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

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Abstract. Critical thinking (CT) is one of the skills of the 21st century and becoming one of the goals in the development of science learning. Teaching CT to the prospective teachers have garnered attention for a while, and the role of future teachers seems more crucial than ever for educational systems in terms of improving CT. This study aims to develop Inquiry-Creative-Process (ICP) learning model to promote CT ability of physics prospective teachers (PPT). This study is a development research that produce a product of learning models that meet the criteria of validity, practicality, and effectiveness. The ICP learning model was validated through the focus group discussion mechanism (*for validity aspect*), the implementation of the ICP learning model in the classroom was observed by a number of observers (*for practicality aspect*). The assessment of CT ability was done after the learning process using the ICP learning model (*for effectiveness aspects*) and then analysed. The findings of this research showed the ICP learning model that developed has been declared valid, practice, and effective to promote critical thinking ability of physics prospective teachers. The results of this study could be empirical evidence that the ICP learning model could promote CT ability of physics prospective teachers.

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 higher education level, as written in the Regulation of the Minister of Research, Technology and Higher Education of the Republic of Indonesia. Global Citizenship Education (GCE) recommends that universities have to facilitate students to analyse issues critically and identify the creative and innovative solutions. A function of higher education is to teach the 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) recognise competences such as CT, problem solving, communication, and teamwork in their accreditation criteria [3].

CT is a component of high-level thinking skills that must be mastered and taught. CT is reflective and reasonable thinking that is focused on deciding what to believe or do [4], its purpose, and self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, or conceptual considerations upon which that judgment is based [5]. CT is a propensity and skill to engage in an activity with reflective skepticism [6]. CT is used to pass judgment on any information, explain the reasons, and able to solve the problem of the unknown [7], so that each individual are able to understand any information or content on a particular thing [8]. Critical Thinking is best understood as the ability of thinkers to take charge of their own thinking [9]. Despite differences among of thought and their approaches to defining critical thinking, there exist areas for agreement. The researchers of critical thinking typically

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agree on the specific abilities encompassed by the definition, which include; a) analysing arguments, claims, or evidence, b) making inferences using inductive or deductive reasoning, c) judging or evaluating, and d) decision making or problem solving.

Educational and professional success requires nurturing one's consistent internal willingness to think critically. To do this, the teacher must provide students with as many models, opportunities, exemplars, and explanations as possible in order to help them operationalise their skills. Educators have long been aware of the importance of CT skills as an outcome of students learning [10]. However, teaching CT remains confusing for many instructors [11]. This is partly due to the lack of clarity of various methods proposed to best teach of CT [11, 12]. At the higher education level, Bissell and Lemons [13] ascertained faculties who teach at universities consider critical thinking a primary objective. It is a sad truth that the average of college students does not think critically, and not all courses include CT. 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 increase learners' CT ability.

Learning models based on inquiry activities have been widely developed for the purpose to increase students' CT ability, since inquiry is an instructional model that aims to guide about how learners think. The processes of scientific creativity in the inquiry activities need to be revealed as a way to increase the CT ability 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 or so-called scientific creativity potentially train the CT ability of learners [14]. Aspects of scientific creativity are in the form of problem finding, problem solving, hyphothesis creating, experiment designing, and product designing [15-19]. These aspects will be integrated with the inquiry model into a set of learning model, the learning model in this study is called Inquiry Creativity Process (ICP). The learning phases of the ICP model are; a) Establishing set and finding problem; b) Creating hyphothesis; c) Designing experiment creatively; d) Solving problem science creatively; and e) Designing product creatively.

This study aims to develop an Inquiry Creative Process (ICP) learning model to increase CT ability of physics prospective teachers. In this study, ICP is seen as a product of learning model. The criteria of good quality products according to Nieveen [20] are valid, practical, and effective.

2. Methods

This research was a development research that paired theory of Borg and Gall [21], and theory of Nieveen [20]. The validation method was used to collect the validity data of the ICP learning model. The validation aspects of the ICP model include content validity and construct validity. Content validity refer to the components of the model should be based on state-of-the-art knowledge, and construct validity refer to the all components of the model should be consistently linked to each other and logically. Validation is intended to obtain suggestions and feedback from validators. The validators were experts who also as user of learning model (lecturer). Technically, the ICP model validation was done through a focus group discussion (FGD) mechanism, its involving 5 (five) experts. Feedbacks from the validators in the FGD were then followed up to improve the ICP model.

