

Discovery Learning Model for Solving System of Linear Equations using *GeoGebra*

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Abstract: In this paper, the authors introduce a discovery learning model to increase students' interest in learning. Software that supports the learning process using this discovery model is *GeoGebra*. This study introduces how to solve system problems in linear equations, both two variables and three variables interactively. From the results of observations as many as 5 times carried out on third grade students in junior high school in Bhayangkari Medan, showed a significant increase in learning interest. The average of student activity at the beginning is 84.04% with good category. While in the main activity, the average of students' activity on (i) contextual understanding is 95.98% with very good category, (ii) Developing mathematical model is 85.14% with good category, (iii) constructing a program is 89.12% with very good category, (iv) interactivity is 96.02% with very good category; (v) interest is 90.84% with very good category. For the final activity, the average of student activity in making conclusion is 94.28% with very good category. Overall, the total average of the observation is 90.77%. This means that the seriousness and interest in student learning has increased.

1 INTRODUCTION

Mathematics has a field of study whose object is abstract. This may be the reason why many people find it difficult to understand the concepts in mathematics. Due to the mathematics become one of the most important subject in the curriculum at the school, while many people are still having trouble then it is necessary to help students to understand the concepts of mathematics. In this era, technology has become an integral part of human life. This is because the benefits provided, in particular in the field of education.

Technology is used as a medium that can assist teachers in learning activities at school, especially in mathematics. For example, when the teacher would sketch geometry. Sometimes teachers will find it difficult to sketch directly. But with the use of technology, issues like that will be easy. In addition, the use of technology in learning mathematics can also be used for some of the following, (Naidoo and Jayaluxmi, 2010).

1. Assist the process of understanding the concept.

2. Help strengthen students' memory about the concepts.
3. Increase student interest and appreciation of the concepts that has been learned.

Technological developments quickly become one focus of which will be developed in the curriculum 2013. One of the principles of learning in the curriculum 2013 is the utilization of information and communication technologies to improve the efficiency and effectiveness of learning. In other words, technology should be integrated in each learning and the technology used must also be adapted to the situation and learning conditions. For that teachers are expected to use technology to support math learning activities so that the learning environment becomes active and fun. In this study, the authors use a computer as a learning medium. The use of computers as a medium of learning in mathematics aims to support students in understanding the concepts in mathematics.

The computer program used in this study is *GeoGebra*. *GeoGebra* developed by Markus Hohenwarter in 2001. (Chrysanthou, 2008) revealed that *GeoGebra* influences the educational practice in

three dimensions, namely: classroom practice, cognitive development and learning attitudes. Correspondingly, Ali Gunay Balim (2009) revealed that *GeoGebra* is able to present an overview so that students can understand the material. Use of *GeoGebra* is very easy. Given interface makes the students more interested in the subject presented by the teacher.

2 DISCOVERY LEARNING MODEL

Discovery learning model is defined as a learning process that occurs when students are not presented with a lesson in its final form, but is expected to organize themselves. It is more emphasis on the discovery of concepts or principles that were previously unknown.

In applying the discovery learning model, teachers act as mentors by providing opportunities for students to learn actively, the teacher should be able to guide directly the learning activities of students in accordance with the purpose. Conditions such as these will change the teaching and learning activities from teacher-oriented to student oriented. The following are the phases in the discovery learning model:

1. Stimulation. Teachers raise the question or ask the students to read or hear a description that includes the issue.
2. Problem Statement. The students were given the opportunity to identify problems and formulated in the form of a question or hypothesis.
3. Data Collection. To answer a question or to prove the hypothesis, the students were given the opportunity to collect data and information needed.
4. Data Processing. Event processing data and information has been obtained by the students, and then interpreted.
5. Verification. Based on the results of processing and Opera-existing hypotheses formulated question should be checked beforehand. Can it be missed or well proven that the results are satisfactory.
6. Generalization. In this last phase the students learn to draw certain conclusions and generalizations.
Illahi (2012).

A basic concept of discovery learning is that teachers should facilitate instruction that allows students to discover predetermined outcomes

according to the level of learning required by the curriculum 2013, Mandrin and Preckel (2009). Hopefully, students will pose relevant questions such as "what if the variables is fewer than the system?" or "what if the coefficient is the multiple of other systems?" Discovery learning allows for deeper thought into the subject.

As an introductory activity, the teacher, acting as facilitator, should prompt students to recall knowledge and experiences from previous lessons, and encourage student participation. The teacher should then guide students in applying already existing knowledge to new information to construct deeper levels of meaning and understanding. This gives students an active opportunity to apply what they already know about the topic to the new situation, (Schunk, 2008).

After introducing the purpose of the lesson, the teacher describes the materials that will be used in the experiment and then models the actions and procedures for the students, GTC (2006). Students begin the actual lesson by asking questions, guided by the teacher prompts, and then try to guess at possible right answers.

3 SYSTEM OF LINEAR EQUATIONS

In mathematics, a system of linear equations is a group of two or more linear equations that involving the same set of variables. For an example, The following is a linear system of three equations consisting of three variables

$$\begin{aligned} 4x - 2y - 3z &= 6 \\ 5x + 3y - 4z &= 2 \\ -x - y + 2z &= 0 \end{aligned} \quad (1)$$

A unique solution to that linear system is an assignment of values to the variables such that all the equations are simultaneously satisfied. A solution to the linear system above is given by $x = 1$, $y = -1$, $z = 0$. since there's no other solution, the solution is said to be unique solution. Since the solution set value of (x, y and z) of this problem is satisfy the equation, the word system indicates that all the three equations are to be considered collectively, rather than individually indeed.

