Confirmatory factor analysis of critical thinking disposition test in university biology

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Abstract. The purpose of this study was to look at the construct validity of the Critical ThinkingDisposition (CTD) Test in Biology. Referring to Facione theory, there are seven indicators of CTD: truth-seeking, open mind, analyticity, systematicity, self-confidence, inquisitiveness, and maturity. The instrument used is ten groups of questions consisting of 7 questions that lead to the CTD. The test is presented in the form of cases relating to biological content and have been validated by experts. The study involved 526 respondents who are biology education students from two universities in Bengkulu with study level (year 1, 2, 3 and 4). After confirming with CFA, the results show that the CTD test has suitable construct validity. This result is supported by the value received from Convergent Validity which includes the factor loading value of more than 0.5, while the Composite Reliability (CR) and Average Variance Extract (AVE) values for seven indicators of CTD are truth-seeking (CR=0.96, AVE=0.72), open mind (CR=0.94, AVE=0.61), analyticity (CR=0.97, AVE=0.76), systematicity (CR=0.96, AVE=0.69), self confidence (CR=0.98, AVE=0.83), inquisitiveness (CR=0.93, AVE=0.56) and maturity (CR=0.97, AVE=0.75). From the results can be concluded that the test has construct validity and high composite reliability to measure the CTD in biology.

1. Introduction
The ability to analyze and evaluate is part of critical thinking skills that are needed in the face of the evolving conditions of the world [1]. Critical thinking is the main target developed in the educational environment. Critical thinking is considered one way to address the global challenges that are being faced. And in fact, critical thinking has been set as the main goal in the academic field, especially education in college [2]. This is also confirmed by the statement that critical thinking is the characteristic of a college graduate [3].

Critical thinking skills allow someone to select, organize, analyze, and use the information they need [3]. Disposition and skills are part of critical thinking that cannot be separated from its role. Disposition is considered a specific component while skill is called as common component [4]. Critical thinking skills lead to a person’s ability to carry out interpretation, analysis, conclusions, evaluation, explanation, and self-regulation. While critical thinking disposition is the attitude that has an important role in determining one’s critical thinking skills [5]. In addition, critical thinking dispositions also involve attitudes, motivations, and thinking habits are considered a factor in determining whether a person is able to use his thinking skills well [5].

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Furthermore, before developing the critical thinking ability of a person should first look at how critical thinking dispositions are as a pre-requisite for having critical thinking skills [6]. Thus, the critical thinking disposition is a pre-requisite to the development of effective critical thinking [7] and the attitude that someone needs in using critical thinking skills [8]. Referring to Facione theory, critical thinking dispositions consists of *truth-seeking, open-mindedness, analyticity, systematicity, self-confident, inquisitiveness and maturity* [9].

Many studies have been conducted both inside and outside the country related to the development effort of the critical thinking disposition of students in college. So far the research is looking at the critical thinking disposition with a general nature that is using inventory scale, there is no research that focuses on specific areas such as biological materials. Given the critical thinking of being a demand in the college curriculum in preparation for the 21st century, it means the need to insert a cognitive domain in critical thinking disposition instruments. Thus, the need for the development of critical thinking disposition instruments is in the form of tests. The instrument test is considered to be more objective than the measurement through the inventory scale. However, inventory scale measurements provide a great opportunity for deceptive answers from respondent [10], [11], [12]. And the fact that a trick answers can cause low validity of an instrument used in measuring a variable [13], [14]. This study shows how the results of the construct validity of the test to measure critical thinking disposition in the biology of higher education. The critical thinking disposition test developed includes biological content that is broadly divided into 4 groups of materials: 1) the diversity of living things and ecology, 2) the structure and function of living things, 3) biotechnology, 4) genetics and evolution. The questions for each group of material are presented in case form consisting of seven questions leading to the critical thinking disposition.

