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The Effect of Scientific Creativity in Inquiry Learning to Promote Critical Thinking Ability of Prospective Teachers

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Abstract—Teaching critical thinking (CT) to the prospective teacher has garnered attention for a while, and the teaching conduction to trained it is important to develop. This study aims to find out the effect of teaching implementation of scientific creativity in inquiry learning to promote the CT ability of prospective teachers. Scientific creativity in inquiry learning is apellation as the inquiry creative process (ICP) learning model. This study is a experimental research conducting with *the randomized pretest-posttest control group design*. Samples were chosen to be treated as experimental and control group. Two sample groups were prospective teacher of physic (PTP) in the faculty of teacher training and education (FKIP), Mataram University, Indonesia. The data of CT ability collected by instrument refer to Ennis-Weir Critical Thinking Essay Test. The data analysis descriptively and statistically were done to process the data of research result. Generally, the results shown that ICP learning model had a significant effect on the improvement of CT ability of prospective teacher of physic. The description of the research findings are described in this article.

Keywords—Scientific creativity, inquiry creative process, critical thinking ability

1 Introduction

One of the essential skills that the learners must have in the 21st century is critical thinking (CT) skill [1]. In some countries, CT has become a major focus and competency in learning at all levels of their education [2]. In Indonesia, CT has also become a very important part of the competence to be achieved at the higher education level, as set forth in the Regulation of the Minister of Research, Technology and Higher Education of the Republic of Indonesia. Global Citizenship Education (GCE) recommends that universities should seek to facilitate students to analyze issues critically, identify creative and innovative solutions. A function of higher

education is to teach students to think. University accreditation boards in some advanced countries, for example, the National Association of Industrial Technology (NAIT), the Accreditation Board of Engineering and Technology (ABET), and the International Technology Education Association (ITEA) recognize competencies such as CT, problem solving, communication, and teamwork in their accreditation criteria [3].

Fostering the development of students' critical thinking is regarded as an essential outcome of higher education [4], and in some countries has become a very important part as the main goal of learning and education [5]. Teaching critical thinking to the prospective teacher has garnered attention for a while, and the role of future teachers seems more crucial than ever before for educational systems in terms of seeking improvement in critical thinking [6]. In the faculty of education and teachers training, teacher educators have to teach and give cognitive skills to prospective teacher before they train them to the students in the classroom [7], and education before becoming a teacher is proper time to intervention activities which promote their critical thinking [8].

Educators have long been aware of the importance of CT skills as an outcome of student learning. However, teaching CT remains confusing for many instructors [9]. This is partly due to the lack of clarity the wide range of methods proposed to best teach of CT [9, 10]. Mitrevski and Zajkov [11] show that the trend of educators in branch countries identified using eighteen models and methods ranging from discussions, demonstrations, project work, to outdoor leasson methods, but there are not explicitly purposed to improve and train critical thinking skills. At higher education level, Bissell and Lemons [12] ascertained faculties who teach at universities consider CT a primary objective. It is a sad truth that the average college student does not think critically, and not all courses include critical thinking. Thompson [13] argued that in learning CT requires a holistic approach and should involve a set of appropriate learning models. Therefore, it is necessary to develop a set of specific learning models to promote learner CT skills. Some previous researchers recommended inquiry as a basis of learning models to promote students' critical thinking skills, because inquiry is a learning model for the purpose of teaching to think [14]. The aim of this study was to find out the effect of scientific creativity in inquiry learning to promote critical thinking ability of prospective teachers.

2 Literature Review

CT is reflective and reasonable thinking that is focused on deciding what to believe or do [15], its purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or conceptual considerations upon which that judgment is based [16]. CT is a propensity and skill to engage in an activity with reflective skepticism [17]. It's used to pass judgment on any information, explain the reasons, and able to solve the problem of the unknown [18], so that each of individuals are able to understand any information or content on a particular thing

[19]. CT is often called independent thinking, reflective thinking, or evaluative thinking, and it's the best understood as the ability of thinkers to take charge of their own thinking [20]. Despite differences among of thought and their approaches to defining critical thinking, there exist areas for agreement. The researchers of CT typically agree on the specific abilities encompassed by the definition, which include: analyzing arguments, claims, or evidence; making inferences using inductive or deductive reasoning; judging or evaluating; and decision making.

Stimulation of creative processes and CT in the context of education and learning are important. The integration of creative and CT has been emphasized in literature in recent decade [21, 22] and the importance of combining these two thought processes to solve the problems [23]. Correlation of both is clear, that problem solving involves stages of generating ideas using creative processes and critical thinking [24]. CT can be considered as a multidimensional cognitive construct, as a result of the creative processes [25]. Halpern [26] conceptualizes critical and creative thinking as complementary, yet not identical processes, claiming that they may vary according to the strategies that are used to develop these skills through instructional programs.

