

The Implementation of 5E Learning Cycle Model by Using Virtual Manipulatives to Improve Students' Understanding Toward Mathematical Objects

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Abstract

The aim of this research is to improve students' understanding in mathematical objects. This research is an action research with 31 eleventh grade students of SMA Parulian 1 Medan as the subject of research. The instruments of this research are the diagnostic and understanding essay test. The reliability of the diagnostic test is 0.77 (high); understanding test I is 0.54 (medium); and understanding test II is 0.43 (medium). The validity of each item in the diagnostic and understanding test are in valid criteria. The results shows that the students' understanding in mathematical objects, those are fact, concept, operation and principle of each are 91%; 92.74%; 75.84% dan 80.65%, and it can be concluded that this research is successful.

Keywords: 5E Learning Cycle Model, Virtual Manipulatives, Understanding toward Mathematical Objects

1. Introduction

The education in Indonesia confronted to the lack of students' achievements in every level. The fact shows that there are so many students argue that mathematics is a difficult subject and they are not interested in mathematics learning. It is caused by the learning that implemented in the classroom still dominated by the teacher (teacher oriented). Suherman et al. (2003) states that the mathematics learning, nowadays, is a conventional mathematics learning that is teacher oriented, in which the students come, sit, watch, practice, go home and forget. The teacher explained the mathematical concepts in ready – made and the task given to the students are routine task. Most of students do not connect the prior knowledge to the new one. The kind of this learning draws that there is no active participation of students to construct mathematical knowledge, which is not appropriate with constructivism.

Model of teaching is a mean which facilitates students – teacher interaction in mathematics learning which is appropriate to the expected learning goals. The results of the inappropriate implementations of model of teaching are the students get bored and make monotonous mathematics learning, thus the students do not pay attention to the learning process. Probability material is one of mathematics content which is taught in senior high school in Indonesia. In order to make it easy to teach, the probability should be contextualized by concrete materials in real life or by using the virtual manipulatives in mathematics learning so that the message could be received by the students. The students can be motivated in learning and eager to learn which improves students' achievements and retention. Furthermore, the students can make the interpretations and connections of the meanings which they could understand by the use of virtual manipulatives.

Based on the observations in Senior High School Parulian 1 Medan, the teacher still use the lecturing method. The mathematics learning is still teacher oriented, that the students are not actively participated in reinvention the mathematical concepts and principles. The students listened, watched and just certain students asked during learning process. The students could not answer the teacher's questions. Furthermore, the student's achievement is lack. It is indicated by the scores of the students' task and homework are low. In addition, the researcher gave the diagnostic test to the students, and based on the results it can be concluded that the number of students achieving the facts is 67.74%; achieving concepts is 41.94%; achieving operations is 35.48%; and achieving principles is 6.45%. That conditions, of course, affect students' achievements. According to the level of students achievement, the number of students in medium achievement level is 19.35%, low is 35.49%; and very low is 45.16%, by the average score is 48.71 (very low). The conclusion is the low of students' achievements is caused by the learning which is not meaningful, that is indicated by the lack of students' participation during learning process which makes students get various difficulties in learning processes, those are the students' difficulties in understanding the facts, concepts, operations and principles that results to the lack of students' achievements.

The problem introduced before need to be solved by the implementation of appropriate model of teaching, that is 5E Learning Cycle model by using virtual manipulatives. The implementation of this model, the students can understand the basic ideas that grounded a concept, know how to find and use the correct concept, and make a conclusion from their observation. It is caused by the 5E Learning Cycle model which is a students oriented model of teaching, that consist of syntax of organized activity so that the students can actively achieve the competences in learning (Ngalimun, 2013). It is appropriate to the Ngohoglu and Yalcin (2006), that they were concluded that 5E Learning Cycle facilitates the students to learn effectively, organize knowledge by meaningful

learning, and give the concepts understanding deeply to the students (Susanti, et al., 2011).

2. Literature

2.1 *Mathematical Objects*

According to Begle, there are four kinds of mathematical objects, those are fact, concept, operation, and principle. Bell argues that the mathematical objects consist of facts, skills, concepts and principles (Siahaan, 2006). Fact in mathematics is a convention, a specific method in expressed mathematical knowledge in words or symbols. Concept is an abstract idea that gives chance to group some objects or situations and to determine whether an object or situation is an example or not according to the abstract idea. Operation is a function which includes one and another mathematical object. Principle is a connection of two or more mathematical objects.

2.2 *Media dan Virtual Manipulative in Mathematical Learning*

In mathematical learning, sometimes, happened a miscommunication. In this case, the content of mathematic can not be accepted by the students optimally, the students cannot understand the content of material well. The worst problem is that the students as the receiver of message mismatch the material given. To avoid this problem, teacher is to arrange the strategy with the use of various media and sources of material (Sanjaya, 2006).

