Improving mathematical understanding and disposition of junior high school students through the 5E learning cycle model

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Abstract. This study aims to determine the increase in the ability of mathematical understanding and the mathematical disposition learned through this model as well as the correlation between the mathematical understanding and the mathematical disposition in mathematics learning. The population of this study was the entire seventh-grade students in one of the junior high schools in Takengon, Indonesia. The two-class samples were randomly selected for the sampling purpose. The 5E learning cycle model was implemented at the experimental class, while the control class was utilized the conventional model. The instrument used to collect the data consisted of two types of tests, namely the mathematical understanding test and the mathematical disposition questionnaires. Based on the t-test analysis, it was found that the increase of the mathematical understanding and disposition of students who learned with the 5E learning cycle model was better than that of those who learned with the conventional model. Additionally, based on the Pearson product-moment correlation-test, it was concluded that there was a correlation between the students' mathematical understanding and their mathematical disposition, with the degree of correlation between them is in the sufficient category. Thus, the application of the 5E learning cycle model could improve students' mathematical understanding and disposition abilities.

1. Introduction

The mathematical understanding is one of the cognitive aspects students ought to acquire in mathematics learning [1]. It is derived from mathematical understanding [2]. It is associated with the individual’s ability to absorb and understand ideas within the mathematical contexts [3]. This ability is considered to be essential for students; a good mathematical understanding will help students to remember, utilize, and reconstruct a concept that has been already learned as well as to solve numerous varieties of mathematical problems and those of others [4]. It can be concluded that the mathematical understanding relates to the level of understanding in which students are capable of comprehending the mathematics itself. In fact, the students' mathematical understanding has not reached the level of optimal. This issue is supported by the research that inferred to the results of the test on the students’ mathematical understanding [5]. It found that the majority of the students had limited mathematical understanding.

Another important aspect, aside from mathematical understanding, that needs to be fortified through mathematics learning in order to ensure its success is the students' attitude and perception towards mathematics. This attitude is called disposition, a characteristic demonstrated by students...
when responding to something in an ideal way [6]. This is in line with the statement which states that disposition shows a tendency to act or behave toward a particular action [7]. However, disposition in mathematics learning is called the mathematical disposition. It relates to the student's behaviour/attitude or way of thinking that develops subsequent to one's habit of utilizing mathematical competencies during his thinking practice when solving a problem [8]. Thus, mathematical disposition talks about the student's concern and attitude when he encounters mathematics learning or mathematical problems. Disposition in mathematics learning should be taken seriously in terms of its development as it can support the success of students’ learning process [9]. This aligns with the statement that a good mathematical disposition results in a strong desire to learn as well as to extend the knowledge students already have [10]. In addition to this, another research also shows that the students' mathematical disposition was still not good enough. It is based on the study that reported that the students' mathematical disposition fell under the category of negative [11]. Another research is in agreement with this study that found that the students' mathematical disposition was still in the moderate category and needs to be improved [12].

To foster the students’ mathematical understanding and disposition, teachers need to decide the appropriate and suitable model of teaching that corresponds with the students’ needs. One of the models believed to be able to develop these abilities is the 5E learning cycle model. A study declares that the 5E learning cycle model is a phase-based model of learning [13]. It is a student-centred learning model [14]. The 5E learning cycle model composed of five phases, namely, engagement, exploration, explanation, elaboration, and evaluation [15]. Each phase is designed in a way that students are actively involved in building and developing their comprehension. There are some advantages of the 5E learning cycle model, namely: 1) encourages students to recall their previous knowledge, 2) helps develop students’ scientific attitudes and their thinking abilities, 3) directs the students’ focus on one problem to support conceptual understanding, 4) develops the students’ potential, 5) trains students to express a concept verbally, and 6) engages students in exploring, expanding and evaluating the concepts [16].

Several studies have been conducted concerning the 5E learning cycle model [17]. The first study showed that the students’ improvements and achievements regarding mathematical communication and disposition were better after the implementation of the 5E learning cycle model than the control group students'. In addition to that, the students' responses to the model implementation were positive. The result of another study [18] agreed that the 5E learning cycle model had a positive impact on the students’ mathematical understanding and connection. A study by [19] also illustrated the same finding that the implementation of the 5E learning cycle model could improve students' comprehension and trigger positive responses. Another research explained that this model could improve students' mathematical communication [20]. Additionally, the teaching-learning process and students' activities were better when this model was implemented compared to those in the classroom with the conventional model. The next study from [21] stated that the implementation of the 5E learning cycle model through metacognitive technique affected the students' critical thinking and creativity as well as their independent learning. However, a similar study that focuses on the implementation of the 5E learning cycle model in order to investigate the students’ mathematical understanding and disposition has not been found yet. Therefore, the research questions in this study are: 1) "Is the development of mathematical understanding and disposition of students in mathematics classroom with the 5E learning cycle model better than that of those in the conventional model of learning and 2) Is there any correlation between the mathematical understanding and the mathematical disposition of students who learned with the 5E learning cycle model?"

