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Preface

The 6th International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS 6)

Universitas Negeri Yogyakarta, Indonesia

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Preface: Proceedings of 6th International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS 6)

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We are pleased to present you the 6th International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS 6) Conference Proceeding. The 6th ICRIEMS was held on 12-13th July 2019 and organized by the Faculty of Mathematics and Science, Universitas Negeri Yogyakarta, Indonesia. We are raising a theme **"Integrating Science, Technology, Engineering, & Mathematics (STEM) and Education for Disaster Risk Reduction and Mitigation"**. We hope that the theme will promote STEM and its education to enhance society knowledge and awareness on disasters. The knowledge could help people and government agencies to reduce and prevent the emergence of a larger disaster impact.

The conference also was an event where prominent practitioners, researchers, students and educators shared their research findings and exchange ideas. Five keynote speakers were given their talk: Prof. Dr. Gultekin Cakmakci, from Hacettepe University, Turkey; Prof. Dr. Wing Mui Winnie So from The Education University of Hong Kong; Martianus Frederic Ezerman, Ph.D, from Nanyang Technological University, Singapore; Prof. Dwikorita Karnawati, Ph.D from Meteorological, Climatological, and Geophysical Agency of Indonesia; and Dr. Insih Wilujeng from Universitas Negeri Yogyakarta. In addition, two invited speakers also contributed: Dr. Hanik Humaida from the Center for Volcanology and Geological Hazard Mitigation of Indonesia; and Dr. Azlan Kamari from Universiti Pendidikan Sultan Idris, Malaysia.

The conference has accepted 210 papers from six countries, i.e. Turkey, Indonesia, Hongkong, Singapore, Malaysia, and Thailand. After an intensive review process, finally 95 papers have been selected for publication. We believe the proceedings will provide the scientists of the world with an excellent reference and be an impetus to stimulate further studies in all related areas. We address big appreciation and many thanks to all authors and participants who have been actively involved in the conference. We also wish to thanks to our scientific committee for their invaluable comments and suggestions.

24 October 2019

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Preface

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Conceptual Framework of Reflective-Inquiry Learning Model to Promote Critical Thinking Ability of Preservice Physics Teachers

Conceptual Framework of Reflective-Inquiry Learning Model to Promote Critical Thinking Ability of Preservice Physics Teachers

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Abstract. Critical thinking has been a crucial competence in 21st century learning and encouraging critical thinking ability at the university level is assumed as an important achievement at higher education. This study was aimed at developing Reflective-Inquiry Learning (RIL) model to promote critical thinking ability for preservice teachers in particular. This study was a pre-developmental stage in which the developed RIL model was constructed in line with the supporting theories and empirical findings. With the result that, it produced a hypothetical framework from RIL model itself. Then, the product of the RIL model was validated with involving 7 experts as validators through a focus group discussion (FGD) process. The assessed aspect of the product consisted of the content validity and construct validity. The results of the product validity were analyzed through a descriptive analysis viewed from the average score of the validity. The result of the validity showed the validity level (Va) of the RIL model was 4.28 and it was said very valid. The conceptual framework of the developed model and the validity result would be further elaborated in this article.

1. Introduction

Critical thinking includes a higher order thinking domain and becomes one of the essential skills that should be achieved by learners in the 21st learning century [1]. A critical thinking learning ought to be internalized by preservice teachers since they come in a university in order to be able to treat their students when they become a real teacher in the future [2]. In addition, encouraging learners' critical thinking development is an important achievement at higher education [3]. The same tune is echoed by Innabi & Elsheikh [4] in which educational institutions should provide and facilitate preservice teachers to develop their critical thinking ability. For instance, in Indonesia, the critical thinking ability become a demand of the learning need for learners. It is stated in Regulation of Ministry of Education and Culture, number 73 in the year of 2013 in accordance with Indonesia National Qualification Framework and Regulation of Ministry of Research, Technology, and Higher Education, number 44 in the year of 2015 associating with Higher Educational National Standard. However, the study by Prayogi et al [1] revealed that the critical thinking ability of teachers who teach science are still relatively low, and this is one of the challenges of education in Indonesia.

