Students' attitude towards mathematics in discovery learning using concrete and virtual manipulative

I Hidayah* and R A Prayoga
Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia

*Corresponding author: isti.hidayah@mail.unnes.ac.id

Abstract. Students’ attitude towards mathematics is a factor that affects students’ learning activities and mathematics achievement. The purpose of this study is to observe the relationship between the indicators that construct students’ attitude towards mathematics in discovery learning using concrete and virtual manipulative. This study uses a quantitative method with a pre-experimental design model. The sample in this study was students of class VIIB as virtual class and VIIC as concrete class at SMP Negeri 31 Semarang. The research sample is given a post-survey after the implementation of discovery learning. SPSS and LISREL are used to analyze the measurement model (CFA). Based on the analysis of goodness of fit statistics, 13 of the 18 parameters state that the causative model of the model in this study is appropriate and compatible to be applied to concrete and virtual classes. In the concrete class, the measurement model shows acceptable reliability and validity. While in the virtual class, the measurement shows that reliability is not fulfilled and there is an invalid indicator, namely anxiety towards mathematics. The average of $R^2$ value of the indicators in constructing students' attitude towards mathematics in concrete class is 47.8% while the virtual class is only 41.4%.

1. Introduction

Based on the 2018 PISA’s result, Indonesia's ranking in mathematics ability is at 71 out of 79 participating countries with a score of 386 below from the standard that has been set which is 462 [1]. This condition explains that the ability of junior high school students in solving mathematical problems is still far below the international average.

Teachers’ beliefs about the use of manipulatives are important factors that could contribute to their effective use of manipulatives during instructional lessons [2]. The National Council of Teachers of Mathematics (NCTM) recommends the use of mathematics manipulatives in learning mathematical concepts at all levels of education. Concrete, visual, and/or virtual representations are mathematical representations that can be used in mathematics learning [3]. Manipulatives are a model of concrete representation. The use of digital technologies in mathematics education has the capacity to address diverse pathways for students to construct and engage with mathematical knowledge. In addition to its computational power, modern technologies can help increase collaboration and bring about more of an emphasis on practical applications of mathematics, through modeling, visualization, manipulation and the introduction of more complex scenarios [4]. Often, mathematics apps include virtual manipulatives, which are an interactive, technology-enabled visual representation of a dynamic mathematical object, including all of the programmable features that allow it to be manipulated, that presents opportunities for constructing mathematical knowledge [5]. As an implementation of the current curriculum in Indonesia (Curriculum 2013), most schools in addition to utilizing manipulatives, have also made use of visual representations of both static or dynamic, such as power points or videos. Emergence into the
21st century features tools that are different, communication that is different, information that is different, and work that is different. Given this shift, education must shift to incorporate computer-based, electronic technologies integrating learning with these technologies [6]. An excellent mathematics program integrates the use of mathematical tools and technology as essential resources to help students learn and make sense of mathematical ideas, reason mathematically, and communicate their mathematical thinking [7].

Discovery learning put students to be able to organize the subject matter by themselves. Teaching materials are not presented in the final form, but students are required to carry out various activities to collect information, compare, categorize, analyze, integrate, reorganize materials and make conclusions. Discovery learning places great responsibility on students so that students do not always depend on others. A key to the success of discovery learning is more meaningful to students than information simply received from others [8].

Another aspect that is no less important in influencing learning outcomes is student attitudes towards mathematics. There are two factors that can influence the mathematics learning process in each student, namely: (1) cognitive factors and (2) non-cognitive (affective) factors. Cognitive factors are related to the brain's ability to think such as the ability to reason. Non-cognitive (affective) factors relate to abilities outside the brain's ability to think. For example feeling happy or unhappy learning mathematics [9]. The research result conducted by Goracke (2009) relating to students' attitudes towards mathematics when using concrete manipulatives showed that overall students enjoyed learning mathematics [10]. Meanwhile, Alshehri's research results (2017) show that the majority of the students indicated that learning with physical manipulatives was a good way to spend math time and that it was easier for them to explain math using physical than virtual manipulatives [11]. Smartphones, tablets, computers are inseparable from students' daily lives so that the use of virtual manipulatives is expected to be able to contribute to better student mathematics learning outcomes. This study aims to describe how the indicators of students' attitudes towards mathematics in learning with concrete and virtual manipulatives.