The use of virtual manipulatives causes the abstract concept which is currently studied can be long term memorized as the students learn by doing, not only by memorizing the facts. Therefore, in learning mathematics we often use virtual manipulatives. Elly (in Sanjaya, 2006) states that virtual manipulatives is a learning media which involves the criteria of concept studied. By using virtual manipulatives, thus (a) teaching learning process is motivated; (b) abstract mathematical concept is provided in concrete form; (c) the relation among the abstract concepts and concrete things in environment can be well understood; (d) abstract concepts which is provided in concrete form namely mathematical model form which is used as a research object or as a tool to research new ideas and relation grows more.

2.2 *5E Learning Cycle Model*

Learning Cycle (LC) is a student oriented model of teaching. LC consists of series of organised activities (phases) in order to facilitate the students actively participated in mastering the competences which should be achieved (Ngalimun, 2013). The students' participation in this learning leads to a significant learning which gives deep understanding of topic for students. It is in line with the research conducted by Nuhoglu and Yalcin (2006) who conclude that learning cycle facilitate students to study effectively, organize significant learning, and give deep concept understanding for students (Rahayu, 2010; Susanti, et al., 2011; Ulya, 2011). Açışli, et al. (2011) explained that LC is a model of teaching that gives opportunities to the students to reinvent the concept by their own way or to settle the concept, avoid misconception, and give opportunities to the students in implementing the concept currently learnt.

It has been so many researches by implementing the LC approach that began from 1960s. The research that support the LC approach is studied in detail by Lawson, Abraham, and Renner, and go to the conclusion that LC can be used to improve the students' ability in science, remember a concept well, improve activity in science and their learning, improve the reasoning ability, and better applied than the conventional approach (Abraham & Renner, 1986; Gerber, Cavallo, & Merrick, 2001; McComas III, 1992 in Hanuscin and Lee, 2008). Supporting to the arguments above, some of studies show that LC model of teaching has a better effect on students' concept understanding rather than expository model (Lawson et.al in Hanuscin and Lee, 2008). LC 5E is an inductive approach used in science learning (Renner, Abraham, & Birnie, 1988, in Nuhoglu and Yalcin, 2006). Atkins & Karplus (1962) formulated this LC for Science Curriculum Improvement Study (SCIS) which is continuation from Piaget model (Nuhoglu and Yalcin, 2006). As a curriculum base, LC links to the experience that will be used by the students to reinvent the new knowledge.

LC should be placed forward because it is appropriate with the Piaget's theory (Renner et.al, in Ngalimun, 2013), learning theory which based on the constructivism. Piaget explains that learning is the development of cognitive domain which contains structure, content, and function. Intellectual structure is an organising of high level of ways of thinking to solve the problem. Content is individual behavior in responding the problem faced. Function is an intellectual development process which contains adaptation and organisation (Arifin in Ngalimun, 2013).

Lorsbach states that LC 5E consists of five phases, (a) engagement, (b) exploration, (c) explanation, (d) elaboration/extension, and (e) evaluation (Ngalimun, 2013). Engagemet phase is the first phase in 5E LC. The students' interest and curiosity to the new topic are tried to be awakened. In this phase, the students are motivated to make some predictions about phenomenon that have to be learnt and proven in exploration phase. Engagemet phase in 5E LC included in assimilation process. Exploration is the second phase in 5E LC. The students are given the opportunities to learn together in small groups without the direct learning from the teacher to test the prediction, write down the result of observation and ideas through some activities like mini research and literature review. Explanation is the third phase in 5E LC. The teacher have to motivate the students to explain

the concept by their own words, ask the proof and clarification from their explanation, and direct them to the discussion activity. In this phase the students discover the terms of the concept they learnt. Elaboration/extension is the fourth phase in 5E LC. The students use the concepts and skills in new situation through some activities like the advanced mini research and problem solving. Evaluation is the last phase in 5E LC. The teacher evaluates the effectiveness of the previous phases and the students' competences or concept understanding through problem solving in new context that motivates the students to do the advanced investigation.

The syntax of 5E LC model by using virtual manipulatives in probability is described as following. *Phase I: Engagement.* The teacher builds students' interest and curiosity. In the beginning of the lesson, the teacher explains the goal of learning by emphasizing the connection of the probability to the real life. The teacher gives the example by demonstrating the virtual manipulative. The teacher asks some questions or guides the students to make some predictions about probability that they have to learn which contains of the fact aspect of probability. *Phase II: Exploration.* The teacher facilitates the students to get discussion with his small group, test the prediction by using the virtual manipulative. The teacher gives the Student's Worksheet to facilitate the students in understanding fact, concept, operation and principles in probability. *Phase III: Explanation.* The teacher facilitates the class discussion. The students explain the prediction in the first phase and had discussed with his friends in their small group in second phase. The teacher asks proof and clarification from their explanation, and directs them to discover the terms of the concept they learnt. In order to make it easy, the students guided by the teacher use the virtual manipulative. The students guided by the teacher made the conclusion based on their learning experience. *Phase IV: Elaboration.* The teacher gives a new problem to the students so that the students can use the concept which has been found in the third phase. In this phase, the student did not use the virtual manipulative. *Phase V: Evaluation.* The teacher gives the test to the student, that the students did it individually. The purpose of this phase is to know whether the students' concept understanding had been achieved or not, or to know the students' misconception for the mathematics learning.