Universities and higher educations have made serious efforts to put critical thinking dimensions into the instructional curriculum. Unfortunately, based on a number of researchers, learners still are not

able to think critically because most of the lecturers do not integrate between learning processes of the critical thinking acquisition and learning practices requiring a various reflection [5, 6, 7, 8]. Besides, various instructions such as inquiry learning activities have been implemented in higher educations to promote learners' critical thinking abilities focused on science learning activities [9]. However, the teaching practice in the class often avoids the core of a critical thinking process, the reflective process [10].

Based on the research findings, the data show some indicators of the critical thinking ability (e.g. analysis, inference, and evaluation) are low by applying inquiry learning model [11, 12]. The reflective thinking concept as a precursor to train learners to think critically is not thoroughly investigated. Most of the studies do not give a solution for effective learning of how lecturers combine both reflective and inquiry learning. In fact, the great success of training learners to think critically is not found [13]. The way the lecturers apply the inquiry learning model tends to emphasize the aspect of "learn to find" and "testing concept or fact simply", whereas the core of learning processes is how learners are able to organize their thinking theoretically and practically in a further complicated context. Therefore, the reflective attributes of every teaching step of the inquiry learning model are important to be done in order that the improvement of critical thinking ability would be optimal.

Integrating the reflective concept and inquiry model as a set of a learning model is called hereafter Reflective-Inquiry Learning (RIL) Model. It is serial learning processes that utilize the inquiry learning model attributed to reflective activities such as providing anomaly phenomena, monitoring, evaluating performance, and continued reflection. These activities are aimed at improving learners' critical thinking ability. In this study, the RIL model is developed to enhance preservice teachers' critical thinking abilities.

1.1. Theoretical Framing

The conceptual framework of the RIL model is constructed from the supporting theories and empirical findings relating to the reflective, inquiry, and critical thinking concepts. The researchers arranged the three concepts started from; the concept of the critical thinking, inquiry learning as the foundation of the critical thinking, and the reflective learning framework.

1.1.1. Critical Thinking Concept. Thinking is a cognitive process or mental activity to attain knowledge. According to Solso [14] in his book of Cognitive Psychology, thinking is a common process considering problems of the mind and generating a form of new mental representation. Critical thinking cannot be amended naturally. Therefore, it should be underpinned by an environmental stimulus and the various atmospheres. Some experts have been exploring the inclination of the individual thinking way and relating to achievement gained. Gallagher in Webb [15] mentioned learners in solving problems have two manners of thinking, convergent and divergent. The convergent thinking is identical with the critical thinking patterns. Meanwhile, divergent thinking is associated with the creative thinking. John Dewey, a philosopher and psychologist, is well-known as a person introducing the critical thinking concepts. Dewey [16] announces critical thinking as reflective thinking. According to Facione [17], critical thinking is basically a detail description from types of characters consisting of the interpretation, analysis, evaluation, inference, explanation, and self-regulation. One of the outstanding contributors to the critical thinking tradition is Robert Ennis. Ennis [18] and Hassard [19] have a similar point of view. Both define the critical thinking concept as a type of logical and reflective thinking focusing on deciding what to believe and what to do.

Almost all people working on the critical thinking field have generated lists of critical thinking skills as a foundation to think critically. Lipman in Jeevanantham [20] argues the critical thinking as a type of critical skills with having a responsibility that facilitates to take a right decision because (a) it depends on criteria, (b) it regulates self-correction, and (c) it has a sense of contexts. Furthermore, Rudinow & Barry [21] state the critical thinking is similar to a set of dainty tools with connecting an intellectual and strategic ability to make reasonable decisions about what to believe and what to do. According to Lai [22] after doing a number of literature reviews and analyzing some experts'

judgments of the critical thinking, he argues the critical thinking can be seen from three main approaches based on its definition. Those are a philosophical approach, cognitive psychological approach, and educational approach. In the philosophical approach, critical thinking more emphasizes the quality and character of being a critical thinker. In cognitive psychology approach, the critical thinking more emphasizes the real action and behavior that can be performed by a critical thinker so that in the critical thinking definition it contains lists of critical thinking skills [23]. Last but not least, in educational approach, critical thinking emphasizes a process to make learners think at a higher level. It is called in the term 'Higher Order Thinking Skills' (HOTs).