2. Method
This is an experimental research that used the quantitative approach. The experimental research is research that tries to seek a particular effect of the treatment under a controlled condition [22]. This study utilized the pre-test-post-test control group design [23]. This design was selected because two groups of samples were involved, namely, the control group and the treatment group.
The population of this study was the entire seventh-grade students in one of the junior high schools in Takengon, Aceh, Indonesia. The students had an average ability in terms of achievement. This school was chosen because it is one of the schools that are open toward innovations of learning; thus, it is easier for the researchers to conduct the research there. The students were randomly selected for the sampling purpose. One class was chosen as the experimental class and the other one as the control class. The experimental class is the Class VII-2 in which the teaching-learning process was performed by implementing the 5E learning cycle model, while the Class VII-4 utilized the conventional model of learning. The conventional model is a learning model that is often used in these schools.

This study used two types of test instruments, namely the mathematical understanding test and the mathematical disposition questionnaire, distributed during the pre-test and the post-test. Essay question was employed for the mathematical understanding test which includes the indicators of mathematical understanding according to [24]; they are: 1) the ability to restate the concepts, 2) the ability to classify objects based on whether the conditions that formulate the concepts are met or not, 3) the ability to apply the concept algorithmically, 4) the ability to provide examples and counter-examples from the concepts, 5) the ability to present concepts in the various forms of mathematical representations, 6) the ability to associate various mathematical concepts, 7) the ability to develop the necessary and sufficient conditions of a concept. Meanwhile, the indicators used to measure the abilities consist of five items adapted from [25]; they are 1) self-confidence, 2) persistence or perseverance, 3) open-minded and flexible, 4) interests and curiosity, 5) monitoring and evaluating. The holistic rubric was used as the scoring guideline for the mathematical understanding, while the Likert-scale items were utilized for the mathematical disposition questionnaire. To test the hypothesis, a statistical analysis of the normality test for the average difference of the test scores was carried out using the t-test, N-gain, and the correlation test.

3. Results and discussion
Data analysis of the pre-test and post-test on the mathematical understanding and disposition for the two classes will be described as follows.

3.1. Students' mathematical understanding ability
Based on the results of the analysis of the pre-test data on the mathematical understanding ability, the experimental class and the control class obtained the average score of 43.74 and 43.62, respectively, with a standard deviation of 19.00 for the experimental class and of 16.18 for the control class. These results indicated that the average score of the pre-test for both classes is the same. The results of the normality test for the two classes revealed that the pre-test data were not normally distributed. The test results of the average difference for the two classes showed that there was no difference between the two classes. Therefore, students' mathematical understanding for both of the classes was homogeneous.

The result of the N-gain normality test also showed that the data on the mathematical understanding of the two classes were not normally distributed. Subsequently, the test for the average difference was carried out by utilizing the Mann-Whitney test with the significant level $\alpha$ at 0.05. The criterion is to reject the null hypothesis ($H_0$) if the p-value is less than alpha ($p < 0.05$) [26].

It can be concluded that the average difference of N-gain test on the students' mathematical understanding had a Sig (2-tailed) value at 0.009. Since the Sig (2-tailed) value was less than the alpha ($\alpha = 0.05$), the null hypothesis ($H_0$) was rejected. To wrap it up, the average of N-gain score on the students’ mathematical understanding in the experimental group was better than that on the control group students. Suffice it to say, the first hypothesis formulated in the study which is “The development of the mathematical understanding of students in the mathematics classroom with the 5E learning cycle model is better than that of those in the conventional model of learning” was accepted. This finding confirmed that applying the 5E learning cycle model in the teaching-learning process influenced the students’ mathematical understanding.
Based on the data analysis of the test on the students’ mathematical understanding, it was found that students who learned using the 5E learning cycle model were better than those who learned with the conventional model. By implementing this model, students were actively involved in developing their own knowledge through discussion, exploration, investigation and problem solving [27]. The 5E learning cycle is a student-centred learning model. It means that students are given the opportunity to develop their knowledge and understanding to perceive a meaningful experience. Thus, the students' role in the classroom is superior to the role of the teacher. Teacher's primary role is as a facilitator to guide students during their learning process. This is supported by [28], who states that teachers are obliged in providing the opportunity for students to build their own understanding.