The implementation subjects of the learning model are 21 physics prospective teachers (PPT) in the faculty of teacher training and education (FKIP), Mataram University, Indonesia. Practicality of the model evaluated from the learning feasibility (LF), the model declared to be practice if LF at least good criteria. The effectiveness of the model was evaluated from the improvement CT ability after the implementation of the model. CT ability was evaluated using the scoring technique adapted from Prayogi et al [22]. The indicators of CT ability in this study were indicators that have been used by previous researchers those are analysis, inference, evaluation, and decision making [1, 22]. While to know the score change of CT ability, it's analysed by using *n-gain* equation. The effectiveness criteria of the learning model is satisfied if there was an increase in critical thinking skills after the implementation of the model, and score of CT ability at least critically criteria in the posttest. Criteria of validity, learning feasibility and critical thinking ability shown as Table 1.

Table 1. Criteria of validity, learning feasibility and critical thinking ability

Validity		**Learning Feasibility**		**Critical Thinking Ability**	
Interval	***Criteria***	***Interval***	***Criteria***	***Interval***	***Criteria***
Va > 4,21	Very valid	Va > 4,21	Very good	X > 17,6	Very critically
3,40 < Va < 4,21	Valid	3,40 < Va < 4,21	Good	11,2 < X ≤ 17,6	Critically
2,60 < Va < 3,40	Quite valid	2,60 < Va < 3,40	Adequate	4,8 < X ≤ 11,2	Critically enough
1,79 < Va < 2,60	Less valid	1,79 < Va < 2,60	Less	-1,6 < X ≤ 4,8	Less critically
Va < 1,79	Invalid	Va < 1,79	Poor	X ≤ -1,6	Not critically

Note: *Va= validity level score; X=CT ability level score*

3. Results and Discussion

The validity results show that the ICP learning model which is developed was declared valid (Va = 4.12). The result of the validators assessment of the ICP learning model are provide in Table 2.

Table 2. Expert validation results on the ICP learning model

	Aspects of validation	**Average score**	**Category**
1. Content validity	The need for development of model.	4.20	Valid
	The model designed based on state-of-the-art of knowledge.	3.95	Valid
2. Construct validity	Consistency and logically of all arrangement components of model.	4.20	Valid
	Va	4.12	Valid

The content validity on aspects of the need for development of the model has a score of Va of 4.20 with valid criteria. This result cannot be separated from the purpose of ICP model development to increase the CT ability of prospective teachers as the need for the main competence of graduates of 21st century skills. The ICP model has also fulfilled the expectation of the higher education requirement in Indonesia. The aspect of needs in this study also becomes the answer of previous research findings that the model of ICP learning as an alternative model that can be used to increase CT ability of prospective teachers, as explained by Fahim and Masouleh [9] that educational success requires nurturing one's consistent internal willingness to think as well as developing one's thinking skills, and the educator should find ways in order to make learners willing and disposed to think critically. In this study, the experts as the validator have agreed that the ICP model has met several aspects of needs both globally and internally, and the most important that the ICP learning model has met the needs aspects in accordance with the regulation of competence to be achieved in learning in Indonesia, for the purpose of CT. Internally in the context of university learning, CT is a crucial skill that students need to develop while at university. It is important for a well-educated person to be able to make well-informed judgments, be able to explain their reasoning and be able to solve unknown problems. Therefore, CT should be developed to the learner from the early learning in university [7]. Content validity on the state-of-the-art aspects has a Va score of 3.95. The development of the ICP model was supported by empirical studies of scientific creativity from recent research references that true scientific creativity can serve as a bridge for CT purposes [14-19].

In construct validity component with main aspect was consistency and logically of all arrangement of component of model, the experts as validator give average score of Va equal to 4.20 with valid criteria. Experts have agreed that the ICP learning model has been consistent and logical in terms of the learning phase, sequence and interrelationships between components in the learning activities. According to Nieveen [20], if all components are consistently linked to each other (construct validity) then the product was considered to be valid.

