The analysis of critical thinking skills test in social-problems for physics education students with Rasch Model

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Abstract. Critical thinking is related to several other abilities, such as decision making and problem solving ability. This study aims to identify measuring power of the critical thinking skills test and calculating parameter test for Physics Education students. The subjects are 44 students with age ranges from 18 to 21 years old. The results of this study indicate the level of critical thinking skills of physics education program students in the low category. This test has moderate reliability coefficient of 0.64, with the most difficult item number is the number 5 and the easiest one is 21 from Rasch Model. Items in the instrument has moderate level of difficulty for physics education students. Moreover, item discrimination of the instrument is quite good, with 9 items which could measure critical thinking skills of physics education students of Universitas Pendidikan Indonesia without creating confusion or misconception.

1. Introduction
Critical thinking skill is one of core competence of 21st century education. This skill is a part of higher order thinking skills (HOTS) [1,2]. In addressing education challenge in 21st century in which adolescent are encouraged to master critical thinking skill, students of university are not only required to focus on the use of critical thinking skills in their disciplines but also to utilize it in addressing social issues and problems. Without the use of critical thinking in addressing those things, decisions made do not seem effective. It is to say that critical thinking skill is highly related to decision making [3,4,5].

Ideally, a critical individual has high awareness on the information they gain. They also pay attention to accuracy, broad thinking, and clarity in evaluation. They are good as well as consistent in decision making [3,6,7]. Critical thinking skills are also related to experience individual faces which contributes to thinking process in solving social problems [8]. In this case, critical thinking skills instrument to solve social problems for physics education students has not been developed and therefore the analysis of assessment construction of critical thinking skills in social problems is needed.

Scientific intelligence is not the only thing needed by students of physics education; social and interpersonal intelligence are also play important role in their lives. In solving daily life problems, interpretation skill in looking at the problems based on their potential is essential for them. Moreover, interpretation skill is a basic skill in critical thinking and thus this skill mastery by students who are in the process of cognitive development in operational formal stage is essential. Therefore, critical thinking skill to solve social problems is necessary for students of physics education.
Development of test item on critical thinking skills on social problems of physics education students is related to educational psychology and guidance components in the form of system support. In carrying out system support to construct test instrument of students’ critical thinking skills, counselors need to consider students’ ability and experience in solving social problems. Students’ critical thinking skills do not merely influenced by students’ ability in solving scientific problems. This argument is supported by a research result which points out that critical thinking is also religiously related i.e. *aqidah* and *akhlag* [9]. In Buddhism, critical thinking can be done by doing *Daimoku* (praying) and utilizing self-regulation in critical thinking to solve life problems [10,11]. Moreover, critical thinking is also closely related to students’ emotional intelligence as well as their speaking skills [12]. All in all, critical thinking is a complex thing in human life.

2. Methods

This research employed quantitative approach in the form of descriptive method. This study has used a quantitative approach with the method of developing cognitive tests based on the development stage in the form of critical thinking skills test [13]. This research involved 44 students of physics education of Universitas Pendidikan Indonesia enrolled in 2017 as the subject. RASCH model was used as data analysis using Winsteps application. To collect the data, the researchers developed critical thinking skill instrument consisting of 23 questions with the aim of measuring 6 aspects of critical thinking skill. The questions are in the form of true-false option and essay. Scores used to assess was in the form of polimous data.

From Winsteps, identification showed item discrimination, difficulty level, reliability, validity, and students’ ability level in answering the items as well as scalogram which represented pattern of students’ answer. Discourse presented in the instruments were about social problems familiar to the students. Facione’s theory was used as aspects in the instrument, comprising of six sub aspects including interpretation, analysis, evaluation, inference, explanation, and self-regulation skills [5]. Those aspect seemed appropriate to be applied in critical thinking skill stages in social science. These aspects specifically measured critical thinking skill of individual. Moreover, most of research related to critical thinking skill employed instrument developed by Facione and most of them also used six aspects mentioned before. Each aspect can be seen in the table below.

| Table 1. Facione’s aspects of critical thinking [6,7,14] |
|---------------|----------------|
| **No** | **Aspect** | **Sub-Indicator** |
| 1 | Interpretation | a. Categorization  
| | | b. Interpreting information  
| | | c. Clarifying information  
| 2 | Analysis | a. Considering various ideas  
| | | b. Identifying arguments  
| | | c. Analysing arguments  
| 3 | Evaluation | a. Judging fact from information  
| | | b. Assessing information quality  
| 4 | Inference | a. Understanding facts  
| | | b. Constructing premise  
| | | c. Explaining conclusion  
| 5 | Explanation | a. concluding result  
| | | b. adjusting to fact  
| | | c. presenting arguments  
| 6 | Self-regulation | a. self-controlling  
| | | b. self-correction  

In developing test instrument on critical thinking skills, the researchers employed cognitive test construction stages based on a model suggested which is shown in the figure below.
Based on the above figure, there are 9 stages in developing creative thinking skill test: 1) determining critical thinking skill construct theoretically along with its variable aspects, 2) constructing blueprint of critical thinking skill based on the aspects, 3) validating aspects of critical thinking skill, 4) writing items, 5) reviewing and revising the item after content and construct validity test, 6) checking items’ validity to the expert/ conducting pilot test, 7) checking construct validity, 8) designing test and counting reliability after the test, and 9) issuing the test [13].