2. Methods
In this study, a quantitative pre-experimental design was used in the form of Posttest-Only Control Design. The description of quantitative research designs can be seen in the Table 1.

| Class | Treatment   | Posttest |
|-------|-------------|----------|
| X1a   | Tc          |          |
| X2b   | Tc          |          |

\[\text{\textsuperscript{a} The implementation of discovery learning using concrete manipulatives}\]
\[\text{\textsuperscript{b} The implementation of discovery learning using virtual manipulatives}\]
\[\text{\textsuperscript{c} Questionnaire on Students' Attitudes towards Mathematics}\]

The population in this study is grade VII of students of SMP Negeri 31 Semarang in the 2019/2020 school year. The samples in this study are students of class VII C as the experimental group 1 and class VII B as the experimental group 2. The data collection method in this study is a Likert scale questionnaire method. In the prerequisite test, the normality test was carried out using the Kolmogorov-Smirnov test assisted with SPSS 20.0, the variance equality test using the Levene test assisted with SPSS 20.0. Furthermore, the data are analyzed using model testing with structural equation modeling (SEM) techniques. SEM is a comprehensive and flexible approach to modeling the relations among variables in a set [12]. SEM allows researchers to build causal models with latent variables. [13]. In this step, the collected data from the questionnaires are processed and analyzed using the LISREL 8.0 software. With SEM, the researcher wants to do a CFA (Confirmatory Factor Analysis) analysis of the variables of students' attitudes towards mathematics towards its indicators. The following is a chart of the data processing process using structural equation modeling (SEM) techniques.
3. Results and Discussion
Affective data analysis is the analysis of data on the results of tests of students' attitudes towards mathematics. The steps used in this research method are:

3.1. Model Specification
The model specification stage describes the relationship between latent variables and manifest variables based on the prevailing theory. In this study, the model analyzed is CFA First Order to make it easier to see the causality relationships tested as in Table 2.

| Latent Variable                     | Manifest Variable      | Symbol |
|-------------------------------------|------------------------|--------|
| Students Attitude towards Mathematics ($\xi_1$) | Mathematics self-confidence | X1    |
|                                     | Enjoyment of mathematics | X2    |
|                                     | Perceived value of mathematics | X3    |
|                                     | Anxiety towards mathematics | X4    |
|                                     | Parents Attitude Toward Mathematics | X5    |

3.2. Model Identification
Based on the data analysis, it was found that the model in this study is over-identified. The total amount of data on the factors forming students' attitude towards mathematics is 15 while the estimated number of parameters is 10. From these results, it can be obtained that the resulting degree of freedom value in the driving factor is 15 - 10 = 5. Because the degree of freedom value is 5 > 0, so the model for the factors forming the student's attitude towards mathematics is over identified, so that the model can be estimated.

3.3. Model Estimation
The model estimate consists of two outputs, namely the estimated output and the standardized output. The estimated output is used in the formation of the measurement equation while the standardized output is used for making decisions on the validity and reliability of the construct.

3.4. Equation of Measurement
The SEM construction results show that from the concrete class all indicators forming student attitudes towards mathematics are valid. Whereas in the virtual class, there are 4 valid indicators and 1 invalid indicator, namely the X4 indicator. Of the two classes, the constructs that form the student's mathematical attitude variable are reliable for the concrete class, while the virtual class is not reliable. This is indicated by the value of construct reliability (CR) which shows the internal consistency of the indicator with a value of >0.70. Meanwhile, based on the extracted variant value, the data is considered reliable because it is >0.50, which means that the amount of variance of the indicator extracted by the formed variable is more than the variance error.

SEM modeling that is formed shows the direction of the causative effect between the variables of students’ attitude towards mathematics with indicators of self-mathematical concepts, enjoyment in mathematics, perceived value of mathematics, mathematics anxiety, and parents' attitudes. The calculation results show that in the 1st order CFA, the standardized factor loading in the concrete class for indicators X1, X2, X3, X4, and X5 is more than the critical value of 0.50. Whereas in the virtual class, the indicators X1, X2, X3, and X5 are worth more than the critical value of 0.50, while for the X4 indicator, it is less than 0.5. The causative relationship between the indicators and the variables is also explained by $R^2$, the average $R^2$ obtained from the 5 indicators for the concrete class is 47.8%, while for the virtual class it is 41.4%. The biggest causative relationship is reflected by the X1 indicator at 70% for the concrete class and. It is the same with concrete, in virtual class the biggest causative relationship is reflected by the X1 indicator, it's just that the size of the causative relationship is 63% in
forming the constructs of students' mathematical attitude variables, lower than the concrete class. Based on this, the indicator that has the highest causative effect in forming students' mathematical attitude variables is the mathematical concept possessed by each individual.

