

PAPER • OPEN ACCESS

Development of a critical thinking skill instrument for physics and chemistry students in higher education

To cite this article: P Dwijananti *et al* 2021 *J. Phys.: Conf. Ser.* **1918** 052076

View the [article online](#) for updates and enhancements.

You may also like

- [Development of assessment instruments to measure critical thinking skills](#)
W Sumarni, K I Supardi and N Widiarti
- [Profile of Students' Critical Thinking Skill Measured by Science Virtual Test on Living Things and Environmental Sustainability Theme](#)
N I Maulida, H Firman and L Rusyati
- [Critical Thinking, Creative Thinking, and Learning Achievement: How They are Related](#)
A Fatmawati, S Zubaidah, S Mahanal et al.



The Electrochemical Society
Advancing solid state & electrochemical science & technology

241st ECS Meeting

May 29 – June 2, 2022 Vancouver • BC • Canada

Abstract submission deadline: Dec 3, 2021

Connect. Engage. Champion. Empower. Accelerate.
We move science forward



Submit your abstract



Development of a critical thinking skill instrument for physics and chemistry students in higher education

P Dwijananti^{1,*}, A Ruwaida², B N Mindyarto² and Wiyanto²

¹Department of Physics, Postgraduate Program, Universitas Negeri Semarang, Indonesia

²Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia

*Corresponding author: pratiwi.dwijananti@mail.unnes.ac.id

Abstract. Critical thinking skill is one of the essential skills needed in the 21st century. Besides being improved through a learning process, critical thinking skill also can be acquired through the evaluation. This study aims to determine the validity and reliability of a critical thinking skill instrument. The research method used is Research and Development (R&D) with the ADDIE model and a quantitative descriptive analysis. The participant of the study are fifty 2nd semester students majoring in Physics and Chemistry. This test consists of sixteen reasoned multiple-choice items. The data are collected by using test and questionnaire. Expert validation shows that this instrument is well categorized with a percentage of 90%. This result shows that the instrument is reliable with a reliability of 0.71. The implementation shows that students' critical thinking skill is low with a score 10.1 out of 64.

1. Introduction

Critical thinking skill is one of the essential skills needed in the 21st century. Critical thinking is an active and skilled interpretation and evaluation of observation, communication, argumentation and information [1]. In other words, critical thinking is a cognitive process and an individual mental activity in solving a problem by making a correct and responsible decision. By thinking critically, people can analyze ideas into something more specific, identify and develop them better.

The benefits of critical thinking are making the individual more objective, more patient and open-minded to the opinions and others' point of view [2]. Besides, the individual becomes work more collaboratively, communicate effectively and solve problems more efficiently [3]. The importance of critical thinking is that the individual can face all the challenges that occur in their career and in their future life [4].

Based on the result of the study [5] [6] in Indonesia show that students' critical thinking skills are still low. It means that students are still not being used to doing critical thinking instruments in various subjects. Meanwhile, the learning objectives of higher education are producing graduates who have the skill to think logically, critically, innovatively, and have quality [8].

Besides being improved through a learning process, critical thinking skill also can be acquired through the evaluation. By accustomed to working on higher-order thinking instruments, students will have the opportunity to polish critical thinking patterns. Also, a large amount of research on critical



thinking skills certainly require an exact evaluation tool. One type of evaluation tool is an open reasoned multiple-choice test in which the students freely write the answers.

Physics is a subject that requires logical thinking. One of the materials is the atomic nucleus which is about the study of the structure of the nucleus, the changes that occur in the atomic nucleus and radioactivity. This material is quite challenging to be understood because it cannot be directly observed and it examines very small objects. Therefore, logical and critical reasoning are needed so the individuals able to know both the conceptual problem and its solution.

This study aims to develop a critical thinking skill instrument for Physics and Chemistry students in the atomic nucleus and determine its validity and reliability. The test instrument is also to be implemented to determine the profile of the critical thinking skills of physics and chemistry students in the atomic nucleus.

2. Methods

The type of research is the Research and Development (R&D) method with the ADDIE model. This model developed by Dick and Carry has five steps, namely (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. The research subjects were selected using random sampling techniques. The data are collected using a test and a questionnaire and are analyzed in a quantitative descriptive method.