This research aims to validate the draft of Critical Thinking Disposition Test in Biology. Therefore Confirmatory Factor Analysis is very necessary to confirm and validate the construct items from the test developed. The results of Confirmatory Factor Analysis describes which construct items can represent indicators of critical thinking disposition. Thus, the Critical Thinking Disposition Test in Biology is valid and have a good instrument criterion for measuring one’s disposition.

2. Methods
This study used the Confirmatory Factor Analysis method to test the construct validity that consisting of three analytical procedures (convergent validity), namely: factor loading, composite reliability, and average variance extract [15]. The relationship between construct items on question developed with critical thinking disposition indicators can be analyzed through the factor loading value. The factor loading value was acceptable when the constructed object has a value of more than 0.5. Composite Reliability was used for the reliability test with value criteria more than 0.7. Average Variance Extract was confirmatory test by looking at the average variance extract between indicators of a latent variable. The last method used the number of the correlation between the construct with its indicators, and the acceptable value of Average Variance Extract is more than 0.5 [16]. The respondents in this research involved 526 students of biology education with the level of study (year 1, year 2, year 3, and year 4). This research was conducted in two Universities in Bengkulu.

Ten question groups were consisting of seven multiple choice questions that lead to critical thinking disposition. The instrument used in this research had been validated by validators that have taken from lecturers who are considered as the experts in biology content and assessment. The experts involved 6 (six) lecturers from Universitas Pendidikan Indonesia and University of Muhammadiyah Bengkulu. The questions form in the Critical Thinking Disposition Test in Biology were presented through cases relating to biological content, in which each case was developed from four main groups of biological aspects.

In this research, there were two procedures performed in analyzing the data. The methods include: 1) Demographic information of respondents (namely: gender, age, grade of study and institution) analyzed by descriptive with using SPSS Software version 20, 2) the construct validity on Critical Thinking Disposition Test in Biology confirmed by Confirmatory Factor Analysis method using AMOS version 20. To assist in the process of analyzing data through Confirmatory Factor Analysis, each
indicator of critical thinking disposition is given a code namely TS for Truth Seeking, OM for Open Mind, AN for Analyticity, SIS for Systematicity, SC for Self Confidence, IN for Inquisitiveness, and MA for Maturity. Furthermore, respondents' answers that have been grouped by code for each indicator are inputted into the AMOS application based on each indicator of critical thinking disposition which is the first step in the Confirmatory Factor Analysis.

3. Result and Discussion

The first step in describing the outcome of Confirmatory Factor Analysis analyzed the feasibility of the overall model fit. There were some methods to identify model fit, namely: Chi Squares test, Goodness of Fit indices, Adjusted Goodness of Fit Indices and Root Mean Squares Residual. From some methods of model fittest, the model could be said as suitable if it has at least one of the methods. However, the model of Critical Thinking Disposition Test in Biology considered would be better if it has more than one of the criteria [17]. Model fit test for critical thinking disposition model could be seen in Table 1:

| Criteria of Feasibility | Criteria Value | Critical Thinking Disposition Test Model |
|-------------------------|----------------|-----------------------------------------|
| CMIN/df                 | ≤ 3            | 2.272                                   |
| RMSEA                   | ≤ 0.08         | 0.049                                   |
| GFI                     | ≥ 0.90         | 0.760                                   |
| RMR                     | < 0.50         | 0.008                                   |
| TLI                     | ≥ 0.90         | 0.927                                   |
| CFI                     | ≥ 0.90         | 0.930                                   |
| PNFI                    | The higher is better | 0.848                   |

Based on Table 1 shows that the critical thinking disposition model with the number of respondents of 526 student's biology education is considered feasible, which it has the CMIN/df is 2.272. The result of the model fit test of critical thinking disposition test after confirmed by Confirmatory Factor Analysis was as shown in Table 1 shows that several of the indicators are fit, among others: RMSEA=0.049, RMR=0.008, PNFI=0.848, TLI =0.927, and CFI =0.930. Only on the Good Fit Index criteria does not meet the value of feasibility is 0.76. But, it is number that is still close to number one, so that the value can even be said to meet the standard of test value. Also, the results show that the model of critical thinking disposition test has more than one value of feasibility criteria. Thus, it can be concluded that the measurement critical thinking disposition model is feasible to use. Furthermore, in Figure 1 can be seen based on Confirmatory Factor Analysis result indicates that the value of 10 question groups for seven indicators of critical thinking disposition is said to be acceptable that has a factor loading more than 0.5.
After obtaining the factor loading for seven indicators of critical thinking disposition, the next step in convergent validity test is analyzing the value of Average Variance Extract and the Composite Reliability which can be seen in Table 2.