The role of technology will be needed in solving the problem of linear systems that have many equations. The theory of linear systems is the basis and a fundamental part of linear algebra. Computational algorithms for finding the solutions

are an important part of numerical linear algebra, and play an important role in computer science, economics, engineering, physics and also chemistry. Solving a problem computationally will be even better if able to provide a visual solution. So that, students' interest in lessons will increase.

The following is one of three possibilities of the solution set in the linear system:

1. It has infinitely many solutions.
2. It has an unique solution.
3. It has no solution.



Figure 1: Solution set of linear System.

3.1 General Behaviour of System of Linear Equations

A linear equation system is determined by the relationship between the number of equations and the number of variables. The following is one of three possibilities of a common problem.

1. A system with more variables than equations has infinitely many solutions, but it may have no solution. It is also known as an underdetermined system.
2. A system with the same number of variables and equations has a single unique solution.
3. A system with fewer variables than equations has no solution. It is also known as an over-determined system.

In the first case, the dimension of the solution set is usually equal to $n-m$, where n is the number of variables and m is the number of equations. Figure 2 illustrate this trichotomy in the case of two variables.

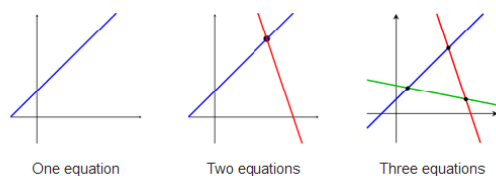


Figure 2: Trichotomy of solution of linear system with two variables.

3.2 Solving Linear System using GeoGebra

There are some methods that can be use to solving a linear system, such as: elimination, substitution, crammer's rule, row reduction and etc. However, this study introduces GeoGebra as a tool for solving linear system.

Figure 3: GeoGebra interface of linear equation system with two variables.

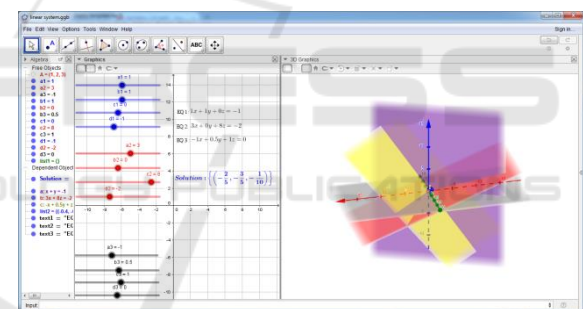
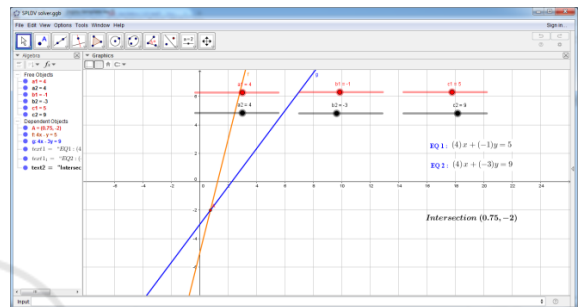


Figure 4: GeoGebra interface of linear equation system with three variables.

With the help of *Geogebra*, students' curiosity will be well stimulated. It is because *GeoGebra* is able to provide visualization of the given problem. So that students no longer have difficulties in understanding the concept of linear equation system problem.

Students will be able to immediately know the relationship between coefficients and equations to the solution of the problem. This is because the program created authors interactively. Students can change the coefficient and constant values in the equation by moving the slider, and simultaneously also can see the shift of the curve formed. Thus, students are expected to further understand the concept of linear equation system problems.

4 OBSERVATION RESULT

Observations were carried out 5 times for third grade students in junior high school in SMP Bhayangkari Medan. The following is an analysis of the results of observation of student learning improvement using discovery learning model with *GeoGebra*.

Based on Table 1, it can be seen that the average of student activity at the beginning is 84.04% with good category. While in the main activity, the

average of students' activity on (i) contextual understanding is 95.98% with very good category, (ii) Developing mathematical model is 85.14% with good category, (iii) constructing a program is 89.12% with very good category, (iv) inter-activity is 96.02% with very good category, (v) interest is 90.84% with very good category. For the final activity, the average of student activity in making conclusion is 94.28% with very good category.

Table 1: Students' learning improvement.

Category of Observation		Activity Observation					Average (%)	Category of Assessment
		Session						
Phase of Activity	Indicator	1	2	3	4	5		
		Score (%)						
Beginning	Preparation	68.6	71.4	85.7	94.3	100	84.04	Good
Main	Contextual Understanding	85.7	97.1	97.1	100	100	95.98	Very Good
	Developing a Math Model	82.9	80	91.4	85.7	85.7	85.14	Good
	Constructing a Program	71.4	80	97.1	100	97.1	89.12	Very Good
	Interactivity	85.7	97.2	97.2	100	100	96.02	Very Good
	Interest	80	85.7	91.4	97.1	100	90.84	Very Good
Closing	Making Conclusion	85.7	94.3	94.3	97.1	100	94.28	Very Good
Total Average of Observation							90.77	Very Good

From the explanation it can be concluded that the application of discovery learning model on solving linear equation system using *GeoGebra* is very helpful for students to better understand the concept of lesson. In addition, students' interest in mathematics will increase as well. Overall, students have a good improvement from all aspects.

5 CONCLUSION

As discussed in this paper, it can be concluded as follows:

1. Discovery learning model is very helpful for students to understand the concept, build self-confidence, and able to improve students' learning ability well.
2. From the results of observations five times, it can be concluded that the use of *GeoGebra* in discovery learning models, especially in learning systems of linear equations, can help increase students' interest in learning. This can be seen from the total value of the average observation is 90.77%.

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