1.1.2. Inquiry as a Teaching Foundation of the Critical Thinking. Learning is an impact resulted from a thinking process. The retention, understanding, and using the active knowledge can be created through learning experiences in which learners think. A number of experts conclude that human being does not have a natural inclination to think critically. People who have high motivation often are similar to those who have low motivation where both people do not think critically [24]. Critical thinking is a higher order thinking domain that should be taught [25]. According to Thompson [26], in the teaching and learning critical thinking, holistic approaches are necessary to be applied and it should involve a set of an appropriate learning model and be oriented on a learning goal that enables learners to manipulate cognitive skills. The learning goals indicating the critical thinking in the curriculum of the elementary level, junior and senior high school level, and higher education level seem inconsistent with how the learning goals are interpreted in practice.

Developing the critical thinking ability in recent decades has been directed through inquiry activities. According to Bailin [27], the learning objectives of inquiry activities are dominantly focused on critical thinking ability such as identifying assumption, using logical thinking, analyzing direct experiences and phenomena, analyzing secondary sources, analyzing arguments by reviewing current scientific knowledge, considering pieces of evidence, and examining logical aspects. National Science Education Standards state that the critical thinking is the most important dimension of the science education in which its main learning activities are through inquiry learning. A scientific inquiry is an activity that refers to diverse ways in which scientist study natural aspects and make explanations of those based on pieces of evidence obtained from the results of an investigation. Besides, inquiry refers to learning activities where they develop knowledge and understanding of the scientific ideas, as well as an understanding of how they learn nature. The inquiry as an activity involves observation, asking questions, checking information sources to confirm what they already know, planning investigations, conducting experiments, using tools to collect, analyze, and interpret the data, proposing answers, explanations, and predictions, and communicating the results [28].

Experts and researchers have developed and modified the inquiry instruction with different terms including the traditional inquiry, guided inquiry, structured inquiry, open inquiry, directed inquiry, inquiry learning, inquiry teaching, authentic inquiry, scientific inquiry, partial inquiry, and full inquiry [29]. National Research Council (NCR) depicts that the inquiry has three level namely: (1) structured inquiry, in which a teacher in the inquiry activities prepares or provides problems and processes for learners to solve those; (2) guided inquiry, in which a teacher raises problems and learners should determine the process and solution of those; and (3) open inquiry, in which a teacher only provides a context of solving problems and learners go to identify and solve the provided problems [30].

Inquiry activities in the learning process have long been introduced by experts ever since the beginning of the 20th century, namely John Dewey who introduced the teaching steps that imply the inquiry activities of it [31]. However, many researchers argue that the scientific inquiry was based on the Atkin-Karplus learning cycles that were popularized in 1962 [32]. In the learning phase, it was introduced the investigation steps that become the forerunners of the inquiry process. Arend [33] explains the inquiry is as a teaching model that aims to teach learners how to think. It means that the inquiry is a teaching foundation to train the higher order thinking skills for learners. The learning task in the inquiry learning plan is oriented to the purposes of content and process. The purpose of a goal means that a teacher plans for learners to attain new knowledge related to the focus of an investigation.

Meanwhile, the purpose of a process means that a teacher also wants the students to study the investigation process especially a process related to scientific investigation and to develop a positive attitude towards the investigation and process applied to investigate. The terms of an inquiry instruction as inquiry-based lesson that has 6 teaching steps that consist of gaining attention and explaining the inquiry process, presenting the inquiry problem or discrepant event, having students formulate hypotheses to explain the problem or event, encouraging students to collect data to test the hypothesis, formulating explanations and/or conclusions, and reflecting the problem situation and the thinking processes used to inquire into it [33].

1.1.3. Reflective Concept in Learning. Reflection as a process of thinking used by Socrates more than 2,000 years ago, but the current approach used to apply the reflection as a regulation in the learning derived from the work of John Dewey [34]. Reflection is defined as the cognitive processes that are conducted to learn from experiences [16]. Reflection is based on the concept of reflective thinking. The most common understanding of the cognitive process of reflection is to analyze and find a way that will lead to the production of new knowledge and experience based on the context of prior knowledge, and the development of alternative ways [35]. John Dewey proposes the reflective approach in learning because it is the most important needs of a learner. Dewey defines reflective thinking as an active, persistent, and careful consideration in the structure of knowledge that supports the belief, knowledge, and results to be achieved. A reflection is a form of checking the process that has been done. Reflection affects the way the teacher plans lessons, the types of a decision made, and general learning practices [36].