The first step is analysis. At this step, the researchers determine the critical thinking aspects that will be used. The critical thinking skill are divided into five aspects, namely (a) elementary education, (b) basic support, (c) inference, (d) advanced clarification, and (e) strategies and tactics [6]. From these aspects, ten indicators of critical thinking are used, namely (1) deduce and judge deduction, (2) analyze arguments, (3) focus on a question, (4) ask and answer questions, (5) define terms and judge definition, (6) induction, (7) make and judge value judgements, (8) judge the credibility of a source, (9) decide on an action and (10) attribute unstated assumptions. These indicators are used as a reference for making questions. In this study, researchers use atomic nucleus as the material of instrument.

The second step is design. At this step, the researchers design the evaluation tools consisted of preparing the guideline, instructions for filling in, instrument, answer keys, rubric assessment, and questionnaire. The instrument developed using open reasoned multiple choice with a total of 30 items. Meanwhile, the questionnaire consists of 12 questions representing aspects of language, appearance, and content.

The third stage is the development. At this step, the developed instrument and questionnaire are validated by experts who are physics lecturers at Universitas Negeri Semarang. If the product is declared valid, the instrument is ready to be tested. Contrarily, if the product is not suitable for use; it must be revised and re-validated for use in a small-scale trial. The results of the instrument validation analysis are shown in Table 1.

Table 1. Result of the instrument validation

Aspects	Experts I	Experts II	Average
Questions according to the indicator	5	4	4,5
Homogeneous and logical answer choices	5	4	4,5
There is only one correct answer key	5	4	4,5
Item questions measure aspects of critical thinking skills	4	4	4
The main question is clearly formulated	4	5	4,5
The main question and the choice of answers are just statements that are needed	4	4	4
The main question does not contain multiple negative statements	5	4	4,5
The main question does not provide an answer key	5	4	4,5
Pictures, charts, tables or graphs are presented clearly	5	5	5
Use the language according to the rules of Indonesian	5	4	4,5
Not using the local language/taboo	5	5	5

The language used is communicative	5	4	4,5
Total	57	51	54
Average			4,5

Table 1 shows that the instrument was declared valid with a score 4.5 or a percentage of 90%. After that, the instrument was tested to twenty 4th semester students of Department of Physics, Universitas Negeri Semarang. The analysis shows that the test instrument has low reliability, so some questions had to be revised and the item was reduced to 20. The instrument revision is done by adding sentences or descriptions to make students more easily grasp the meaning of the question. The instrument that has been revised then re-validated by the expert. After declared valid, the instrument test can be used on a large-scale trial. The results of the student response questionnaire validation are shown in Table 2.

Table 2. Result of the questionnaire

No.	Validator	Total Score	Percentage	Category
1.	Expert I	34	97,14%	Valid
2.	Expert II	29	82,86%	Valid

Table 2 shows that the student response questionnaire is valid with a score percentage of 90%. This means that the questionnaire is suitable for a research.

The fourth step is implementation. After being revised, the instrument and questionnaire are ready to be tested on a large-scale trial. Implementation of the instrument is carried out online using Edmodo while the questionnaire is administered using google form.

The last step is evaluation. At this step, the researchers analyze the results of large-scale trial. The result will determine the validity and reliability. Meanwhile, student response questionnaire analysis is useful for knowing student responses to the instruments. Besides, the implementation results also show the profile of the critical thinking skills of Physics and Chemistry students.

3. Result and Discussion

3.1 Instrument

The instrument tested on fifty 2nd semester students majoring in Physics and Chemistry, Universitas Negeri Semarang. The instrument consists of 20 items with a time allocation of 90 minutes. The results of the large-scale trial validation are shown in Table 3.

Table 3. Result of the large-scale trial validation

No. Item	Total	Category
1, 2, 3, 4, 6, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20	16	Valid
5, 8, 9, 10	4	Invalid

Table 3 shows the results of the empirical validation. From the 20 questions, 16 questions are categorized as valid and reliable with a reliability of 0.71. These 16 questions are then used to determine the profile of students' critical thinking skill. This score is included in the high category, so the instrument is suitable to be used to measure students' critical thinking skills. A reliable and valid instrument can measure students' abilities precisely and accurately in accordance with learning objectives [9]. Aspects and indicators of critical thinking skills for each valid item are shown in Table 4.