At the implementation step in the classroom, the ICP learning model was considered practice, it was measured from the learning feasibility with the very good criteria (LF=4.25). Learning feasibility of each meeting shows in the Table 3.

Table 3. Learning feasibility of ICP learning model based on assessment of observers

Learning phases	*Learning feasibility*				*Mean*	*Mean of LF*	*Category*
	Meeting of learning						
	1st	*2nd*	*3rd*	*4th*			
I	3.4	4.0	4.5	4.0	3.97	4.25	Very good
II	4.0	4.0	4.0	4.5	4.13		
III	4.0	4.0	4.0	4.5	4.13		
IV	4.5	5.0	4.0	5.0	4.63		
V	4.5	4.5	4.5	4.0	4.37		

The ICP learning model consists of five learning phases, those are; establishing set and finding problem; creating hyphotheses; designing experiment creatively; solving problem science creatively; and designing product creatively. Observation result of learning feasibility using ICP learning model were done very good (LF = 4.25). It's because of the supports, especially the availability of the learning tools, including handbook (module) and worksheet. When learning tools were designed well, it can give information which help learner more effective to accomplish learning objectives. Good designed learning tools were functioned as communication tool, learning plan tool, learning plan for students, learning resources, and learning evaluation tool. The support from module was also very important in this study. The material in the book was arranged systematically so it can condition students to learn [23]. The worksheet in this study were designed as the guidelines of learning feasibility in inquiry activity according to ICP learning model to train students' CT ability.

Measurement results of CT ability showed that the mean score on pretest consist of 0.52 with the criteria of "less critically" and posttest consist of 17.5 with the criteria of "critically." N-gain value of 0.72 with the criteria of "high." The results are thoroughly provided on Table 4.

Table 4. Measurement results of CT ability

CTs interval	***Criteria***	***Pre test***		***Post test***		***N-gain***	***Criteria***
		Freq.	***Mean***	***Freq.***	***Mean***		
$X > 17{,}6$	VC	0	0.52	11	17.5	0.72	High
$11{,}2 < X \leq 17{,}6$	C	0	(Less critically)	10	(Critically)		
$4{,}8 < X \leq 11{,}2$	CE	1		0			
$-1{,}6 < X \leq 4{,}8$	LC	17		0			
$X \leq -1{,}6$	NC	3		0			
Amount		21		21			

Note: *VC (Very critically), C (Critically), CE (Critically enough), LC (Less critically), NC (Not critically)*

The effectiveness of the ICP learning model is measured by improving physic prospective teachers CT ability. The results indicate that there is an increasing ofCT ability after the implementation of the ICP learning model from "less critically" to "critically." This indicates that the developed ICP learning model was considered effective. 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 to correlate and interrelate between two or more theories and concepts in learning physics. The use of ICP learning model obviously increased the PPT ability in developing their CT. The result of this current study was parallel with the previous relevant study which found that the intervention of scientific creativity to develop CT ability was significantly effective [24], 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 CT [1].

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The enhancement of CT ability of PPT 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 CT ability. 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 correlated with some of the dimensions of CT, especially when the learners were thinking in the context of problem solving. When the learners were thinking in a given context (critical thinking), they used various thinking processes (creative thinking). The properties of CT were linked to the creative abilities during problem finding and problem solving [25]. Creative problem finding ability was defined as a kind of intellectual trait or ability that was 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. Furthermore, when problems were facing, hypothesis were needed to define the most appropriate way to solve those problems, those will automatically reinforce to think critically [26]. Creatively product design was a part of scientific creativity in which the learners are demanded to be able to design scientific product as the result of scientific creativity [19], those points were the important invention in terms of developing prospective teachers CT ability.

The ICP learning model has been effective in improving the CT ability of prospective teachers on aspects of analytical, inference, evaluation, and decision making. Its effectiveness is influenced by the validity of the model to improve CT, and also learning feasibility which are very good. When learning was well designed and properly planned it can help learners to achieve the expected learning objectives.

4. Conclusion

The ICP learning model was developed consist of five phases of learning, those are; establishing set and finding problem; creating hyphotheses; designing experiment creatively; solving problem science creatively; and designing product creatively. The results showed that the ICP learning model have been valid, practice, and effective to improve the CT ability of physics prospective teachers, including aspects of analysis, inference, evaluation and decision making.

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