Instrument analysis for motivation and interest in mathematics learning using confirmatory factor analysis (CFA)

Achi Rinaldi¹*, Betha Ria Indriani¹, Rikka Yulina¹, M. Indra Saputra¹, Komarudin¹, Yetri Y¹

¹Universitas Islam Negeri Raden Intan Lampung, Indonesia.

*Corresponding author: achi@radenintan.ac.id

Abstract. Many studies in mathematics education discusses the relationship of latent variables that are measured directly. If latent variables measure directly, it will cause a bias in estimation. It is necessary to measure instruments that explain the relationship between latent variables and indicator variables, which should not be measured directly. This study aimed to analyze indicators of interest and motivation to learn mathematics, while the method we used is the Confirmatory Factor Analysis (CFA). Indicators of the interest in learning mathematics are 1) Feeling of Happiness, 2) Student Curiosity, 3) Student Attention, 4) Student Involvement, while the indicators for motivation are 1) Perseverance in Learning, 2) Facing Difficulties Ability, 3) Sharpness in Attention 4) Achievement in Learning, 5) Independent in Learning. Four indicators of interest in mathematics show that only two indicators are qualified based on the Kaiser Mayer Oikin (KMO) score of 0.611 for the indicator of student curiosity and 0.507 for student involvement indicators. While the three indicators of motivation, which qualified based on the KMO score of 0.685 for perseverance in learning, 0.628 for facing difficulties ability, and 0.616 for the sharpness of Attention.

Keywords: Confirmatory Factor Analysis, Indicator variable, Interest, latent variable, Motivation

1. Introduction

Mathematics plays a crucial role as a subject lesson [1], but many students do not like mathematics [2]. It needs more serious attention in a growing interest in learning mathematics for students [3]. Determination of appropriate indicators is one strategy to resolve the problem [4]. Unfortunately, research in education is still focusing on analyzing the relationship between variables, such as emotional intelligence, on mathematical communication, which is a latent variable [5].

Interest is an activity carried out by students who have a fixed tendency to pay attention and remember some activities [6]. Interest can also be interpreting as a sense of excitement in something [7]. So the interest in learning mathematics is giving more attention to mathematics learning [8]. To foster an interest in learning mathematics, we need a greater focus on indicators that support interest in learning mathematics [9]. The indicators contained in latent variables of interest in learning mathematics include 1) Feeling of Happiness, 2) Student Curiosity, 3) Student Attention, 4) Student Involvement [10]. Indicator variables above will be analyzed by factors that can see whether the indicator is appropriate in its measurement [11].

Motivation to learn is the whole of the driving force that is found in students to result in the emergence of learning activities [12], which will ensure the continuity of the learning process also gives
direction to the learning activities so that the objectives to be achieved by the learning subject can be realized [13]. The indicators contained in the latent variables of learning motivation include mathematics 1) Perseverance in Learning 2) Tenacious in Dealing with Difficulties 3) Sharpness of Attention in Learning 4) Achievement in Learning 5) Independent in Learning [14].

So much research in education involves variable latent with measure directly. The latent variable cannot be measured directly [15]; for this reason, the researcher conducts a factor analysis with the Confirmatory factor analysis technique to re-examine the indicator variables that have been determined in previous studies. The latent variables that we use for this research are motivation and interest.

2. Method
This research used quantitative research methods with factor analysis techniques. Factor analysis is divided into two, namely Exploratory Factor Analysis (EFA) and Confirmatory factor analysis (CFA) [16]. EFA is a casual modeling technique that seeks to explain the relationship or correlation between a set of observed variables (manifests) using an unobserved linear combination [17]. CFA is a multivariate analysis technique to confirm the model that has been hypothesized [18].

Confirmatory Factor Analysis (CFA) is an analytical technique used in this study. Indicators conducted by previous researchers about interest in learning mathematics will be confirmed again, resulting in straightforward and also suitable indicator variables in explaining all existing indicators. We use as many as 111 respondents as sample size.

The equation used in explaining the x measurement model can be stated as follows [19]. The general model of Confirmatory Factor Analysis is as follows:

\[ x = \Lambda_x \xi + \delta \]

With information:
\( x \): indicator variable
\( \Lambda_x \): loading factor (\( \lambda \)) between indicators
\( \xi \): (KSI), latent variable
\( \delta \): measurement error related to X

In the CFA, the procedures performed, including calculating the correlation between the observed indicators. There are several techniques used in CFA, including are:

- **Kaiser Mayer Olkin (KMO) and Bartlett’s**
  KMO test aims to determine whether all data that has been taken is enough to be factored. The KMO value of each variable > 0.50 and the p-value must be < 0.05. If this value is not sufficient, the factor analysis cannot be continued.

- **Extraction Factor**
  Extraction Factor is used to reduce indicators to produce fewer factors

- **Rotation Factor**
  When the extraction factor, if the reduction results from the indicator do not produce the main component, it is necessary to do the Rotation factor.

