not significantly difference in increasing CT ability between classes after the implementation of the ICP learning model.

3. Results and Discussion

The result of the CT ability test of prospective physics teachers who are processed descriptively is shown in Table 1. The result of CT ability involving in 4 higher educational institutions (UNRAM, IKIP, UM, and UIN) shows average CT ability score on pretest of -2.13, with criteria of "not critically" (not critically, if: $X \leq -1.60$), and the posttest score of 16.34 with criteria of "critically" (critically, if: $11.20 < X \leq 17.60$), with n-gain of 0.71 with "high" criteria. From these results, it can be declared that the ICP learning model is effective in promoting the critical thinking ability of prospective physics teachers.

Table 1. The data of CT ability of prospective physics teachers in 4 group tested

Group	*Mean score & criteria*					*N-gain*	*Criteria*
	N	*Pretest*	*Criteria*	*Posttest*	*Criteria*		
UNRAM	20	-2.40	not critically	16.60	critically	0.72	high
UM	9	-1.89	not critically	16.22	critically	0.70	high
UIN	16	-1.38	not critically	15.81	critically	0.67	medium
IKIP	16	-2.88	not critically	16.75	critically	0.76	high
Average		*-2.13*	*not critically*	*16.34*	*critically*	*0.71*	*high*

Statistical analysis was performed to evaluate the effectiveness of the ICP learning model with predetermined hypothesis testing criteria. Homogeneity tests, normality tests, t-tests, and ANOVA tests were conducted. The variance homogeneity test using Levene's test, and the normality test using the Kolmogorov-Smirnov normality test in each of the four groups showed that the data variance was homogeneous and normally distributed with a significance value of all test groups greater than 0.05. The results of the homogeneity test of variance dan normality test provided in Table 2 and Table 3.

Table 2. The results of the homogeneity test of variance (Levene's test)

Data	Group	Levene test statistic	dF	Sig.
Pretest-Posttest	UNRAM	0.209	38	0.650
	UM	0.381	16	0.546
	UIN	0.658	30	0.424
	IKIP	0.668	30	0.287

Table 3. The results of the normality test (Kolmogorov-Smirnov normality test)

Data	Group	Kolmogorov- Smirnov test	N	Sig.
Pretest-Posttest	UNRAM	0.098	20	0.200
	UM	0.170	9	0.200
	UIN	0.155	16	0.200
	IKIP	0.111	16	0.200

The results of testing the critical thinking ability of each group using the t-test show that the significance value of the test (0.000) for all groups smaller than the alpha test (0.05), thus the hypothesis H_1 is accepted, its meaning that there is an increase in critical thinking ability of prospective physics teachers between the pretest score and the posttest score after implementation the ICP learning model in all of these groups. The result of the t-test is provided in Table 4.

Table 4. The result of the t-test (independent samples test)

	Group	*t-test for Equality of Means*		
		t	*df*	*Sig.*
Pretest-Posttest (Equal var. assum.)	UNRAM	-31.996	19	0.000
	UM	-27.651	8	0.000
	UIN	-22.965	15	0.000
	IKIP	-33.358	15	0.000

Analysis of differences in the improvement of critical thinking ability of all classes was tested using ANOVA (F-test). The ANOVA test results show that the significance value (0.473) is greater than the alpha test (0.05), thus that H_0 is accepted (there is no significant difference in the increasing critical thinking ability between all groups after the implementation of the ICP learning model). This means that the ICP learning model has the same effect on improving the critical thinking ability of prospective physics teachers in all groups tested. The ANOVA test results are provided in Table 5.

Tabel 5. The ANOVA test result

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	9.764	7	1.395	0.955	0.473
Within Groups	77.384	53	1.460		
Total	87.148	60			

The results of the statistical analysis show that the ICP learning model has been consistently in promoting the critical thinking ability of prospective physics teachers. The implementation of the ICP learning model to the prospective teachers of physics is in line with the demand that a physics learning has to master CT ability into it to correlate and interrelate between two or more theories and concepts in learning physics. The use of the ICP learning model increased the PPT ability in developing their CT. The result of this current study is parallel with the previous relevant study which found that the intervention of scientific creativity to develop CT ability is significantly effective [23].

The ICP learning model has strongly built critical thinking ability because it is by following the emphasis of the principles of constructivism learning. The constructivist perspective views teaching as not transferring knowledge from a teacher to learner, but an activity that allows the learner to develop their knowledge. Constructivist principles are based on ideas where learning develops knowledge actively, rather than accepting it passively in packages, from teachers (lecturers) or outside sources. The processes of creativity in inquiry activities have underpinned constructivist principles in learning. In addition to emphasizing the aspect of critical thinking, several advantages of the ICP learning model when implemented, which can encourage the curiosity of learners, create collaborative learning, encourage a sense of responsibility, support a positive classroom, and develop skills in learning itself.

The aspects of critical thinking that are promoted through the implementation of the ICP learning model in this study include the ability to analyze, inference, evaluate, and decision making. In the aspect of analysis, prospective physics teachers can identify the actual relationship between statements, questions, concepts, descriptions, or other. In the aspect of inference, prospective physics teachers can identify the elements needed to draw reasonable conclusions, to form guesses and hypotheses, to consider relevant information. In the aspect of evaluation, prospective physics teachers can assess the credibility of statements, representations, descriptions, perceptions, experiences, situations, judgments, beliefs, or opinions. The final aspect of critical thinking is being able to decision making, that is the process of choosing choices or actions between a set of alternatives on the basis of criteria or strategy. Achieving these aspects are caused by learning that emphasizes the exploration of scientific creativity through inquiry activities. Strengthening the scientific inquiry aspects of reasoning has helped prospective physics teachers in their tendency to think critically. According to Bailin [24], the objectives in inquiry activities focus a lot of critical thinking, for example; identifying assumptions, using logical thinking, analyzing direct events and phenomena, critical analysis of secondary sources, analyzing arguments by reviewing current scientific understanding, considering evidence, and examining the logic.

The results of this study, in general, have shown that ICP learning models have been effective in promoting the critical thinking ability of prospective physics teachers. The ICP learning model uses a systematic and well-organized learning activity through some experimental activities which involve scientific creativity and scientific process skills in it. Scientific process skill has a great effect on learning because it helps the learner to improve higher mental skills, such as critical thinking, decision making, and problem-solving [25, 26]. It can be an instrument that improves critical thinking ability. For the sake of a broader teaching and learning results, it is important to teach some steps to reach and conquer the knowledge itself, in which it is definitely needed whey the learners conducting a scientific experiment during the learning process.

4. Conclusion

The ICP learning model has proven its effectiveness in promoting the critical thinking ability of prospective physics teachers. Moreover, this model has also consistently improved the critical thinking ability when implemented in different subjects in several higher education institutions administering the educational programs that produce prospective physics teachers. The findings in this study are also important reasons for using the ICP learning model as an alternative learning model that can be used by educators in general to promote critical thinking ability.

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