Improving mathematics self-concept through comprehensive mathematics instruction model

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Abstract. The learning process of mathematics in high school now shows that it has not been able to improve students' mathematics self-concepts. This is indicated by the fact that high school mathematics self-concept students are still relatively low. Therefore, there needs to be an effort to improve these variables, considering that these variables are very important in supporting students' academic success, especially in mathematics. This study discusses how the implementation of the CMI model in mathematics learning can improve high school mathematics self-concept. This research is a quasi-experimental study. Samples were taken purposively from the population of high school students in Subang, West Java, Indonesia. The instruments used in the study consisted of mathematics self-concept questionnaire and observation sheets. The CMI model is a learning model that accommodates three stages namely develop, solidify and practice. CMI provides many opportunities for students to play an active role in asking questions, explaining the answers to mathematical questions they get, and transferring the knowledge they have with their classmates. The activity will indirectly build the confidence side of students in doing mathematics. The results of the study indicate that the CMI model can improve high school mathematics self-concept.

1. Introduction

Current education generally uses students mathematics self-concept to see their academic achievements. This is based on several studies which state that there is a significant correlation between students' mathematics self-concepts and their academic achievements. Adegoke [1] states that there is a positive relationship between students' mathematics achievement with mathematics self-concept. Mathematics self-concept can be a strong predictor of school performance and in making education and employment choices [2]. Mathematics self-concept is defined as a person's perception of himself regarding his mathematical abilities and skills, pleasure and interest in doing mathematics activities [3]. Research conducted by Adegoke [1] state that cognitions related to thinking ability and positive feelings about themselves can provide benefits in making choices, planning and achievement in the future.

Based on the PISA report, Indonesia is a country that has a significant increase in the mathematics self-concept index [4]. This should be a capital for Indonesia in improving students’ mathematics achievement, because according to PISA, in every country incorporated in the OECD, mathematics
self-concept is positively associated with their performance in mathematics. Given the importance of mathematics self-concept, the authors are interested in conducting further research on efforts to improve mathematics self-concept.

The comprehensive mathematics instruction (CMI) model is a learning model consisting of three components, namely teaching cycle, learning cycle and continuum of mathematical understanding. The teaching cycle component consists of three stages, namely launch, explore and discuss. At each of these stages, students play an active role in teacher guidance. The role of students can be active in asking questions, explaining the answers to mathematical questions obtained, and transferring the knowledge they have with classmates. This activity will indirectly build the side of students' self-confidence in doing mathematics. Thus, it is suspected that the CMI model can improve students' mathematics self-concepts.

The purpose of this study is to describe whether the improvement of students’ mathematics self-concept who have learned with the CMI model is better than students who get conventional learning. In the end, the results of this study will contribute to the improvement of students' mathematics self-concepts. This increase will affect the development of positive student self-concepts. This positive self-concept will improve the integrity index in the National Examination, so that in the long term, it is expected that students can become professionals in their scientific, honest, and have integrity to participate in building Indonesia.

2. Method
This research is a quasi-experimental study, with a quantitative approach. In this study involved three variables, namely learning factors as independent variables, students’ mathematics self-concept (MSC) as the dependent variable and students’ prior knowledge in mathematics (PKM) as control variables. The research design used was nonequivalent control group design as follows.

$$\text{O}_1 \quad \text{X} \quad \text{O}_2 \quad \text{O}_3 \quad \text{O}_4$$

The population of this study is all high school students of class XI in the 2017/2018 Academic Year in Subang, West Java. The selection of high school students as a population is because MSC needs to be increased at the level of high school students to help high school students in determining their way of life after graduating from high school. Decision making of students in choosing a college or work (for those who do not continue), according to Marsh [5] is strongly influenced by the MSC. Thus, this research is expected to be used as a process that can help high school students in making the right decisions for their future. Sampling is done by purposive sampling technique, where the sample is taken based on the consideration of the average UN scores of mathematics subjects in all high schools in Subang, West Java. In this study SMA N 3 Subang was designated as a sample school. This study uses two types of instruments, namely test instruments in the form of description questions to measure student’s PKM and non-test instruments in the form of questionnaires to measure students’ MSC and observation sheet to observe the implementation of the CMI model.