*Figure 1. The Procedures of CFA*
3. Results and Discussion

3.1 Latent Variables Interest in Learning Mathematics

The results of the factor analysis performed on the mathematics learning interest indicator are shown in Figure 2. The values contained in the arrow from the latent variable to the indicator variable indicate the KMO value.

In Figure 2, $\xi_1$ as a latent variable of interest in learning mathematics, $x_1$ is the first indicator of interest in learning mathematics that is feeling happy, $x_2$ is the second indicator of interest in learning mathematics that is the relationship of students, $x_3$ is the third indicator of mathematics learning interest that is the attention of students, $x_4$ is the fourth indicator of interest in learning mathematics, namely student involvement. The results of the analysis carried out from the Figure 2 above show that the KMO and $p$-value values that meet the requirements are only the second and fourth indicators with the acquisition of KMO values respectively 0.611 and 0.50. Thus, of all the indicators that have been determined, there are only two indicators that can be determined by factor analysis. These indicators are the relationship between students and the involvement of students.

The next stage is Communalities which aims to see whether the questions can explain the factors or not. The terms of the question are considered to be able to explain the factor if the Extraction value $> 0.50$. The output is obtained as follows:

| Initial | Extraction |
|---------|------------|
| K.PSR 1 | 1.000      | .719   |
| K.PRS 2 | 1.000      | .541   |
| K.PRS 3 | 1.000      | .609   |
| K.PRS 4 | 1.000      | .614   |
| K.PRS 5 | 1.000      | .542   |
| K.PRS 6 | 1.000      | .618   |
| K.PRS 7 | 1.000      | .634   |
The results of the extraction conducted on the indicators of student interest can be seen in Table 1, which shows all the questions meet the extraction requirements with a value > 0.50. The next step is to determine the total variance explained in the indicators of student interest with the condition value of eigenvalues > 1; the results show that there are only three component 1, component 1 with eigenvalues value = 1.827 (26.107%), component 2 with eigenvalues value 1.437 (20.533%), component 3 with eigenvalues value 1.013 (14.469%), so from the three components, it can explain 61.109% variation.

The second indicator of interest in learning mathematics is the involvement of students with a total of 4 items after an anti-image correlation is obtained the KMO value that meets the requirements of only three items. Then from the three items, the extraction values were obtained as follows:

Table 2: Communalities Involvement of Students

|       | Initial | Extraction |
|-------|---------|------------|
| KTRL 1 | 1.000   | .402       |
| KTRL 2 | 1.000   | .229       |
| KTRL 4 | 1.000   | .526       |

Extraction results show that there is one main component in the indicator of student involvement with an extraction value of 0.526. Meet the extraction requirements > 0.50, namely KTRL 4. After extracting the next step is determining the value of each question. The results obtained are eigenvalues = 1.158 (38.549%). The questionnaire that has been distributed to 111 respondents with a total of 20 questions can be explained into four components, with the distribution of 3 components for students' interest and 1 component to explain the involvement of students.

3.2 Latent Variables Motivational Learning Mathematics

Figure 3 explains the results of the latent variables of mathematics learning motivation which consist of five latent variables as explained in the previous theory.
In the Figure 3 $\xi_2$ as a latent variable of motivation to learn mathematics, is the first indicator that is perseverance in learning, is the second indicator of namely tenacious in facing difficulties, is the third indicator that is attention in learning, is the fourth indicator of achievement in learning, is the fourth indicator that is independent in learning. The results of the analysis carried out from the diagram above show that the value of KMO and $p$-value that meet the requirements are only the first, second, and third indicators with the acquisition of KMO values respectively 0.685; 0.628 and 0.616. Thus, there are only three indicators that can be determined by factor analysis, these indicators are perseverance in learning, tenacious in facing difficulties, and the sharpness of attention in learning.

4. Conclusions and Suggestions
The latent variables of interest in learning mathematics there are four indicator variables namely feeling happy, students' interest, students' attention, students' involvement, but after the first step in factor analysis it turns out that there are only two indicator variables that can meet the requirements for factor analysis, namely interest students and student involvement. The questions contained in the latent variable interest in learning mathematics consists of 20 questions, from these questions can be explained into three factors.

The latent variables of mathematics learning motivation are five indicator variables, namely perseverance in learning, tenacious in facing difficulties, sharpness in attention, participating in learning and independent in learning, but after the first step in factor analysis it turns out that there are only three indicator variables that can meet the requirements to analyze factors, namely perseverance in learning, tenacity in the face of difficulties, the sharpness of attention in learning. The questions contained in the latent variable motivation to learn mathematics consists of 25 questions, from these questions can be explained into six factors. From these results, we suggest using more sample sizes to get convinced about the distribution of data; we can also make some modeling to describe the association pattern for all of the latent variables in the feature.

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