Table 2. Convergent Validity

| Constructs            | Truth-seek | Open mind | Analyticity | Systematicity | Self-confident | Inquisitiveness | Maturity |
|-----------------------|------------|-----------|-------------|---------------|----------------|-----------------|----------|
| 1 AVE                 | 0.72       | 0.62      | 0.76        | 0.69          | 0.83           | 0.56            | 0.75     |
| 2 CR                  | 0.96       | 0.94      | 0.97        | 0.96          | 0.98           | 0.93            | 0.97     |
| Factor Loading        |            |           |             |               |                |                 |          |
| 3 Convergent Validity |            |           |             |               |                |                 |          |
| 4                      | 0.817      | 0.718     | 0.887       | 0.740         | 0.973          | 0.742           | 0.747    |
| 5                      | 0.823      | 0.801     | 0.931       | 0.782         | 0.933          | 0.832           | 0.937    |
| 6                      | 0.797      | 0.786     | 0.943       | 0.778         | 0.934          | 0.766           | 0.908    |
| 7                      | 0.855      | 0.750     | 0.919       | 0.877         | 0.898          | 0.809           | 0.955    |
| 8                      | 0.795      | 0.796     | 0.947       | 0.834         | 0.921          | 0.634           | 0.839    |
| 9                      | 0.839      | 0.733     | 0.787       | 0.867         | 0.835          | 0.792           | 0.849    |
| 10                     | 0.836      | 0.753     | 0.823       | 0.787         | 0.760          | 0.674           | 0.812    |
From Table 2 the Average Variance Extract and the Composite Reliability value of the seven critical thinking disposition indicators are acceptable. The analysis of Average Variance Extract is the last step in looking at convergent validity. The Average Variance Extract value is as follows: truth-seeking 0.72, open mind 0.62, analyticity 0.76, systematicity 0.69, self-confidence 0.83, inquisitiveness 0.56, and maturity 0.75. Furthermore, the reliability value of Critical Thinking Disposition Tests in Biology was analyzed through Composite Reliability. Composite Reliability can be used as another alternative in looking at the reliability of an instrument [18]. The analysis found that all indicators have good reliability value (more than 0.7) that is truth-seeking 0.96, open mind 0.94, analyticity 0.97, systematicity 0.96, self-confidence 0.98, inquisitiveness 0.93, and maturity 0.97.

Based on the findings can be concluded that the Critical Thinking Disposition Tests in Biology has good convergent validity. It describes that Critical Thinking Disposition Tests in Biology have met the criteria of good instruments. The questions on the test have been considered to represent each biology material and indicators of critical thinking disposition, so that can measure one's disposition in biology. The use of Critical Thinking Disposition Test in Biology can provide a significant contribution in realizing curriculum objectives in higher education, namely creating graduates who have critical thinking skills. The existence of this test can help educators determine what efforts will be made in improving one's critical thinking both disposition and ability.

4. Conclusion
Based on Confirmatory Factor Analysis it can be concluded that the Critical Thinking Disposition Test in Biology in higher education has acceptable construct validity. The result of construct validity test shows that 10 question groups for all critical thinking disposition indicators are valid. The questions also indicate the high Composite Reliability. Thus, this instrument can be used to measure critical thinking disposition of students in the biological context. For further researcher can use this instrument in the learning process for students of biology education. It is used to predict the extent to which the disposition of students to have the ability to think critically. Critical thinking disposition is fundamental in determining the success of one's academic field, besides that it is one of the efforts in facing the 21st century.

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