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# Factor Analysis at Item Test Conceptual Understanding Of Numerical Method

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**Abstract**

*Factor analysis at item test conceptual understanding of numerical method aims to find out whether the conceptual understanding indicators used can confirm a construct and ensure that the test is complied with the indicator. Data analysis is done using confirmatory factor analysis. Based on data analysis, one factor is formed with Eigen value 2.352 and variation is 58.8%. This result shows that the indicators of conceptual understanding ability are valid, and the test prepared in accordance with the indicators of conceptual understanding ability.*

***Keywords****: conceptual understanding, confirmatory factor analysis*

## 1. Introduction

Conceptual understanding is one of the skills that need to be developed in learning, especially mathematics learning. In learning mathematics, students must understand mathematical concepts in order to be able to solve problems and be able to apply the learning in the real world. The mathematical concept is said to be understood if the concept has been internalized and is related to the knowledge that has been possessed by students. This is as stated by Stylianides (2007), a mathematical idea or procedure or fact is understood if it is part of an internal network. More specifically, mathematics is understood if its mental representation is part of a network of representations. The degree of understanding is determined by the number and the strength of the connections. A mathematical idea, procedure, or fact is understood thoroughly if it is linked to existing networks with stronger or more numerous connections.

Through conceptual understanding, students will be able to master, interpret, and explain concepts, operations, and mathematical relations then apply these concepts to suitable situations. In addition, students are able to understand what is taught, know what is being communicated, and can take advantage of the content of the material being studied, which in this case students can use it to analyze problems then transform it into models and forms of mathematical equations. Of course, this will greatly help students in learning a material, especially material on the subject of numerical methods. The numerical method is one method in mathematics that is used to solve a mathematical problem. Numerical methods provide an approximation solution with a certain degree of accuracy and involves calculating numbers based on an algorithm. Of course, this characteristic brings up some difficulties in its application, including the difficulty in analyzing questions and carrying out work steps based on existing algorithms. This is also supported by the research of Syahbana (2013) which states facts related to student difficulties in completing numerical methods, namely: difficulty in working steps in getting the completion of each iteration to the next iteration, difficulty determining the coefficient value of each variable and entering the variable values from each iteration, difficulties in understanding/ analyzing the problem and understanding the basic concepts, not being careful in carrying out the counting operations, not paying attention to positive/negative signs, and being confused in determining the results of the iterations and using them in finding the next solution. Therefore, deep understanding of concepts and broad insights in studying the material of numerical method needed.

Student's conceptual understanding can be known through a measurement. Measurements can be done using instruments in the form of tests. Tests are generally used to assess and measure student learning outcomes, especially cognitive learning outcomes relating to mastery of teaching material or material. According to Gronlund (1985), a test is a

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systematic instrument or procedure for measuring a certain behavior. Based on these definitions, the test can be used to determine the achievement of a learning achievement that is formulated in the learning design and can be used to evaluate and estimate the abilities of students.

A good instrument needs to go through several stages of preparation. Among them are determination of test indicators to fit the objectives of compiling an instrument and testing the quality of instruments both validity and reliability. Validity and reliability are a prerequisite for an instrument can be used in measurement. In truth, validity is affiliated with accuracy and suitability (Anastasi & Urbina, 1997). The experts said that the concept of validity is the degree to which a test can measure what it wants to measure (Sawilowsky, 2007). While reliability refers to an index that shows the extent to which a measurement tool can be trusted or reliable. In measuring reliability, the attention of researchers is aimed at the stability, accuracy and homogeneity of instruments. In measuring the validity of an instrument, attention is paid to the content and usability of the instrument. In this condition the validity is in the form of construct validity and content validity (Zuriah, 2009). Construct validity refers to the assumption that the measuring instrument used contains one precise operational definition of a theoretical concept. While content validity refers to an instrument that has content conformity in disclosing or measuring what will be measured.