Table 4. Aspects and indicators of critical thinking skill

Aspects	Indicators	No. Item
Elementary Education	▪ Focus on a question	2, 3
	▪ Analyze arguments	11, 13
	▪ Ask and answer questions	12, 17

Basic Support	▪ Judge the credibility of a source	16
	▪ Deduce and judge deduction	1
Inference	▪ Induction	7, 18
	▪ Make and judge value judgments	6, 14
Advanced Clarification	▪ Define terms and judge definition	4, 15
	▪ Attribute unstated assumptions	19, 20

Table 4 shows that the instrument represents four aspects and nine indicators of critical thinking skills so that it can validly be used.

3.2 Questionnaire

After working on the instrument, students then fill out a questionnaire via a google form. The responses are used as a reference for the achievement of the critical thinking instrument in terms of language, appearance and content. Students fill out the questionnaire according to their opinion towards the instrument. The results of the student questionnaire are shown in Table 5.

Table 5. Results of the student questionnaire

Category	Total	Percentage
Very Good	14	28%
Good	36	72%

Table 4 shows that students gave good responses to the critical thinking skill instrument. The average score is 45.42 from a total score of 60 or a percentage of 75.70%. It means that the instrument of critical thinking skills is well accepted by students.

3.3 Profile of Critical Thinking Skill

The profile of students' critical thinking skills are divided into several categories, namely high, medium, low, and very low. The results of the student's critical thinking skill profile can be seen in Figure 1.

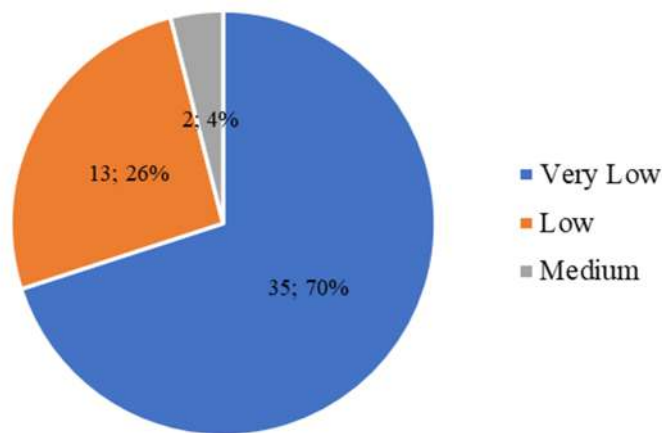


Figure 1. Result of profile of critical thinking skill

Figure 1 shows that 35 students are in the very low category, 13 students are in the low category and 2 students are in the medium category. The results of the profil of student' critical thinking skill have an average score of 10.1 from a maximum score of 64 or a percentage of 15.84%. These results are included in the very low category. The results of the analysis of aspects of critical thinking skills can be seen in Figure 2.