The results of this study correspond to the study [29], which stated that there were differences in the development of the mathematical understanding of students who learned with the 5E learning cycle model than that of those with the conventional learning model. A study by [30] also agreed with the finding, stating that there were differences on the average of the mathematical understanding between students who learned with the 5E learning cycle model and those with the traditional learning model. Therefore, it can be stated that the students' mathematical understanding taught with the 5E learning cycle model was better than that of those who were taught traditionally. This statement is supported by some studies reporting that the implementation of the 5E learning cycle model promoted students' potential in order to increase their understanding of the mathematical concepts [31,32].

3.2. Mathematical disposition of students
The pre-test data on the mathematical disposition obtained from the questionnaires were changed from the ordinal data into the interval data by using the method of successive interval (MSI). Based on the data analysis, it was found that the average scores for the experimental and control classes are 24.91 and 23.15 with standard deviations at 6.67 and 5.19, respectively. The results of the normality test showed that both of the classes were normally distributed. Meanwhile, the results of the homogeneity test also showed that the data of both classes were derived from the homogeneous population.

Furthermore, the test for the average difference on the mathematical disposition was carried out using the t-test, with a significant level α at 0.05. The criterion test is to reject the null hypothesis \( H_0 \) if the p-value is less than or equal to alpha (\( p \leq 0.05 \)). It can be concluded that the average difference of N-gain test on the mathematical disposition for both of the classes was \( t = 3.821 \) and had a Sig (2-tailed) value at 0.000. Since the Sig (2-tailed) value was less than the alpha (\( \alpha = 0.05 \)), the null hypothesis \( H_0 \) was rejected. Thus, the average of N-gain score on the mathematical disposition of the experimental class was better than that of the control class. Suffice it to say, the second hypothesis formulated in the study which is “The development of mathematical disposition of students in the mathematics classroom with the 5E learning cycle model is better than that of those in the conventional model of learning” was accepted.

The results of this study concluded that the increase in the students' mathematical disposition that took part in the learning process using the 5E learning cycle model was better than that of those who learned in a conventional way. This fact illustrates that applying the 5E learning cycle model in the teaching-learning process increases students' mathematical disposition. Through the learning process with this model, students were given the opportunity to work in groups and to apply or broaden their understanding of the concepts. These findings are supported by the study [33] that stated that the implementation of the 5E learning cycle model promoted students’ potential to increase their mathematical disposition in mathematics learning.

The correlation analysis between the mathematical understanding and the mathematical disposition was calculated using the SPSS 16.0. The correlation analysis between the mathematical understanding and the mathematical disposition of students who learned with the 5E learning cycle model was 0.587, and the value of significance was 0.000; thus, the null hypothesis \( H_0 \) was rejected. As a result, the alternative hypothesis \( H_1 \) which states that “there is a significant correlation between the mathematical understanding and the mathematical disposition of students who learned through the 5E
learning cycle model” was accepted, with the degree of correlation between the two variables was in the sufficient category.

The findings showed that there was a correlation between the mathematical understanding and the mathematical disposition of students who learned through the 5E learning cycle model. This statement is based on the finding of the correlation coefficient value, which is $r > 0$ (the direction of the relationship between the two variables). Thus, there was a positive correlation between the mathematical understanding and the mathematical disposition, which means that the development in the mathematical understanding will be followed by the increase in the mathematical disposition. This finding is supported by the results of the study [34], which states that there was a positive correlation between mathematical understanding and conceptual understanding of students. Another study found a similar finding [36] that the mathematical disposition was one of the factors that influence the success of students’ learning when they are faced with a problem that requires a solution.

4. Conclusion

Based on the data analysis and discussion, it can be concluded that: (1) the development on mathematical understanding and the mathematical disposition of students who learned with the 5E learning cycle model was better than that of those who learned with the conventional learning model; (2) the increase of the mathematical disposition on those who learned with the 5E learning cycle model was better than that on those who used the conventional learning model, and (3) there was a significant correlation between the mathematical understanding and the mathematical disposition of students who learned with the 5E learning cycle model.

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