Reflection leads students to deeper learning [37] and the achievement of knowledge which is more complex, integrated, and useful [38]. Some studies show that reflection is important for successful learning processes [39, 40]. For instance, Davis [39] presents that the reflection helps learners create new relationships between the initial and acquired knowledge and it makes the learning process more effective. Reflection is relevant to the learning process, but it is also a challenging activity because what learners think and feel about their experiences may be different from the actual event [41]. In addition, some studies show that instead of evaluating their own experiences, learners tend to wait for the teacher to present the results of an evaluation [42]. That is why there is a need to guide learners to reflect their learning. The reflection can be guided in many ways, for example providing the guided questions to show specific elements of an activity [43, 44], using portfolios to record important events during activities of at the end of activities [45, 46], recording actions to be further evaluated [47, 48], and requesting a feedback from other friends who can provide alternative views of the activities carried out [49].

The process of the reflection is based on the type of the reasoning where the analysis phase is associated with the awareness, acceptance, action processes. This awareness process is important because pedagogical practices are based on trust at the awareness level of the context being learnt. The acceptance in the learning context doesn't convince the learners about the concept of the truth or untruth, but it creates conditions for how learners convince themselves of the truth of the concepts being studied [36].

Based on the literature study there are several important points that connect the concepts of critical thinking, inquiry, and reflection in learning which are the basic frameworks for developing RIL models which then become the framework of teacher mindset, there are the reflective thinking as a precursor to training critical thinking, reflection influences the types of decisions that are made, helps create relationships between acquired knowledge, and makes the learning process more effective. Furthermore, reflective thinking acts as a driver of critical thinking during the process of problem solving in inquiry. Moreover, learner who are active in reflection can encourage the development of a better understanding of the inquiry process and support critical thinking.

2. Methods

This study was a part of the development research. Based on the theoretical review and empirical findings, the conceptual framework of the RIL model was developed and subsequently validated. The research procedure was adapted from the previous study [1, 9, 50]. The results of the validation process were used to measure the quality of the developed model. The RIL model was categorized as a product of instructional models. According to Nieeven [51], a product can be said to be qualified if it meets a valid, practical, and effective category. This study was aimed at formulating the validity of the conceptual framework of the RIL model to promote the critical thinking ability of pre-service physics teacher.

The validation method was employed to know the validity of the RIL model. The validation was done with considering two aspects of validities which are content validity and construct validity. Content validity refers to all components of the model that should be based on the state-of-the-art of acknowledgment. Meanwhile, the construct validity is all components that should be consistently and logically linked to each other [52]. The validation process of the RIL model was carried out through the processes of Focus Group Discussion (FGD) involving 7 validators that consist of some experts and the practitioners as users of the model. The assessment of the validity used validation sheets with a Likert scale. Then, the assessment determines the validity level of the RIL model. The validity criteria of the model can be seen in Table 1.

Table 1. The validity criteria of the RIL model

Interval (Va = Validity Level)	Criteria
Va > 4,21	Very valid
3,40 < Va ≤ 4,21	Valid
2,60 < Va ≤ 3,40	Quite valid
1,79 < Va ≤ 2,60	Less valid
Va ≤ 1,79	Invalid

3. Results and Discussion

Reflective-inquiry learning (RIL) model is the developed learning model in this study by integrating the reflective attributions into the specific inquiry learning model phases to train learners' critical thinking ability. The framework of the development and RIL model hypothetic provided in Figure 1 and Table 2 as follows.