3. Result and Discussion
An increase in MSC analysis was conducted to see changes in the condition of MSC students after learning factors were given in each student's PKM category. The conditions of the initial MSC is students’ MSC score before being given learning factors, while the final MSC condition is the student's MSC score after learning is given. Changes in MSC conditions from type of negative MSC to positive MSC are said to be an increase. The grouping of MSC types adopted from the research conducted by Delima, Rahmah & Akbar [6]. The following will be explained about the first step MSC improvement analysis, namely to see the increase in student MSC based on the learning factors obtained. Tabulation of the data on the number of students who experience changes in the conditions of the initial MSC and final MSC on each learning factor is shown in the following table.
Table 1. MSC Change Data Tabulation based on Learning Factors

|                     | CMI Model |            | Conventional Model |            |
|---------------------|-----------|------------|--------------------|------------|
|                     | Positive MSC | Negative MSC | Positive MSC | Negative MSC |
| Initial MSC         | 18,8      | 0,0        | 26,5              | 0,0        |
| Negative MSC        | 60,0      | 31,2       | 14,7              | 58,8       |

Table 1 shows that the increase in MSC occurred in both classes that received CMI learning and classes that received conventional learning. The most increase occurred in the class that received CMI learning, where there were 60% of students who experienced a change in conditions from negative MSC to positive MSC. Meanwhile, in the class that received conventional learning, students who experienced an increase in MSC were only 14.7%. Both in the class that received CMI learning and the class that received conventional learning, no student experienced a change in MSC from positive to negative. The proportion of students who experienced an increase in MSC both in the CMI class and conventional class had a significant difference. To find out whether the difference is statistically significant, hypothesis testing is done by the Fisher test using the alpha significance level (α) of 5%. The following are the results of the Fisher test.

Table 2. Fisher Test

|                | Value | Exact Sig. (2-sided) |
|----------------|-------|-----------------------|
| Fisher's Exact Test | 93,949 | 0,000 |
| N of Valid Cases     | 66    |                       |

Based on Table 2, the Exact Sig (2-sided) value is 0.000. This value is smaller than α, then H₀ is rejected. This means that the proportion of students who experience changes in the initial conditions of MSC and the end of MSC on each learning factor differs significantly. Thus, it can be concluded that the proportion of MSC increase in students in the class who received CMI learning differed significantly from those who obtained conventional learning. In Table 1 it is shown that the largest proportion of MSC increases occurred in the class that received CMI learning, this means that the increase in MSC of students who received CMI learning was better than students who received conventional learning.

The next step is to analyze the increase in MSC of students based on the acquisition of N-gain MSC scores of students. This analysis is to find out whether there are differences in the average N-gain MSC score between students who get CMI learning and students who get conventional learning. The following is a statistical description of the student's N-gain MSC score data.

Table 3. Descriptive Statistics MSC N-gain Score

| Learning Factors | Mean | SD |
|------------------|------|----|
| CMI              | 0,222| 0,160 |
| Konvensional     | 0,069| 0,134 |

Table 3 shows that the mean N-gain MSC score between students who get CMI learning is different from students who get conventional learning. To test the significance of these differences, the prerequisite test is first, namely the normality test. The results of the normality test show that there is one data group that does not have a normal distribution, so hypothesis testing uses the Mann-Whitney U test, with the following hypothesis and decision criteria.

Hypothesis:

H₀: There was no significant difference between the increase in MSC of students who received CMI learning and those who obtained conventional learning.
There was a significant difference between the increase in MSC of students who received CMI learning and those who obtained conventional learning.

Decision criteria: Rejected $H_0$ if $\text{Asymp. Sig. (2 - tailed)} < \alpha$, by using $\alpha = 5\%$

The following are the Mann-Whitney U test results for N-gain MSC student score data.

**Table 4. The Mann-Whitney U Test Results**

| Learning Factors | Mann-Whitney U | Asymp. Sig. (2 - tailed) |
|------------------|----------------|-------------------------|
| CMI : Conventional | 239,000         | 0,000                   |

Based on Table 4, it was found that $H_0$ was rejected, meaning that there was a significant difference between the increase in MSC of students who received CMI learning and those who obtained conventional learning. The MSC score of students who get CMI learning is greater than those who get conventional learning. In other words, learning the CMI model is effective for increasing students’ MSC. In the research conducted by Delima [7], it was suggested that CMI learning was effective to improve students’ mathematical thinking skills. Meanwhile, Isiksal, et. al. [8] and Adegoke [1] suggest that there is a significant positive relationship between students’ MSC and mathematical learning achievement. Mathematics learning achievement can be seen from students’ achievement of mathematical thinking skills [8]. Therefore, it is reasonable to say that students’ MSC can be improved through learning using the CMI model. The teaching cycle component in the CMI model provides an opportunity for students to play an active role in teacher guidance. The active role of students can be active in asking questions, explaining the answers to mathematical questions obtained, and transferring the knowledge they have with classmates. This activity will indirectly build the MSC side of students. Thus, it can be concluded that learning the CMI model can improve students’ MSC. This is in line with the 2012 PISA report which stated that Indonesia is a country that has a significant increase in the MSC index.