In relation to the measurement of conceptual understanding abilities, the instruments in the form of tests used in this measurement must really contain an appropriate operational definition of conceptual understanding ability. From this operational definition, dimensions and indicators of conceptual understanding ability are then developed. For this reason, testing construct validity can be an important step in ensuring that the tests prepared are in accordance with the elements of a construct of conceptual understanding ability. Test of construct validity can be done in several ways, one of which is using confirmatory factor analysis. In factor analysis, two construct terms are known, namely empirical constructs and latent constructs (McGrath, 2011). Confirmatory factor analysis are intended for analysis of latent variable modeling (latent-variable modeling) (Gorard & Taylor, 2004). This confirmatory factor analysis is useful to test whether a construct has unidimensionality or whether the indicators used can confirm a construct or variable (Ghozali, 2016).

Therefore, it is necessary to test of construct validity using confirmatory factor analysis on tests of numerical method conceptual understanding to ensure that the tests prepared are in accordance with the indicators of a construct of conceptual understanding and to test whether those indicators can confirm a construct of conceptual understanding ability. Based on the elaboration, it is necessary to conduct research that aims to determine whether the indicators of conceptual understanding used can confirm a construct and ensure that the tests prepared are in accordance with these indicators.

## 2. Methods

This research is a descriptive exploratory study with the subject of 6$^{th}$ semester students of the Mathematics Education Department IKIP PGRI Bali. The object chosen is the midterm test of numerical method in the form of a essay test. This data was analyzed using confirmatory factor analysis with the help of SPSS software. The steps taken in data analysis, namely collecting response data from midterm test of numerical methods, testing the feasibility assumption of analysis, and determining eigenvalues. Factor analysis is actually related to construct validity, where the use of factor analysis techniques can be used to test construct validity in a measuring instrument. Factor analysis is a procedure in identifying and grouping items or variables in a study because of similar constructs.

## 3. Results and Discussion

The conceptual understanding ability test that was compiled in this study was built based on the indicators of the conceptual understanding ability. The grid of concepual understanding ability test is described in Table 1.

ISSN: 2541-7207 DOI: 10.23887/jpi-undiksha.v8i1.18289

**Tabel 1.** The Grid of Conceptual Understanding Ability Test

| Indicator | Subindicator |
|---|---|
| 1) Ability to restate a concept<br>2) Ability to review necessary conditions or enough conditions from the concept<br>3) Ability to use, utilize, and choose certain procedures or operations<br>4) Ability to apply concepts or algorithms to problem solvin<br>5) Ability to present concepts in various forms of mathematical representation | 1) Determining the numerical method and the iterative steps in accordance with the image<br>2) Determining the solution to a problem using numerical methods |
| 6) TAbility to give examples and not examples of concepts | 3) Determining the appropriate interval in finding the root of equation using the method false position based on the image |
| 7) The ability to classify objects according to certain characteristics according to the concept | 4) Choosing the right data to be used in the interpolation method and determining the solution based on existing data |

To ensure that the test prepared is in accordance with the indicators of a construct of conceptual understanding and to test whether the indicators can confirm a construct of the conceptual understanding ability, then construct validity is tested using confirmatory factor analysis.

Before using confirmatory factor analysis, the basic assumptions of this analysis must be fulfilled. The assumptions underlying whether or not factor analysis can be used is matrix data must have sufficient correlation. The test that can be used to test this assumption is Keizer-Meyer-Olkin Measure of Sampling Adequacy (KMO MSA). The results of the KMO-MSA test using SPSS are presented in Table 2

**Table 2.** The Results of The KMO-MSA Test

| | | |
|---|---|---|
| *Kaiser-Meyer-Olkin Measure of Sampling Adequacy* | | 0.745 |
| *Bartlett's Test of Sphericity* | *Approx. Chi-Square* | 77,619 |
| | *df* | 6 |
| | *Sig.* | 0,001 |

To be able to do a factor analysis, the KMO value must be > 0.5. Based on the results of the analysis, it can be seen that the KMO value is 0.745> 0.5 so that factor analysis can be done. The results of the analysis also show that the Bartlett's Test value is 77.619 with a significance of 0.001 which indicates that the factor analysis test can be continued.

An indicator can be said to be a significant measure of the factors it measures if it has a value of Measure of Sampling Adequacy (MSA) greater than 0.4. The results of the MSA test using SPSS are presented in Table 3.