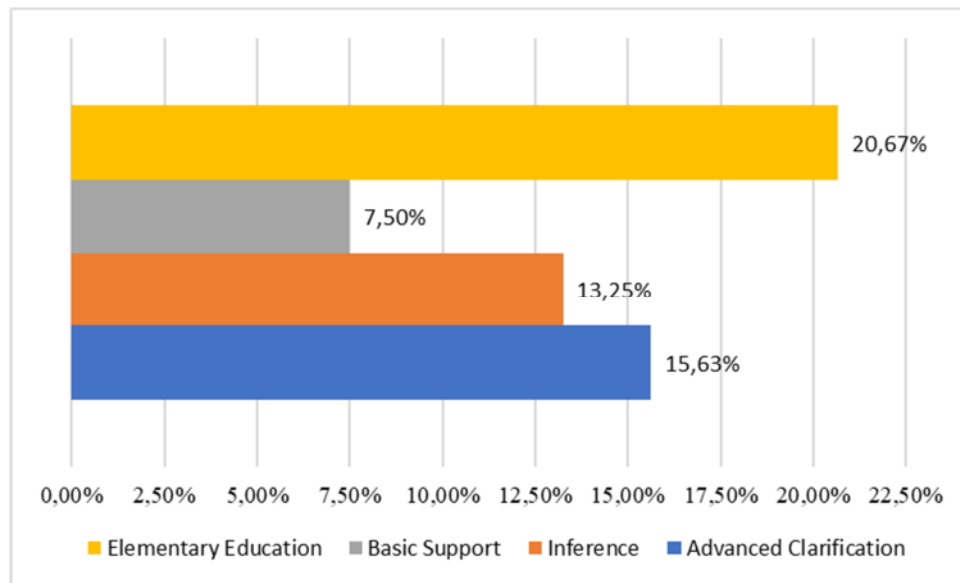


Figure 2. Result of aspects of critical thinking skill

Figure 2 shows the percentage for each aspect of students' critical thinking skills. The aspect of elementary education has the highest percentage, namely 20.67% while aspect with the lowest percentage is basic support with a percentage of 7.50%. The four aspects of critical thinking skills are included in the very low category.

Several factors cause low critical thinking skills, namely: lack of practice, lack of information, biased perception and limited learning time [10]. Little knowledge also makes it difficult for students to find the correct solution even though they can know and analyze a problem [11]. The tests that are carried out online also affect the condition of students. If the internet connection is unstable, it will reduce student motivation. Motivation is one of the important factors in encouraging enthusiasm for learning and carrying out an activity to achieve a goal. On the other hand, one of the challenges of online testing is internet access [12]. Meanwhile, the edmodo media will run slower if there is internet disruption [13]. There are some students who cannot access questions on Edmodo due to unstable internet speeds. As a result, students find it difficult to solve all the questions until the time ends. Students are also used to doing on multiple-choice questions so that it is challenging to work on multiple-choice questions based on having to write down the reasons in answering them. It is because, during high school, students are not familiar with doing questions with discourse and problem contexts that use higher order thinking skill [14].

4. Conclusion

The critical thinking skill instrument, with 16 questions, was declared valid and reliable with a reliability of 0.71. The sixteen questions represent 4 aspects and 9 indicators of critical thinking skills. Student response to the instrument was also good with a percentage of 75.70%. The profile of critical thinking skill of Physics and Chemistry students is in the very low category with a score of 10.1 from a maximum score of 64 or a percentage of 15, 84%.

References

- [1] Fisher A 2009 *Critical Thinking An Introduction* (Cambridge: Cambridge University Press) p 10
- [2] Karakoc M 2016 *J. Hum. Soc. Sci.* **6** 81
- [3] Zivkovic S 2016 *Proc. Int. Conf. on Teaching and Learning English as an Additional Language (Antalya)* vol 232 (Turkey: Elsevier Ltd) p 103
- [4] Evens M, An Verbugh and Elen J 2013. *Higher Edu* **2** 139
- [5] Ennis R H 2011 *The Nature of Critical Thinking: An Outline of Critical Thinking Dispositions*

- and Abilities* (Illinois: University of Illinois) p 2-4
- [6] Bustami Y, Suarsini E and Ibrohim 2019 *J. Bioedu* **7** 59
- [7] Pradana S D, Parno and Handayanto S K 2017 *J Pen. Eval. Pend.* **21** 62
- [8] Direktorat Jendral Pendidikan Tinggi 2014 *Buku Kurikulum Pendidikan Tinggi* (Jakarta: Kementrian Pendidikan dan Kebudayaan)
- [9] Tows M H 2014 *J. Chem. Edu* **91** 1426
- [10] Peter E E 2012 *J. Math. Comp. Sci. Rsch.* **5** 42
- [11] Enciso O L U, Enciso DFU and Daza MdPV 2017 *J Rastros Rostros* **19** 81
- [12] Alruwais M, Wills G and Wald M 2018 *J. Inf. Edu. Tech* **8** 35
- [13] Wankel C 2011 *Educating Educators with Social Media* (United Kingdom: Emerald Group Publishing Limited) p 24
- [14] Kurniyasari H, Hidayat S and Harfian BAA 2019 *J. Bio.Pemb. Bio.* **4** 4