Profile of critical thinking skills of pre-service physics teachers: a preliminary study

T F Dholo\textsuperscript{1,2*}, H Firman\textsuperscript{1}, I Kaniawati\textsuperscript{1} and D Rusdiana\textsuperscript{1}

\textsuperscript{1}Program Studi Pendidikan IPA, Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229, Bandung 40154, Indonesia
\textsuperscript{2}Program Studi Pendidikan Fisika, FKIP, Universitas Flores, Jl. Sam Ratulangi, Ende 86318, Indonesia

*theresiafloretina@uniflor.ac.id

Abstract. Critical thinking skills is one of the high-level thinking skills that students must have in this era of technology and information. Critical thinking is needed for students who are preparing to enter a complex working field. This study aims to determine the profile of critical thinking skills of pre-service physics teachers at the University of Flores. The method used is descriptive survey method. The result of the study shows that: 1) The students' critical thinking skills are spread in 5 categories, namely "very high" by 10%, "high" by 22.5%, "medium" by 32.5%, "low" by 10% and "very low" 25%; 2) Students need to be familiarized with questions that stimulate critical thinking skills; 3) A physics-based thinking test tool is needed for critical students of pre-service physics teacher.

1. Introduction

Science education has an important role in improving the quality of education, especially in producing quality learners, that is, people who are able to think critically, creatively, logically, and take the initiative in responding to issues in society caused by the impact of the development of science and technology [1]. If all kinds of high-level thinking skills are mastered well by teachers, then they will be more professional in performing their duties. Thus, the extent to which the ability of high-level thinking is owned by science teachers can be used as an indicator of quality in working as a teacher. The greater the ability of high-level thinking mastered by science teachers, the higher the ability to achieve professional standards proclaimed [2].

The main purpose of education in general, and higher education in particular, is to improve students' critical thinking skills [3]. As a human resource that will produce quality human beings, then pre-service teachers are expected to have high quality thinking skills. Therefore, pre-service teacher's thinking ability needs to be improved. One of the high-level thinking skills that a pre-service teacher must have in the 21st century is the critical thinking skills.

Critical thinking is the process by which a person tries to answer a difficult question and the information is not found rationally at this time [4]. A person who is critical is someone who has the skill in trying to answer a difficult question where the information is limited and can be explained rationally. A person who thinks critically will be able to answer important issues well. In addition, they can also use abstract ideas to be able to model problem solving effectively.
Critical thinking is necessary, especially by students preparing to enter the complex working field. It can be proved that critical thinking can strengthen students' academic perceptions, which have a positive impact on their academic experience. Critical thinking is also very important in everyday decision-making, especially to avoid less-reliable external influences such as factual and fictitious fusion in the media, political lies, and dangerous suggestions from those who claim to be experts [5].

Critical thinking can not only be developed in learning as an effect of accomplishment in physics course, but it must also be supported by an evaluation that reflects critical thinking. Educational measures can be identified by evaluation [6]. This means that if pre-service teachers have the competence of physics knowledge and is expected to think critically, then the types of physics questions given also must train critical thinking. The test can be defined as a number of questions that have correct or false answers [7]. The test is one way to estimate the extent of human capability indirectly, which is through a person's response to a number of stimuli or questions. Therefore, in order to obtain accurate information, reliable tests are required. The forms of tests used in educational institutions can be categorized into two, namely objective tests and non-objective tests [7].

Physics's tests are very important in measuring the extent to which the competence of science-based critical thinking skills possessed a pre-service teacher before the practice in the field. A student must be prepared both in scientific and pedagogic ability to practice successfully in the field and become a teacher who is ready to work. This physics qualification test model is supported by previous research results which show that students' critical thinking is not enough developed, as many as 57% of students have wrong conclusions about the meaningfulness of physics concept problem [8].

