

# Application of Discovery Learning Model for Solving System of Linear Equations Using GeoGebra

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## Abstract

This study aims to determine the mathematical problem solving ability of students to the issue of system of linear equation using GeoGebra. The author introduces a discovery learning model to introduce students in order to create interest in students towards mathematics problems. As the result, students' interest towards mathematics, especially on the topic of system of linear equations was increasing.

## INTRODUCTION

Mathematics has field of study whose object is abstract. This may be one reason why many people find it difficult to understand the concepts in mathematics. Due to the mathematics become one of the most important lessons 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 benefit provided, in particular in the field of education. Technology is used as a medium that can assist teacher 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 student's 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, each 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.

## 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 the 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 existing hypothesis formulated question should be checked beforehand. Can it be missed and well proven that the result are satisfactory.

6. **Generalization.** Illahi (2012), In this last phase the students learn to draw certain conclusions and generalizations,

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). Student begin the actual lesson by asking questions, guided by the teacher prompts, and then try to guess at possible right answers.

### SYSTEM OF LINEAR EQUATIONS

In mathematics, a system of linear equations (or linear system) is a collection of two or more linear equations involving the same set of variables. For example,

$$\begin{aligned} 3x + 2y - z &= 1 \\ 4x + 3y + 4z &= -2 \\ -x + \frac{1}{2}y + z &= 0 \end{aligned}$$

is a system of three equations in the three variables  $x, y, z$ . A solution to a linear system is an assignment of values to the variables such that all the equations are simultaneously satisfied. A solution to the system above is given by  $x = 1/3, y = 2/3, z = 2/3$ .

Since it makes all three equations valid. The word "system" indicates that the equations are to be considered collectively, rather than individually.

In mathematics, the theory of linear systems is the basis and a fundamental part of linear algebra, a subject which is used in most parts of modern mathematics. Computational algorithms for finding the solutions are an important part of numerical linear algebra, and play a prominent role in engineering, physics, chemistry, computer science, and economics. A

system of non-linear equations can often be approximated by a linear system, a helpful technique when making a mathematical model or computer simulations of a relatively complex system. Very often, the coefficients of the equations are real or complex numbers and the solutions are searched in the same set of numbers, but the theory and the algorithms apply for coefficients and solution in any field. For solutions in an integral domain like the ring of the integers, or in other algebraic structures, other theories have been developed, see Linear equation over a ring. Integer linear programming is a collection of methods for finding the "best" integer solution (when there are many). Grobner basis theory provides algorithms when coefficients and unknowns are polynomials. Also tropical geometry is an example of linear algebra in a more exotic structure.

A solution of a linear system is an assignment of values to the variables  $x_1, x_2, \dots, x_n$  such that each of the equations is satisfied. The set of all possible solutions is called the solution set.

A linear system may behave in any one of three possible ways:

- The system has infinitely many solutions.
- The system has a single unique solution.
- The system has no solution.



Figure 1: Solution set of linear System

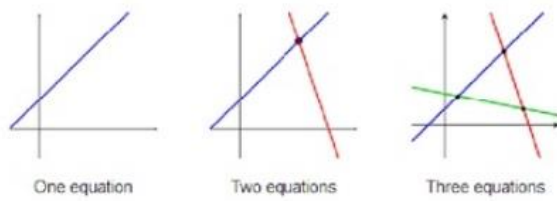
### General behaviour of system of linear equations

In general, the behaviour of a linear system is determined by the relationship between the number of equations and the number of unknowns:

- Usually, a system with fewer equations than unknown has finitely many solutions, but it may have no solution. Such a system is known as an underdetermined system.
- Usually, a system with the same number of equations and unknowns has a single unique solution.
- Usually, a system with more equations than unknowns has no solution. Such a system is also known as an overdetermined 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.

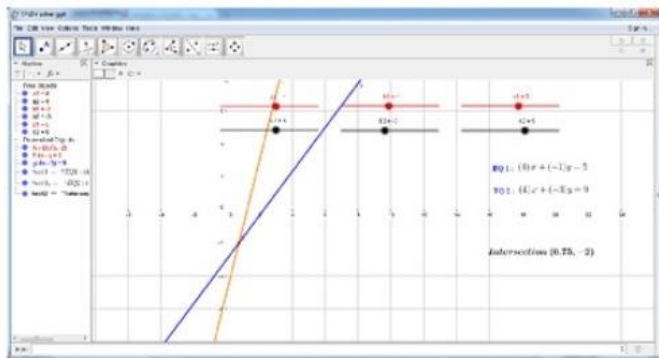
The following pictures illustrate this trichotomy in the case of two variables:



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

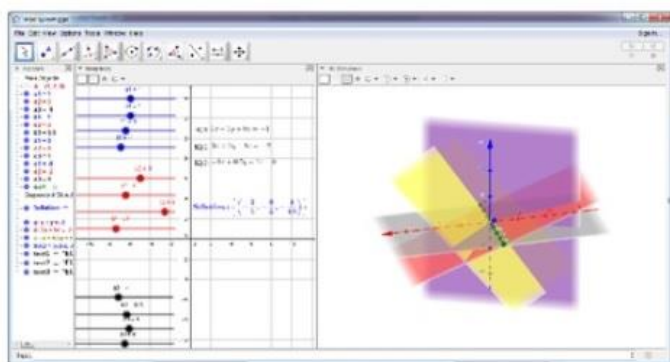
### Solving linear system using GeoGebra

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 introducesd GeoGebra as a tool for solving linear system.



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

With the help of GeoGebra, student's curiosity will be well stimulated. This 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.



**Figure 4:** GeoGebra interface of linear equations system with three variables

Students will be able to immediately know the relationship between coefficient 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.

### OBSERVATION RESULT

The following is an analysis of the results of observation of student learning improvement using discovery learning model with GeoGebra application.

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) make 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.

**Table 1:** Students' learning improvement

Phase of Activity	Category of Observation	Activity observation					Average (%)	Category of Assessment
		Session						
		1	2	3	4	5		
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

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

### CONCLUSION

As discussed in this study, 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's learning ability well.
2. Computer learning media is very well applied in the learning of mathematics so that students can see visually the form of various problems.

3. GeoGebra is an interactive application that is able to help students to understand concepts, able to increase student's curiosity towards various mathematical problems, and able to explain various possible alternatives through visualization shown by GeoGebra

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