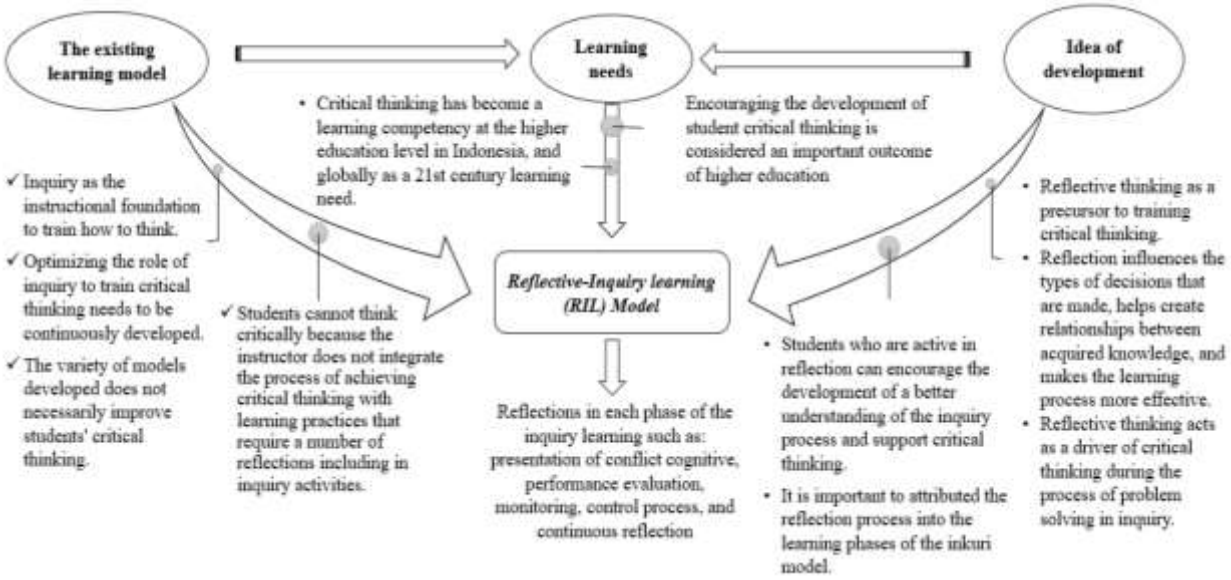

Figure 1. The Framework of RIL Model Development

Table 2. Hypothetic Framework of Reflective-Inquiry Learning (RIL) Model

Learning Phase	Learning Process with Integrating Reflective Process
Phase 1. Orientation	• Preparing pre-service teacher to learn and describe the process and learning objectives
Phase 2. Providing Problems	• Presenting cognitive conflict with authentic phenomena and requesting pre-service teachers' responses • Monitoring pre-service teachers' responses toward the provided phenomena (*monitoring process*). • Conducting correction if the pre-service teachers' responses are inappropriate with the context being studied (*control process*)
Phase 3. Formulating hypothesis	• Encouraging pre-service teachers to hypothesize problem situation stated initially • Examining the correlation between hypothesis and problem condition stated to be confirmed with each proposed hypothesis (*performance evaluation*)
Phase 4. Examining hypothesis	• Asking pre-service teacher to examine hypothesis through an experiment • Asking pre-service teacher to explain how they collect data to examine the hypothesis through experimental activities (*control process, performance evaluation*)
Phase 5. Formulating explanation	• Asking pre-service teacher to formulate explanations and making a generalization (*control process*) • Confirming each explanation arranged (*performance evaluation*)
Phase 6. Reflection	• Involving pre-service teacher to check the processes that they have done and identifying mistakes to be continuously corrected (*continuous reflection*).

The framework of RIL model hypothetic arranged was validated by experts and users. The validation was done through FGD activities involving 7 validators. The validity assessment was focused on two aspects, the content validity and construct validity. The result of validation can be seen in Table 3 as follows.

Table 3. Expert validation results on the ICP learning model

Nu		Aspects of validation	Average score	Category
1	Content validity	The need for developing the model	4,42	Very valid
		The model designed in line with the state-of-the-art of knowledge.	4,10	Valid
2	Construct validity	Consistency and logic of all arrangement components of the model.	4,32	Very valid
		Validity Level (Va)	*4.28*	*Very valid*

The validity level of the developed RIL model, in general, is very valid with 4.28 of the validity level (Va). It is said very valid because Va > 4,21. The content validity seen from the aspects of the need for model development was very valid with 4,42 of the validity level. Some descriptions that

show the validity of aspects of the need of model development include that the development of the RIL model aims to enhance the critical thinking ability as a need of the 21st century learning skills, global learning needs, and learning needs in accordance with the Indonesian National Qualification Framework and Higher Education National Standard. The development of the RIL model is in line with science learning needs that emphasize the process of knowledge acquisition through explorations and experiments in general. In addition, developing the RIL model also bridges the gap between the expected competencies of the 21st century learning outcomes that have critical thinking ability. In fact, the pre-service teachers' ability to think critically is low and teachers are not fully successful to train them.