**Tablel 3.** The Results of The MSA Test

| | | **Indicator1** | **Indicator2** | **Indicator3** | **Indicator4** |
|---|---|---|---|---|---|
| Anti-image Covariance | Sub-indicator1 | 0.749 | -0.204 | -0.119 | -0.059 |
| | Sub-indicator2 | -0.204 | 0.683 | -0.147 | -0.107 |
| | Sub-indicator3 | -0.119 | -0.147 | 0.565 | -0.276 |
| | Sub-indicator4 | -0.059 | -0.107 | -0.276 | 0.615 |
| Anti-image Correlation | Sub-indicator1 | 0.798(a) | -0.286 | -0.183 | -0.087 |
| | Sub-indicator2 | -0.286 | **0.784(a)** | -0.237 | -0.165 |
| | Sub-indicator3 | -0.183 | -0.237 | **0.708(a)** | -0.468 |
| | Sub-indicator4 | -0.087 | -0.165 | -0.468 | **0.721(a)** |

*a Measures of Sampling Adequacy* (MSA)

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Based on the results of the MSA test, it appears that the MSA value of sub-indicator 1 is 0.798, the MSA value of sub-indicator 2 is 0.784, the MSA indicator 3 is 0.708, and the MSA sub-indicator 4 is 0.721. This shows that sub-indicator 1, sub-indicator 2, sub-indicator 3, and sub-indicator 4 can be said to be factors that influence the conceptual understanding ability of numerical method.

Confirmatory factor analysis will group each indicator into several factors based on the Eigen value> 1.

**Table 4.** Eigen Value

| Component | Initial Eigenvalues | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1 | 2.352 | 58.800 | 58.800 |
| 2 | 0.707 | 17.674 | 76.474 |
| 3 | 0.543 | 13.581 | 90.055 |
| 4 | 0.398 | 9.945 | 100.000 |

Based on the data in the table, it can be seen that formed 1 factor with eigen value 2.352 and variation of 58.8%. If sub-indicator 1, sub-indicator 2, sub-indicator 3, and sub-indicator 4 are sub-indicators of the construct indicators of conceptual understanding ability. Then they will automatically group together with high loadings factor.

**Table 5.** Loadings Factor Velue

| | Component |
|---|---|
| | 1 |
| sub-indicator1 | 0.698 |
| sub-indicator2 | 0.761 |
| sub-indicator3 | 0.823 |
| sub-indicator4 | 0.780 |

Based on the data in the table, it can be seen that sub-indicator 1, sub-indicator 2, sub-indicator 3, and sub-indicator 4 grouped in 1 factor. So it can be concluded that the construct of the conceptual understanding ability has unidimensionality or in other words the indicator of conceptual understanding ability is all valid.

The conceptual understanding ability is the ability to organize knowledge into a coherent whole. This ability allows students to learn new mathematical ideas and concepts by relating them to the knowledge they already have. This is as stated by Barmby (2007) that understanding in mathematics as a network is generated from representations related to mathematical concepts. In other words, to understand mathematics is to make connections between mental representations of mathematical concepts. Furthermore, according to Kilpatrick (2001) which states that conceptual understanding is related to a comprehensive and functional understanding from mathematical ideas both concepts, operations, and mathematical notation. Students with conceptual understanding know more than just separate facts and methods, but know the importance of mathematical ideas and the benefits of these ideas. Students who learn mathematical facts and ideas with understanding will be able to explain the facts and ideas again, and be able to explain the interrelationships between concepts. So that they will be able to create their own procedures.

Numerical methods as one of the subjects in mathematics needed deep understanding of concepts and broad insights. This is because the characteristics of this subject bring up some difficulties in its use, including the difficulty in analyzing questions and carrying out work steps based on existing algorithms. For that measurement of the conceptual understanding ability needs to be done so that the learning process can be evaluated.