The analysis continued at the next stage, namely to see the increase in MSC based on students’ PKM categories on each learning factor obtained. Tabulation of data for many students in the class who received CMI learning and experienced changes in MSC conditions based on students’ PKM categories is shown in the following table.

**Table 5. Tabulation of MSC Change of Students Obtaining CMI Learning based on Students’ PKM**

| Initial MSC Type of MSC Categories PKM | Positive MSC | % Final MSC | Negative MSC |
|----------------------------------------|--------------|-------------|--------------|
| Percentage of | Low PKM | Moderate PKM | High PKM | Low PKM | Moderate PKM | High PKM |
| Positive | Low | 6,2 | 0,0 | 0,0 | 0,0 | 0,0 |
| Moderate | 0,0 | 12,5 | 0,0 | 0,0 | 0,0 | 0,0 |
| Negative | Low | 21,9 | 0,0 | 0,0 | 18,8 | 0,0 |
| Moderate | 0,0 | 12,5 | 0,0 | 0,0 | 3,1 | 0,0 |
| High | 0,0 | 15,6 | 0,0 | 0,0 | 9,4 | 0,0 |

Table 5. shows that the increase in MSC of students who received CMI learning occurred in each PKM category. The highest increase in MSC occurred in the low PKM category with a proportion of 21,9%. In addition, an increase in MSC also occurs in students with moderate and high PKM categories. The proportion of MSC increase is 12,5% and 15,6% respectively. Then the data tabulation will be displayed, many students who get conventional learning, who experience changes in MSC conditions based on students’ PKM categories, as follows.
Table 6. Tabulation of MSC Change of Students Obtaining Conventional Learning based on PKM

| Initial MSC | % | Final MSC |
|-------------|---|-----------|
| Type of MSC | PKM Categories | Positive MSC | Negative MSC |
|             | Low PKM | Moderate PKM | High PKM | Low PKM | Moderate PKM | High PKM |
| Positive    | Low     | 8,8        | 0,0      | 0,0   | 0,0        | 0,0     |
|             | Moderate| 0,0        | 11,8     | 0,0   | 0,0        | 0,0     |
|             | High    | 0,0        | 5,9      | 0,0   | 0,0        | 0,0     |
| Negative    | Low     | 0,0        | 0,0      | 0,0   | 5,9        | 0,0     |
|             | Moderate| 0,0        | 5,9      | 0,0   | 0,0        | 41,1    |
|             | High    | 0,0        | 8,8      | 0,0   | 8,8        | 0,0     |

Table 6. shows that the increase in MSC of students who obtain conventional learning only occurs in students with moderate and high PKM categories, with proportions of 5.9% and 8.8% respectively. Different from students who received CMI learning, in the class that received conventional learning, students with low PKM did not experience MSC changes. This shows that based on the PKM category that each student has, the proportion of MSC increase in the class that receives CMI learning is different from the class that has conventional learning.

To find out whether the difference was significant, a test of the difference in N-gain MSC scores was carried out for students who received CMI learning and those who obtained conventional learning. However, the following is given a description of the N-gain score data of students who received CMI learning and students who obtained conventional learning based on PKM.

Table 7. Descriptive Statistics Students’ MSC N-gain Score based on PKM

| Learning Factors | Low PKM | Moderate PKM | High PKM |
|------------------|--------|--------------|---------|
|                  | Mean   | SD           | Mean    | SD     | Mean | SD     |
| CMI              | 0,167  | 0,142        | 0,243   | 0,193  | 0,309| 0,130 |
| Conventional     | 0,023  | 0,052        | 0,060   | 0,110  | 0,116| 0,201 |

Table 7. shows that the biggest differences occur in students with moderate PKM categories. However, an analysis is needed to test the significance of these differences. The prerequisite test is that the normality test is carried out first, with the result that there are data that are not normally distributed, namely groups of students with low and medium PKM. Therefore, hypothesis testing for both groups used the Mann-Whitney U test. Meanwhile, for groups of students who had high PKM they had a normal distribution, so testing hypotheses for that group, using the t-test. The following are the hypotheses and decision criteria.

Hypothesis:

H₀: There were no significant differences between the N-gain MSC scores of students who received CMI learning and those who obtained conventional learning in each PKM category.

H₁: There were significant differences between the N-gain MSC scores of students who received CMI learning and those who obtained conventional learning in each PKM category.

Decision criteria: Rejected H₀ if $\text{Sig.}(2 - \text{tailed}) < \alpha$, by using $\alpha = 5\%$

The following are the results of hypothesis testing of N-gain MSC score data of students.