Previous studies pertaining to critical thinking tests, both general critical thinking and critical thinking tests in Science education are: 1) "Redesigning general courses of education in promoting critical thinking", using paper and pencil tests with 15 items of questions with short answers of the critical thinking assessment test model (CAT). The CAT testing model assesses several important aspects of critical thinking, namely evaluation and interpretation of information, problem solving, creative thinking, and communication [2]; 2) "Critical assessment of critical thinking assessed in higher education: a CCTA and HCTA validation study", it was found that critical thinking instruments CCTT and HCTA share the advantages and disadvantages of psychometric quality, since these two instruments can represent critical thinking skills as a combination of skills, expertise, and disposition as a critical thinker. Each test has its own advantages and disadvantages [9]. Both of these studies are still limited to critical thinking test research in general.

Research development of critical thinking test in physics that is: 1) "Description of Instrument Test of Critical Thinking Skill of Optical Material Material", it is found that quality of critical thinking skill test developed on optical instrument material for junior high school students is 38.9% test item accepted, 61.1% test is revised, and no test items are rejected [10]; and 2) "Construction of Critical Thinking Skills Tests Instrument Related to Temperature and Heat Materials", it was found that the quality of the test instrument constructed is valid and has high criterion reliability and based on hypothesis test result has 2 different mean values, the result is the test instrument that is constructed, can distinguish critical thinking skills among students who get a learning process that trains critical thinking skills, with students who get a learning process that does not train critical thinking skills [11]. The overall research is still limited to critical thinking skills tests on junior high school students.

Given the importance of critical thinking skills for the pre-service physics teachers, it is necessary to draw the initial skill of critical thinking of the pre-service physics teacher. Therefore, the writing of this paper aims to obtain a profile of critical thinking skills possessed by said pre-service teachers, before going to the field, that is measured through the workings of physics test questions based on critical thinking skills.

2. Method
The method used in this preliminary study is descriptive survey method. Quantitative and qualitative data in field study were obtained by using test and questionnaire. The data were collected at the Physics Education Program of the University of Flores on May 12, 2017. Research subjects in this preliminary
study are 40 students of semester VI of Physics Education program of academic year 2016/2017. The data were obtained by the test and the questionnaire given to the students of the sixth semester of the physics education program. The data gathering instrument in this preliminary study activity is about 40 test items and a questionnaire. Data were analyzed through descriptively qualitative. The percentage score is calculated using the equation:

\[
\text{Percentage Score} = \frac{\text{earned score}}{\text{total score}} \times 100\% \tag{1}
\]

The percentage of critical thinking ability obtained from the calculation is then categorized according to the following table.

**Table 1. Category percentage of critical thinking ability [12].**

| Interpretation (%) | Category      |
|--------------------|---------------|
| 81,25 < x ≤ 100    | Very High     |
| 71,5 < x ≤ 81,25   | High          |
| 62,5 < x ≤ 71,5    | Medium        |
| 43,75 < x ≤ 62,5   | Low           |
| 0 < x ≤ 43,75      | Very Low      |

3. Result and discussion

3.1. Result

Data of research result consist of data of physics test result based on thinking of critical thinking and questionnaire result data. Description of the results of physics tests based on critical thinking skills 40 students of semester VI physics teacher candidate of University of Flores obtained the percentage value of each student that is (%): 12, 16, 16, 20, 24, 28, 32, 36, 40, 48, 52, 52, 64, 64, 64, 68, 68, 68, 68, 72, 72, 72, 72, 72, 72, 72, 72, 76, 76, 80, 84, 84, 88 and 92 with mean of 58%. From the distribution of the data, the data are presented in table 2.

**Table 2. Frequency distribution of percentage value of student critical thinking ability.**

| Percentage Score (%) | Frequency |
|----------------------|-----------|
| 81,25 < x ≤ 100      | 4         |
| 71,5 < x ≤ 81,25     | 9         |
| 62,5 < x ≤ 71,5      | 13        |
| 43,75 < x ≤ 62,5     | 4         |
| 0 < x ≤ 43,75        | 10        |
| ∑                    | 40        |

Table 2 shows frequency distribution of percentage value of student critical thinking ability, on average, it can be said that critical thinking ability of pre-service physics teacher still low (58%). This can be seen in table category of critical thinking ability possessed by students as in table 3 below.