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Measuring the conceptual understanding ability is done by using an instrument in the form of an essay test which is arranged based on indicators of conceptual understanding ability. According to NCTM (in Syahbana. 2013), indicators of conceptual understanding ability consist of: 1) Ability to restate a concept; 2) Ability to review necessary conditions or enough conditions from the concept; 3) Ability to use, utilize, and choose certain procedures or operations; 4) Ability to apply concepts or algorithms to problem solving; 5) Ability to present concepts in various forms of mathematical representation; 6) Ability to give examples and not examples of concepts; and 7) The ability to classify objects according to certain characteristics according to the concept. This seven indicators are the basis of the sub-indicators that compile the tests of numerical method conceptual understanding, namely determining the numerical method and the iterative steps in accordance with the image, determining the solution to a problem using numerical methods, determining the appropriate interval in finding the root of equation using the method false position based on the image, choosing the right data to be used in the interpolation method and determining the solution based on existing data.

Of course, the test that is prepared must really represent the indicators and these indicators can really measure the student's conceptual understanding ability of understanding the concept of the numerical method. To ascertain this, the construct validity test was carried out using confirmatory factor analysis. Confirmatory factor analysis is useful to test whether a construct has unidimensionality or whether the indicators used can confirm a construct or variable and ensure that the tests prepared are in accordance with the indicators of a construct of conceptual understanding ability.

To be able to carry out confirmatory factor analysis, initial assumptions are needed. The initial assumption test was conducted to test the feasibility of the analysis, namely to see the fulfillment of assumptions as a condition for factor analysis. The criteria for knowing whether a data can be use factor analysis are determined by two things, namely the value of the Kaiser-Meyer Olkin (KMO) coefficient and Bartlett's Sphericity test. Based on the results of the analysis it can be seen that the KMO value is 0.745 > 0.5 which indicates that factor analysis can be done. Furthermore, Bartlett's Sphericity test was obtained at 77.619 with a significance of 0.001 which indicates that the factor analysis test can be continued. In addition, the Bartlett's Sphericity test value is also used to determine whether there is a relationship between variables. Based on the results of the analysis obtained a significance value of less than 0.05 so that it can be stated that the variables are correlated with each other.

To find out that an indicator is a significant measure of the factors, it is based on the value of the Measure of Sampling Adequacy (MSA) which is greater than 0.4. Based on the results of the MSA test, it can be seen that the MSA value of sub-indicator 1 is 0.798. The MSA sub-indicator 2 is 0.784. The MSA sub-indicator 3 is 0.708, and the MSA sub-indicator 4 is 0.721. This shows that sub-indicator 1, sub-indicator 2, sub-indicator 3, and sub-indicator 4 can be said to be factors that influence the conceptual understanding ability of the numerical method.

If the four test sub-indicators really are constructs that construct the conceptual understanding ability test. Then through confirmatory factor analysis each sub-indicator will be grouped into 1 factor. The number of factors formed from several sub-indicators is seen from the eigenvalue. Eigen value is the total variance explained by each factor or is a contribution of certain factors to all variants of the initial variables. The requirement to be a factor is a large Eigen value that is 1 or more. So, the factors must be chosen with Eigen value at least 1. Based on the data analysis, there is 1 factor with Eigen value is 2.352 and variation of 58.8% is formed. So, it can be concluded that the construct of the conceptual understanding ability has unidimensionality or in other words indicators of the conceptual understanding ability are all valid, and the tests prepared are in accordance with the indicators of a construct of the conceptual understanding ability.

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## 4. Conclusions and Suggestions

Based on the results of confirmatory factor analysis. it was found that the tests prepared were in accordance with the indicators of a construct of conceptual understanding ability. In addition, it can be concluded that the indicator of conceptual understanding consists of: 1) The ability to restate a concept; 2) The ability to review necessary conditions or enough conditions from the concept; 3) The ability to use, utilize, and choose certain procedures or operations; 4) The ability to apply concepts or algorithms to problem solving; 5) The ability to present concepts in various forms of mathematical representation; 6) The ability to give examples and not examples of concepts; and 7) The ability to classify objects according to certain characteristics are the construct of the conceptual understanding ability test.

Based on the analysis and conclusions obtained. It is recommended that the conceptual understanding ability test of numerical methods can be used to evaluate the learning process of numerical methods and estimate the sconceptual understanding ability of numerical methods of students.

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