Learning models based on inquiry activities have been widely developed for the purpose to promote learner CT skills [27], since inquiry is an instructional model that aims to guide about how learners think [14]. The processes of scientific creativity in the inquiry activities need to be revealed as a way to promote CT skills of physics prospective teachers. The development of learning models by integrating creativity processes with scientific inquiry activities needs to be explored and developed for that purpose. Creative processes (scientific creativity) potentially train the critical thinking ability of learners [28]. Aspects of scientific creativity are in the form of problem finding, problem solving, creating hypotheses, design experiment, and product design [29, 30, 31, 32, 33]. These aspects will later be integrated with the inquiry model into a set of learning model. In its development process as a learning model, scientific creativity in inquiry learning is apellation as inquiry creative process (ICP) learning model. The hypothetical framework of ICP learning model presented in Table 1.

Table 1. The hypothetical framework of ICP learning model

Learning phases	Learning activities
Preparation and identification of the problems	Preparation and presentation of learning objectives Learner find as many issues as they relate to learning materials Learner choose one core problem to be tested Learner formulate the problem to be tested
Creating and formulating the hyphotheses	Learner formulate hypotheses according to the selected problem Learner re-examine the relevance of the hypothesis with the formulation of problems that has been prepared
Creatively experiment designing	Learner identify and define operationally the variables in the hypothesis to be tested Learner prepare steps of hypothesis testing in the form of creative experimental procedures.
Science creatively problem solving	Learner implementing the experimental steps that have been prepared. Learner checking the accuracy of the implementation of the experimental steps they have undertaken. Evaluate experimental results based on previously formulated hypotheses. Learner conclude the experimental results.
Creatively product design	Learner make an experimental resume that includes detailed explanations with concept support from relevant sources.

3 Methodology

This study is an experimental research conducting with *the randomized pretest-posttest control group design* [34]. Samples were chosen to be treated as experimental group (ICP learning model) and control group (conventional model). Sample randomization was done based on existing population. Two sample group in this study were prospective teachers of physic (PTP) in the faculty of teacher training and education (FKIP), Mataram University, Indonesia. The sample for the experimental and control group was conducted with 42 (n=42) participant, 21 (n=21) PTP were assigned to the experimental group, while 21 (n=21) were in the control group. Pretest and posttest were given to the both groups of samples the results were analyzed.

Data of CT ability collected by instrument of critical thinking essay test refers to four indicator of critical thinking ability that is measured, that are analysis, evaluation, inference, and decision making. Data analysis of was analyzed descriptively using multilevel scale (five scales) referring to Ennis-Weir Critical Thinking Essay Test (EWCTET) scoring technique where highest score of +3 and lowest -1. The categorization of critical thinking ability was done with five criteria from not critically to very critically [35]. Increased students' critical thinking scores were analyzed using the N-Gain equation.

Statistical data analysis was also performed in this study, the data analysis uses one-way-anova preceded by normality and homogeneity test of sample. All statistical data analysis using the *Statistical Package for Social Science* (SPSS) 23.0 software tool.

4 Results and Discussion

Descriptively, the test result of prospective teachers' critical thinking testability can be seen through the Table 2 below.

Table 2. Critical thinking test result

Sample group	N	Critical thinking score (CTs) & criteria				n-gain	Criteria
		Pretest	*Criteria*	*Posttest*	*Criteria*		
Experiment	21	0,52	Less critically	17,48	Critically	0,72	High
Control	21	0,57	Less critically	3,85	Less critically	0,13	Low

Obviously, it was found that the mean score gained by the participants of experimental group on critical thinking ability test at the pretest is 0,52 which is then classified into "less critically" (less critically, if: $-1,6 < CTs \leq 4,8$), and the mean score gained at the posttest is 17,48 which is classified into "critically" (critically, if: $11,20 < CTs \leq 17,60$) it was happened after having some treatments on ICP learning model, in which the *n-gain* is 0,72 that is categorized into "high" category. Conversely, the mean score gained by the participants of CT ability test on control group at the pretest is 0,57 which is classified into "less critically" and the mean score on the posttest is 3,85 which is categorized into "less critically," with n-gain at the 0,13 with the "low" criteria.

The statistical analysis was conducted to find out the effect of ICP learning model on improving the prospective teachers' CT ability. The hypothesis of the study states that there is a significant effect of using ICP learning model on impoving the prospective teachers' CT ability. The data were obtained from the results of pretest and postest of prospective teachers CT ability. The data were analyzed by the SPSS for windows version 23.0. The analysis was preceded by normality test using One-Sample Kolmogorov-Smirnov Test and homogeneity test using Levene's Test of Equality of Variances. The summary of the result of normality and homogeneity test are provided in Table 3.

Table 3. The summary of the result of normality and homogeneity test

Group of data	Kolmogorov-Smirnov		Levene's Test	
	N	*Sig.*	*Levene's test score*	*Sig.*
Pretest of CT ability	42	0,200	0,000	0,992
Posttest of CT ability	42	0,200	0,970	0,331

Based on Table 3, it can be stated that the data were normally distributed and all the variances were homogeneous (sig normality and homogeneity >0.05). The comparation between the result of prospective teachers' CT ability on experimental group and those gained by the control group were found by analyzing the differences scores gained by the two groups on one-way anova analysis, the brief result of one-way anova analysis are provided on the Table 4.