3. Research Methodology

This research is an action research which aims to improve the students' understanding in mathematical objects through the implementation of 5E Learning Cycle model by using virtual manipulatives in probability. The subject of this research is 31 students in eleventh grade of SMA Parulian 1 Medan. First data source is taken from the diagnostic test to know students' initial ability and difficulties for mathematics learning. Second data source is based on the understanding test. Statistical test is used to know the validity and reliability of the test. The research procedures consist of (1) planning; (2) carrying out the action and observation; (3) analyzing and interpreting of research data; and (4) evaluating and reflecting.

4. Result and Discussion

Initial observation is done through giving diagnostic test to the students in order to know students' initial abilities and their difficulties during learning. The results of observation are explained in detail as follows. Data obtained in the all cycles is served in the table 1.

Table 1. Level of Students' Understanding toward Mathematical Objects

Percentage	Level	Tes Diagnostic		Cycle I		Cycle II	
		<i>f</i>	%	<i>f</i>	%	<i>f</i>	%
90% - 100%	Very high	-	-	2	6.45%	7	22.58%
80% - 89%	High	-	-	7	22.58%	15	48.39%
65% - 79%	Medium	6	19.35%	14	45.16%	6	19.35%
55% - 64%	Low	11	35.49%	5	16.13%	2	6.45%
0% - 54%	Very low	14	45.16%	3	9.68%	1	3.23%

The implementation of 5E Learning Cycle by implementing virtual manipulatives can increase students' understanding toward mathematical objects on probability material. This is based on post-test in eleventh grade in SMA Parulian 1 Medan. Based on data analysis, it is obtained that the mean score of class is getting higher in each understanding test given. In the understanding test I, the mean gets higher 24.66 than initial test, and in understanding test II gets higher 7.66 than understanding test I (see table 2). It draws that the implementation of 5E Learning Cycle by using virtual manipulatives can increase students' understanding toward mathematical objects on probability material, which is from low becomes medium, and medium becomes high. Besides, it is found that students doing mistakes become less starting from the mistakes in the initial observation or diagnostic test, mistakes during cycle I and mistakes during cycle II.

Tabel 2. The Result of Understanding Test toward Mathematical Objects

Indicators	Pre test	Post test I	Post test II
Students' Percentage understanding fact	67.74	90.00	91.00
Students' Percentage understanding concept	41.94	90.00	92.74
Students' Percentage understanding operation	35.48	64.00	75.84
Students' Percentage understanding principle	6.45	53.70	80.65
Classical Average	48.71	73.37	81.03

The improvement of students' understanding toward mathematical objects can be drawn by determination of average normalized gain ($\langle g \rangle$) by using the formula $\langle g \rangle = \frac{(\%post) - (\%pre)}{(100 - (\%pre))}$, where the angle brackets indicate the class average (Hake, 2008: 498). Based on data analysis, it is obtained that $\langle g \rangle$ value in cycle I and II is 0.481 and 0.630 for each, which means the improvement of students' understanding in cycle I and II is in medium criteria for each. Furthermore, it is obtained some differences between cycle I and II. Here is provided the detail explanation in table 3.

Table 3. The differences between Cycle I and II

	Cycle I	Cycle II
Students' classical achievement	74.19 %	90.32 %
Mean	73.37	81.03
The achievement of mathematical aspects	Operation and principle are not yet well achieved	All aspects are well achieved
Mathematical management criteria	Good	Very good

Data obtained based on the result of research shows that the action done can improve students' understanding toward mathematical objects on probability material and can solve the difficulties faced by the students while teaching-learning process runs.

5. Conclusion and Suggestion

Based on data analysis and observation, it can be concluded that the implementation of 5E Learning Cycle by using virtual manipulatives can improve students' understanding toward mathematical objects in probability material in eleventh grade SMA Parulian 1 Medan. Based on the conclusion, it can be drawn these following suggestions to:

- teachers, are suggested to consider students' understanding toward mathematical objects as understanding on mathematical objects links to students' achievement. Besides, it is necessary to make students actively participated while learning, therefore teachers are suggested to implement 5E Learning Cycle model of teaching by using virtual manipulatives.
- students, are expected to actively participated while learning process runs, such as asking questions, sharing ideas while 5E Learning Cycle is implemented, so that understanding toward mathematical objects can be achieved.
- other researcher, it is suggested to consider the result of this research to implement 5E Learning Cycle by using virtual manipulatives for further research on probability material or other materials.

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