Meanwhile, the smallest causative relationship in the concrete class is reflected by the X4 indicator by 25%. In the virtual class the smallest causative relationship is also reflected by the X4 indicator, it's just that the size of the causative relationship is 0% in forming the constructs of students' mathematical attitude variables, lower than the concrete class. Based on this, the indicator that has the lowest causative effect in forming students' mathematical attitude variables in concrete and virtual classes is anxiety about mathematics which is owned by each individual.

3.5. **Overall Model Compatibility Test**

Based on the parameters combination analysis of the goodness of fit statistics, 13 of the 18 parameters state that the causative model in this research model for both concrete and virtual classes is generally considered good. This indicates that the variables of students' attitude towards mathematics have a causative relationship with the indicators that compose these variables both in class using concrete manipulatives and class using virtual manipulatives. Next, we see the results from Table 3. and Table 4. Model Evaluation Result of CFA 1st order, the $R^2$ average of the concrete class (=0.478) is higher than the $R^2$ average of the virtual class (=0.414).

### Table 3. Model Evaluation Result of CFA 1st order Concrete Class.

| Variable          | Indicator | Coefficient | Error Var | $R^2$ Standard Loading | Error Var (standardized) | CR | VE | Validity | Reliability |
|-------------------|-----------|-------------|-----------|------------------------|--------------------------|----|----|----------|-------------|
| Students          | X1        | 0.26        | 0.03      | 0.7                    | 0.83                     | 0.3|     | Valid    |             |
| Attitude          | X2        | 0.4         | 0.1       | 0.61                   | 0.78                     | 0.39|     | Valid    |             |
| Towards Mathemat- | X3        | 0.28        | 0.08      | 0.5                    | 0.71                     | 0.5| 0.81| Valid    | Reliable    |
| ics               | X4        | 0.25        | 0.19      | 0.25                   | 0.50                     | 0.74|     | Valid    |             |
|                   | X5        | 0.24        | 0.12      | 0.32                   | 0.56                     | 0.68|     | Valid    |             |

### Table 4. Model Evaluation Result of CFA 1st order Virtual Class.

| Variable          | Indicator | Coefficient | Error Var | $R^2$ Standard Loading | Error Var (standardized) | CR | VE | Validity | Reliability |
|-------------------|-----------|-------------|-----------|------------------------|--------------------------|----|----|----------|-------------|
| Students          | X1        | 0.24        | 0.03      | 0.63                   | 0.80                     | 0.37|     | Valid    |             |
| Attitude          | X2        | 0.3         | 0.07      | 0.58                   | 0.76                     | 0.42|     | Valid    |             |
| Towards Mathemat- | X3        | 0.25        | 0.1       | 0.39                   | 0.62                     | 0.61| 0.74| 0.4     | Not Reliable|
| ics               | X4        | 0.02        | 0.18      | 0.0014                 | 0.04                     | 1.00|     | Invalid  |             |
|                   | X5        | 0.28        | 0.09      | 0.47                   | 0.68                     | 0.53|     | Valid    |             |

3.6. **Discussion**

The results of the study indicate that the construction of indicators in composing students' attitudes towards mathematics in class with concrete manipulative is better than a class using virtual manipulatives. This is shown in the CFA1st Order test results, that the virtual class is not reliable. Reliable here does not refer to a good or bad instrument quality in measuring student attitudes towards mathematics but it shows that students' attitudes towards mathematics in virtual classrooms are not good enough by the indicators that compose it.

The results showed that all indicators in the concrete class constructing students' attitudes towards mathematics are valid. This is indicated by the standardized factor loading value which is more than 0.5. Whereas in the virtual class, there is an indicator that are not valid in constructing students' attitudes towards mathematics, namely the anxiety towards mathematics indicator it is because the standardized factor loading value for this indicator is 0.00 and less than 0.5. It turns out when we look from an invalid indicator, the standardized factor loading value is less than 0.5 which causes student attitudes towards mathematics in virtual class is not reliable.

The value of $R^2$ for the concrete class in the self-mathematical concept indicator is 0.7 while for the virtual class is 0.63. This shows that in both experimental classes, the indicator of self-mathematical
concepts can be said to be good for constructing student attitudes towards mathematics. Students feel more confident in their ability to learn and do well in solving mathematical problems. The use of manipulatives has a relationship with students' mathematical concepts [14].