Table 4. The results of one-way anova analysis

Group	Sum of squares	Df	Mean square	F	Sig.
Between Groups	1947,524	1	1947,524	619,198	0,000
Within Groups	125,810	40	3,145		
Total	2073,333	41			

The result of one-way anova analysis shows that the significance of testing (0.000) is less than the result of alfa testing (<0,05), which then concluded that there is a significant different between prospective teachers' CT ability at the experimental group and the control group which is then lead the research conclusion into saying that there is significant effect of ICP learning model in improving the prospective teachers' CT ability. Thus, the alternative hypothesis of the study is accepted.

The implementation of 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 ICP learning model obviously increased the PTP ability in developing their critical thinking. The research finding of the research shows that through ICP learning model, the PTP enhance their critical thinking. Those enhancements were mostly enhanced from "less critically" category increased into "critically" category. 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 [36], in line with the result of this study, the implementation of exploration an creative ideas in the acquisition inquiry activity is highly enhance prospective teachers ability in developing their critical thinking [35].

The enhancement of prospective teacher's critical thinking ability through ICP learning model cannot be separated from the intervention of each phases implemented during the learning process in ICP model in which the phases of learning were consistently training the critical thinking ability of prospective teacher. The problem finding and science creatively problem solving which are the dimension of scientific creativity, both have a correlation in the context to train critical thinking. The cognitive dimensions of creative thinking certainly correlations with some of the dimensions of critical thinking, this is especially obvious when the students are thinking in the context of problem solving. When the students are thinking in a given context (critical thinking), they make use of various thinking processes (creative thinking). The properties of critical thinking are linked to the creative abilities during problem finding and problem solving [37]. Creative problem finding ability is defined as a kind of intellectual trait or ability that is demonstrated in the process of producing and expressing new-found questions in a unique, novel and useful and purposeful way, using existing contexts and experience. It is embodied not only in the quantity, but also in the diversification (types) and in the originality of the problems found [38].

Creating hypotheses is one of important parts in developing scientific creativity [39]. When problems are facing, hypothesis are needed to define the most appropriate way solving those problems [14], those will automatically reinforce to think critically [40]. Creatively product design is a part of scientific creativity in which the learners are demanded to be able to design scientific product as the result of scientific

creativity [33], those points are the important invention in terms of developing prospective teachers CT ability.

The findings of this research answered the main facing problems in the teaching and learning of science, it was found that teaching science is not the matter of transferring knowledge only, furthermore, it is also about keeping the learner to be more creative and having a critical thinking in every single activity involves in the teaching and learning of science in the classroom practice, particularly at the physics subject at whole level of education [41]. Through ICP learning model, learning was prepared in such a way as into free space for innovative teaching and to promote inquiry and problem-solving strategies, leading students to achieve and show knowledge at the higher cognitive levels such as critical thinking ability. Moreover, ICP learning model also provide a process in which the learners are demanded to have a critical thinking. For this reason, students who have undergone some critical thinking lessons can produce a greater number of possible solutions to problems than those who have not had any training [42]. The ICP learning model uses a systematic and well-organized learning activity through some experimental activities which involves scientific creativity and science process skills in it. Science process skill has a great effect in learning because it helps learner to improve higher mental skill, such as critical thinking, decision making, and problem solving [43, 44]. Science process skill can be instrument that can improve 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 [45], in which it is definitely need whey the students conducting a scientific experiment during the learning process [46, 47].

5 Conclusion

After all, it can be inferred that there is some improvements on critical thinking ability of prospective teachers in which there were some significant different found between pre-condition where most of them were classified into “less critically” and post-condition where the prospective teachers are dominantly categorized into “critically” as the effect of ICP learning model. The finding says that the ICP learning model deserves to use as the alternative learning model, mainly if the teacher or lecturer want to promote critical thinking ability of prospective teachers.

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Title and Abstract

Title	The Effect of Scientific Creativity in Inquiry Learning to Promote Critical Thinking Ability of Prospective Teachers

Abstract

Teaching critical thinking (CT) to the prospective teacher has garnered attention for a while, and the teaching conduction to trained it is important to develop. This study aims to find out the effect of teaching implementation of scientific creativity in inquiry learning to promote the CT ability of prospective teachers. Scientific creativity in inquiry learning is apellation as the inquiry creative process (ICP) learning model. This study is a experimental research conducting with the randomized pretest-posttest control group design. Samples were chosen to be treated as experimental and control group. Two sample groups were prospective teacher of physic (PTP) in the faculty of teacher training and education (FKIP), Mataram University, Indonesia. The data of CT ability collected by instrument refer to Ennis-Weir Critical Thinking Essay Test. The data analysis descriptively and statistically were done to process the data of research result. Generally, the results shown that ICP learning model had a significant effect on the improvement of CT ability of prospective teacher of physic. The description of the research findings are described in this article.

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Keywords Scientific creativity, inquiry creative process, critical thinking ability

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