The content validity seen from the designed model based on state of the art of knowledge was valid with 4.10 of the validity level. Descriptions of the RIL model showing the great aspects include that the development of the RIL model is a recommendation to improve the inquiry learning model which aims to train the critical thinking ability with integrating reflection aspects in the teaching process. Intervening the reflection process in the inquiry activities is a new paradigm of the knowledge transferability process. Through the reflection process, the structuring cognitive process happens and it helps learners to develop their better understanding of instructional materials and the inquiry process itself. In addition, the development of the RIL model includes a new model that can be used to treat learners' critical thinking ability. Seen from the phase of the process analysis and decision making, the inquiry learning activities can be conducted through reflective thinking processes.

Assessing the construct validity of the RIL model is viewed from the consistency and logical aspects of the model. The validation result shows that those aspects are very valid with 4,32 of the validity level. The criteria showing the consistency and logicality of the RIL model include that the model arrangement is based on the theoretical review and empirical support related to the model arrangement purposes, the teaching phases show the logic learning activity orders and are consistent with the scientific inquiry learning activities. In addition, the teaching phases integrate the reflective processes in the learning activities.

In the FGD activities, the validators agreed that the hypothetical framework of the RIL model is consistent in arranging the teaching steps to treat learners to think critically. The RIL model construction shows an integrative process between inquiry activities and reflective activities to promote learners' critical thinking ability. Critical thinking is a reflective process to analyze and evaluate information to make decisions on what to believe and what to do [10]. From here, critical thinking ability can be learnt through learning models that have activities that require learners to learn autonomously [53]. For example, the inquiry learning focuses on two aspects which are the content and process. It aims to train how to learn to think [33]. Reflection can be linked to various learning methods including inquiry learning [40]. The inquiry learning is a process of finding new activities in which learners formulate the hypothesis and examine it through experimental way or observation [54].

Teaching critical thinking through inquiry learning is not only limited to finding facts but how to interpret the facts [50]. Reflection in learning requires learners to be curious, open-minded, and responsible for the knowledge they have or they are exploring. Furthermore, the reflective learning requires learners to carry out a systematic cycle of self-evaluation through an open discussion or written analysis during the learning process guided by the teacher [55]. In the context of the inquiry teaching and learning, the reflective inquiry is the thinking individual process to measure learners' own experiences to gain an understanding of the assumptions and implications from an event in everyday life. The general phenomenon that people understand about inquiry learning is limited to learning models that facilitate students to learn to find and examine concepts or facts in a simple way. Due to the absence of inquiry learning models that integrate the reflection attribution of inquiry learning steps, the statement of the inquiry learning is able to increase learners' critical thinking ability is just a theory, but is practically weak.

The inclination of the cognitive, psychomotor, and psychological development works in conditions of insufficient information sources to process information related to the environment and one's self [56]. The relevant information on the specific phenomena also tends to have irrelevant information.

This is in accordance with the logic that the relevant information in certain circumstances can be irrelevant in different conditions. Therefore, the attribution-reflection is very important to make learners perform the learning activities in line with the learning objectives to be achieved. It is critical thinking as the demand for 21st century skills. An efficient process requires activities that allow learners to keep reflecting the learning and thinking process so that they remain in the desired learning activities.

The strong relationship between the reflection and the inquiry process is seen when learners actively do reflection process that can encourage developing their better understanding about the instructional materials content and the inquiry process [57]. Reflection can be done in the scientific inquiry activities by providing the conflict phenomena (cognitive conflict) [58]. The cognitive conflict helps the assimilation process become more effective and meaningful to form the learners' intelligence. Providing cognitive conflict helps learners reflect the concepts and explanations of the phenomena being learnt. This process is provided to develop their learning activities and encourage their critical thinking to understand the whole concepts [59]. Reflection can also be done by a monitoring process and process control [13]. Monitoring is important because it is in line with the decision making [60, 61, 62, 63]. Reflection is carried out consistently and continuously in every learning process. This activity leads learners to think about what they have done as a manifestation of the critical reflection [64].

4. Conclusion

RIL model is a learning model based on scientific inquiry activities that intervene with reflective processes. The development of the model in specific is aimed at training the pre-service physics teacher to think critically. The validation results showed that RIL model was valid theoretically. Besides, the content and construct validity were valid. It means that the RIL model enables to promote pre-service physics teachers' critical thinking ability. From the theoretical basis that has been described, experts also suggest that the aspects of critical thinking that need to be developed are analysis, inference, evaluation, and decision making. However, the continuous study in the model implementation is important to be conducted to evaluate the practicality and effectiveness of the RIL model.

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