**Table 3. Frequency distribution of overall critical thinking ability of students.**

| Interpretation        | Frequency | Percentage (%) | Category |
|-----------------------|-----------|----------------|----------|
| 81,25 < x ≤ 100       | 4         | 10             | Very High|
| 71,5 < x ≤ 81,25      | 9         | 22,5           | High     |
| 62,5 < x ≤ 71,5       | 13        | 32,5           | Medium   |
| 43,75 < x ≤ 62,5      | 4         | 10             | Low      |
| 0 < x ≤ 43,75         | 10        | 25             | Very Low |
| ∑                     | 40        | 100            |          |
Table 3 shows that overall students’ critical thinking skills are spread out in 5 categories from very high, high, medium, low, and very low. There are still students who have low critical thinking skills and very low because students are not accustomed to solve the problem of physics-based critical thinking skills. This is obtained through the results of student answers on the questionnaire sheet that was distributed in relation to the form of the problem done before. Most students are not familiar with the form of test questions as they do. During this test of physics that is followed both on the task, midterm exam, and final exam of the semester, the problem is related to pure physics science content not on the question of accomplishment that honed his critical thinking skills.

3.2. Discussion
Critical thinking is rational thinking in judging things. Critical thinking skills are closely related to the critical thinking process according to the procedure of thinking in the indicators [4]. Science stimulates the power of human thought that can bring about the curiosity and desire to understand natural phenomena. What, why, and how this natural phenomenon works is part of building scientific information that can be observed, validated, and tested. In the achievement of the goal, the study of physics is not emphasized on the understanding of physics concept alone, but rather directed to the effects of the accomplishment of learning one of which is the skill of thinking [13]. Skills are very important to be developed, because it will direct the pattern of acting every individual in the community later. Physics as one part of science that studies natural phenomena in the form of concepts, laws, and theories that most abstracts require critical thinking skills to learn the concepts

The field of physics is divided into mechanics, thermodynamics, waves and optics, electricity, magnetism, and modern physics [14]. The whole field of study has a great emphasis on the thinking of a pre-service physics teachers who studies it. Not only demanded in the mastery of the concept alone, but rather on improving thinking skills in connecting concepts with one another logically. Therefore, critical thinking can not only be developed in learning alone as an effect of accompaniment in the study of physics, but also must be supported by an evaluation that reflects critical thinking [8].

One form of evaluation tool is a test. In conducting the research, the researcher measures a variable may use self-made instruments or measuring instruments that have been used in previous research or in the form of standard measuring instruments in foreign languages [15]. In this study, researchers used a test tool that has been developed previously. As an instrument used to measure critical thinking skills, it is necessary that standardized, coordinated standards are required during the assessment development process, including constraints, designing assessments, trials and field tests to evaluate the psychometric quality of assessment items and scale, establish standards for determining levels proficiency, and examine validity and reliability [16]. The form of the test used is a double-tapped multiple-choice written test with 5 (five) answer options with 40 question items.

From the test results obtained that overall, students’ critical thinking skills are spread in 5 categories that is very high by 10%, high by 22.5%, medium by 32.5%, low by 10%, and very low 25%. There are still students who have low critical thinking ability and very low with the percentage of 35% of the total students, because students are not accustomed to solve the problem of physics-based critical thinking skills or in other words students are not trained in the ability to think of a concept of physics. The questions used in the tests faced by students so far are limited to the concept of physical content without the effect of the ability to think. This is also due to the limited number of physics-based critical thinking test tools [2, 9, 10, 11]. If pre-service teacher are getting trained continuously, then their critical thinking skills will be better. Therefore the importance of physics-based test measuring the ability of critical thinking for pre-service physics teacher.