3. Results and Discussion
The result of the research shows that critical thinking skill of physics education students was low. Specifically, 17 out of 44 students has low critical thinking skills. The test of critical thinking skills used to measure itself had the difficulty level of moderate. The test containing 23 items had moderate reliability coefficient of 0,64. Reliability coefficient of students in doing the test was 0,74 while reliability coefficient of items in the test developed was 0,98. Estimated reliability analyzed using Winsteps application are presented in the following figure.
Based on the picture above, there are two scores namely item separation and person separation. Separation score shows quality of instrument as well as respondent in the research. The bigger the separation score is, the better the instrument in identifying subject and item ability (based on difficulty level) in a broad sale is. Formula used to see the grouping by separating strata is shown below:

\[ H = \left( \frac{4 \times \text{separation} + 1}{3} \right) \]  

(1)

It can be seen that item separation score is 6.45 and therefore \( H = \left( \frac{4 \times 6.45 + 1}{3} \right) = 8.9 \) rounded to 9. It means that there are 9 items which are considered good to measure students’ critical thinking skills. The most difficult item was number 5 while the easiest one was number 17. The developed items had various item discrimination and difficulty level. The distribution of item discrimination and difficulty level can be seen in the figure below.
Figure 3. Analysis of items on Critical thinking skills test

From the above figure, it can be seen that an item is considered good and can be used in a test if its item discrimination is between 0.4 and 0.85 or 0.4 < Pt Measure Corr < 0.85. To find out whether an item is clear and does not create confusion as well as misconception for the students, Outfit MNSQ (0.5 < MNSQ > 1.5) and Outfit ZSTD (-2.0 < ZSTD > 2.0) should be considered as well as norm on Pt. Measure Corr [15,16]. Taking into account those three columns, the analysis showed that item number 6, 7, 8, 9, 10, 12, 13, 18, dan 22 are good items which means that they were clear and did not create confusion. All items had good scores on Outfit MNSQ and Outfit ZSTD except number 5. However, all items had good item discrimination so those 9 items can be used to measure critical thinking skills of students. All 23 items developed had various difficulty level distribution which can be identified in Rasch model analysis in Winsteps. The distribution can be seen in Wright map analysis below.
Figure 4. Wright Map Analysis on Critical Thinking Skills Test

It can be identified from the figure above that item number 5 has the highest difficulty level, while item number 4, 15, 22, 7, 8, 12, 10, 13, 14, 2, 16, and 18 are on moderate category. Item number 3, 6, 9, 11, 1, 19, 20, 17, 23, and 21 has low level of difficulty. Level of measuring power of the developed instrument can be seen in the following figure:

Figure 5. Test Information Function
It can be seen in the test information function above that the curve slope is in fluctuation. The graphic furthermore implies that all 23 items tested only measured students whose ability are low and average. This is also supported by the results of reliability analysis on Infit and Outfit MNSQ scores in figure 2 which shows the result of the score which is close to 1 (1 is an ideal score for Infit and Outfit MNSQ while score of Infit and Outfit ZSTD is considered ideal if it is close to 0). On the person and item table, mean scores of Infit and Outfit MNSQ as well as Infit and Outfit ZSTD are quite ideal to measure critical thinking skills of physics education students of Universitas Pendidikan Indonesia.

In discuss of the implication of Rasch Model analysis in this study is able to test the suitability of physics education students ability on items that are constructed simultaneously. Rasch Model has advantages such as, the ability to provide linear scale at the same interval, able to predict data that is not detected, has the ability to estimate accurately, has the ability to detect the inaccuracy of measurement models, and produce measurements that can be imitated [15]. In addition, in the Rasch analysis the resulting analysis model is fit statistics, so that the results of the analysis are able to provide information about the data obtained are ideal data to represent respondents' abilities with patterns of answers to items with a certain level of difficulty [16]. The parameters used in the Rasch Model are information and outfits from mean square and standardized values.

4. Conclusion
This critical thinking skills instrument could measure critical thinking skills of physic education students with moderate measuring power. This instrument has 0,64 reliability score with the item reliability coefficient of 0,98 and students reliability coefficient in answering the items of 0,74. Items in the instrument has moderate level of difficulty for physics education students. Moreover, item discrimination of the instrument is quite good, with 9 items which could measure critical thinking skills of physics education students of Universitas Pendidikan Indonesia without creating confusion or misconception. Therefore, it can be used in diagnosis test since it is able to measure students who have low to average abilities. However, this instrument cannot be used as selection test for students of physics education in Universitas Pendidikan Indonesia because its measuring power only reached moderate and it has only 9 good items represented by their good validity, item discrimination, and difficulty level.

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