Table 8. Hypothesis Test Result N-gain MSC Score Data based on Learning Factors and PKM

| PKM Categories | Learning Factors | Sig. Test of Homogenity | Test Statistics Value | Sig. Test of Hypothesis |
|----------------|------------------|-------------------------|-----------------------|-------------------------|
| Low            | CMI : Konvensional| 15,000                  | 0,034                 |
| Moderate       | CMI : Konvensional| 32,000                  | 0,013                 |
| High           | CMI : Konvensional| 0,309                   | 2,326                 | 0,034                  |
Based on Table 8, it was found that in each PKM category, the Sig. < α, so H₀ is rejected, meaning that in each PKM category, there is a significant difference between the increase in MSC of students who get CMI learning and those who get conventional learning. PKM is knowledge that students already have before participating in learning with the CMI model. This knowledge can provide convenience for students in learning the material to be taught by the teacher, on the contrary, without this knowledge students will have difficulty learning the next material [9]. Ausubel's learning theory suggests that meaningful learning occurs when students can connect new phenomena with their prior knowledge and the learning tasks provided must be in accordance with the stages of intellectual development of students [10]. Thus, it can be concluded that PKM affects student learning achievement.

Meanwhile, Marsh, Byrne & Yeung [11] who found that there is a reciprocal effect between academic achievement and academic self-concept, these two variables influence each other, where changes in students’ academic self-concepts can cause changes in academic achievement also vice versa. This research is also reinforced by Marsh & Martin [12] who found that academic self-concepts provide an important role in improving students’ academic achievement. So, it is reasonable to say that PKM affects the increase in student MSC.

Based on the results of the study, the CMI model was able to improve the students' MSC, because the CMI model provided many opportunities for students to play an active role in asking questions, explaining the answers to mathematical questions they obtained, and transferring the knowledge they had with their classmates.

4. Conclusion
The improvement of students’ mathematics self-concept who have learned with the CMI model is better than students who get conventional learning. There were significant differences between the N-gain MSC scores of students who received CMI learning and those who obtained conventional learning in each PKM category. The CMI model provides many opportunities for students to play an active role in asking questions, explaining the answers to mathematical questions they get, and transferring the knowledge they have with their classmates.

References
[1] Adegoke B A 2015 The Big-Fish-Little-Pond Effect on Mathematics Self Concept of Junior School Student in Academically Selective and Non-Selective Schools Journal of Studies in Education 5 2 (Preprints http://dx.doi.org/10.5296/jse.v5i2.7121)
[2] Nagy G et al 2010 The Development of Students’ Mathematics Self-Concept in Relation to Gender: Different Countries, Different Trajectories? Journal of Research on Adolesences 20 2 (Preprints DOI: 10.1111/j.1532-7795.2010.00644.x)
[3] Githua B N and Mwangi J G 2003 Students’ Mathematics Self Concept and Motivation to Learn Mathematics: Relationship and Gender Differences among Kenya’s Secondary – School student in Nairobi and Rift Valley Provinces. International Journal of Educational Development 23 (Preprints: http://library.unesco-icba.org/English/Girls%20Education/All%20Articles/Secondary%20Ed/Students%E2%80%99%20Mathematics%E2%80%93Concept%20and%20Motivation%20to%20Learn%20Mathematics.pdf)
[4] OECD 2013 PISA 2012 Result : Ready to Learn : Student’s Engagement, Drive and Self-Belief III (OECD Publishing)
[5] Marsh H W 2010 The Structure of Academic Self Concept: The Marsh/ Shavelson Model Journal of Psychology 82 4
[6] Delima N, Rahmah M A, and Akbar A 2018 The Analysis of Students’ Mathematical Thinking based on Their Mathematics Self-Concept J.Phys.: Conf. Ser. 1108012104 (doi:10.1088/1742-6596/1108/1/012104)
[7] Delima N 2019 Model Comprehensive Mathematics Instructions untuk Meningkatkan Kemampuan Mathematical Thinking dan Mathematics Self-Concept Siswa (Bandung, Indonesia: Disertasi SPS UPI)
[8] Isiksal M et al 2009 Mathematics Anxiety and Mathematical Self-Concept: Consideration in Preparing Elementary-School Teachers Social Behavior an Personality 37 5
[9] Dick W and Lou C 2005 The Systematic Design of Instructional Third Education (Boston: Pearson)
[10] Harefa A O 2013 Penerapan Teori Belajar Ausebel dalam Pembelajaran Majalah Ilmiah Wastu Dharmawangsa 36
[11] Marsh H W, Byrne B M, and Yeung A S 1999 Causal ordering of academic self-concept and achievement: Reanalysis of a pioneering study and revised recommendations Educational Psycholigist 34 3
[12] Marsh H W and Martin A J 2011 Academic self-concept and academic achievement: Relations and causal ordering British Journal of Educational Psychology 81 1