4. Conclusion
Based on the results and discussion, it can be concluded that: 1) the critical thinking ability of students spread in 5 categories is very high by 10%, high by 22.5%, medium by 32.5%, low by 10%, and very low 25%; 2) students need to be familiarized with questions that stimulate critical thinking skills; 3) a physics-based thinking test tool is needed for critical pre-service physics teachers.
Acknowledgments

The authors are grateful to the Rector University of Flores, especially to the Head of the physics education study program that has allowed authors to conduct this preliminary study.

References

[1] Liliasari 2003 Pengembangan Keterampilan Berpikir Tingkat Tinggi Mahasiswa Mahasiswa calon guru Melalui Model Pembelajaran Kimia Jurnal Pendidikan 2
[2] Rowe M P, Gillespie B M, Harris K R, Koether S D, Shannon L Y and Rose L A 2015 Redesigning a General Education Science Course to Promote Critical Thinking CBE—Life Sciences Education 14 1–12
[3] Wijana N, Nala I G N, Tirtayasa I K and Sutajaya I M 2007 Pembelajaran Sains Melalui Pendekatan Ergonomi Mengurangi Keluhan Muskuloskeletal, Kebosanan dan Kelelahan Serta Meningkatkan Motivasi dan Prestasi Belajar Siswa SD 1 Sangsit Kecamatan Sawan Kabupaten Buleleng Indonesian journal of biomedical sciences 3 1
[4] Inch E S, Warnick B and Endres D 2006 Critical Thinking and Communication the Use of Reason in Argument Fifth Edition (Boston: Pearson Education Inc)
[5] Franco A and Almeida L 2015 Real World Outcomes and Critical Thinking: Differential Analysis by Academic Major and Gender Paidëia 25 61 173-181
[6] Arikunto S 2015 Dasar-Dasar Evaluasi Pendidikan Edisi 2 (Jakarta: Bumi Aksara)
[7] Mardapi D 2008 Teknik Penyusunan Instrumen Tes dan Non Tes (Yogyakarta: Mitra Cendikia)
[8] Erceg N, Aviani I and Mesic 2013 Probing Student’s Critical Thinking Process by Presenting Ill-Defined Physics Problems Revista Mexicana de Fisica 59 65-76
[9] Verburgh A, Francois S, Elen J and Janssen R 2013 Research Article the Assessment of Critical Thinking Critically Assessed in Higher Education: A Validation Study of the CCTT and the HCTA Education Research International 1-13
[10] Nur’asiah R R F, Siahaan P and Samsudin A 2015 Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains 2015 (SNIPS 2015)
[11] Ritdamaya D and Suhandi A 2016 Konstruksi Instrumen Tes Keterampilan Berpikir Kritis Terkait Materi Suhu dan Kalor JPPPF - Jurnal Penelitian & Pengembangan Pendidikan Fisika 2 2 87
[12] Setyowati A 2011 Implementasi Pendekatan konflik Kognitif dalam Pembelajaran Fisika untuk Menumbuhkan Kemampuan Berpikir Kritis Siswa Kelas VIII Jurnal Pendidikan Fisika Indonesia 7 89-96
[13] Suparno and Dholo T F 2014 The Effectiveness of Physics Teaching and Learning using Experimental and Demonstrational Method on Process Skill and Cognitive Aspect on Year Ten SMA Negeri 1 Ende Students Proceeding of 27th International Congress for School Effectiveness and Improvement
[14] Tipler P A 2001 Fisika Untuk Sains Dan Teknik (Jakarta: Erlangga)
[15] Kartimi 2012 Pengembangan alat ukur berpikir kritis pada konsep termokimia Jurnal Scientiae Educatiae 1 1 1-14
[16] Liu O L, Frankel L and Roohr K C 2015 Assessing Critical Thinking in Higher Education: Current State and Directions for Next-Generation Assessment (Princeton: Educational Testing Service)