In both experimental classes, the indicator of enjoyment of mathematics can be said to be good in constructing student attitudes towards mathematics when using manipulatives. This is indicated by the value of $R^2$ in the concrete class of 0.61 and in the virtual class of 0.58. These results indicate that the use of manipulative makes students enjoy learning mathematics and the subject itself which shapes students' attitudes towards mathematics. This is in line with research conducted by Cockett, A. (2015), who found that students generally enjoy using manipulatives in learning mathematics [15].

On the indicator of perceived value in mathematics, the value of $R^2$ in the two experimental classes is 0.5 for the concrete class and 0.39 for the virtual class. Although the value of R2 is not as big as an indicator of mathematical concepts and enjoyment of mathematics, the value of R2 is sufficient to show a causative relationship between students' attitudes towards mathematics for the two experimental classes. This shows that the use of manipulatives fosters students' beliefs about the importance of mathematics in everyday life and in the future in constructing students' attitudes towards mathematics.

In the indicator of anxiety towards mathematics, the value of $R^2$ in the concrete class is 0.25 which indicates that this indicator is good enough in constructing students' attitudes towards mathematics. Meanwhile, the value of $R^2$ in the virtual class is 0.00, which indicates that there is almost no relationship between the indicator of anxiety towards mathematics and students' attitudes towards mathematics. In the concrete classroom, the use of manipulatives reduces the feelings of anxiety, fear, and nervousness that arise in relation to learning activities towards mathematics. This is in line with Iossi, L.'s research which states that the use of learning strategies such as manipulatives can reduce students' anxiety about mathematics [16].

The value of $R^2$ on the indicator of parent attitudes towards mathematics for concrete class is 0.32, while for virtual class is 0.47. This shows that the attitudes of parents to concrete and virtual classes have a sufficiently causative relationship to students' attitudes towards mathematics. Thus, the use of manipulatives affects the interests, encouragement, and beliefs of students' parents in their children's abilities. This is in line with Shamila and Yoon's research which shows that parental influence has a positive relationship to students' attitudes towards mathematics [17].

The causative relationship between the latent variable and the indicators that have been described, the average value of $R^2$ from the 5 indicators for the concrete class is 47.8%, while for the virtual class it is 41.4%. So as a whole, it shows that the use of concrete manipulatives is better in constructing students' attitudes towards mathematics when compared to the use of virtual manipulatives. This is in line with Alshehri, S's research which states that most students show that learning with concrete manipulatives is a good way to spend time in learning mathematics and makes it easier for students to explain mathematics concrete manipulatives [11].

Manipulatives are useful in helping students learn mathematical concepts. Using manipulatives explicitly in a direct way helps students learn concepts more easily [14]. Students must feel a connection to the concepts they must understand in order for learning to be relevant and lasting. Clearly, this study and others show that manipulatives can help achieve this goal. Manipulatives give students the opportunity to be actively involved in meaningful learning experiences, enabling them to take ownership of their learning. After using manipulatives, students acquire the ability to transfer their concrete knowledge to symbolic knowledge, and finally, to real-life situations [18].

This shows that students make active use of manipulatives when they are learning new concepts and selective and strategic use of physical manipulatives can foster the development of rule construction [19]. Ghana argues that studies done at all different grade levels and in several different countries indicate that mathematics achievement increases when manipulatives are being used. The use of manipulatives over the long-term provides more benefits than short-term use does [20].
4. Conclusion
The causative model of students' attitude towards mathematics with the forming indicators in discovery learning with concrete and virtual manipulatives is good. The average size of the causative relationship of students attitudes towards mathematics in discovery learning using concrete manipulatives is higher than discovery learning using virtual manipulatives. The attitude indicators have high effect towards students' mathematics on discovery learning with concrete and virtual manipulatives in the same order. In discovery learning with concrete manipulatives from big to small are indicators of self-concept mathematics (70%), enjoyment (61%), values in mathematics (50%), parents attitudes (32%), and anxiety (25%). Meanwhile, virtual manipulative in discovery learning is the concept of self-mathematics (63%), enjoyment (58%), parents attitudes (47%), values in mathematics (39%), and anxiety (0%). Anxiety indicators have the smallest effect on the formation of students' attitude towards mathematics; even in virtual class, the anxiety indicator can be said not a good indicator in constructing students' attitudes towards mathematics.

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