

LEARNING SYSTEM OF LINEAR EQUATIONS WITH APTITUDE TREATMENT INTERACTION MODEL FOR VOCATIONAL HIGH SCHOOL

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ABSTRACT

This project aims to employ the aptitude treatment interaction model in the teaching system of linear equations as an alternative learning approach for high school students pursuing vocational careers. Instructional design was utilized to develop the learning model. An essential aspect of applying the aptitude treatment interaction model to learning design is the analysis of student requirements. Learning outcomes and performance goals are thoughtfully considered and aligned with instructional objectives. The findings suggest that educators should utilize the aptitude treatment interaction model when teaching systems of linear equations. The effectiveness of the learning model depends on how well it is tailored to the student's abilities.

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INTRODUCTION

The System of Linear Equations with Three Variables (SLETV) is one of the subjects taught at the 10th-grade vocational school level. The problems presented in this context are highly relevant to everyday life. They are often framed as word story problems, contributing to the perceived high level of difficulty in this topic (Dewi & Kartini, 2021). The frequency of errors students make when solving contextual problems related to the linear problem system reflects the challenges students encounter. Mistakes often originate during mathematical modeling, where students struggle to determine the appropriate method to address the problem. This issue becomes evident when they perform arithmetic operations using methods such as substitution or elimination (Supartinah & Hidayat, 2021). Additionally, some students memorize the completion steps without comprehending the underlying process, leading to further challenges (Rita et al., 2021).

A study conducted at one of the vocational schools in Mataram, Indonesia, revealed a remarkably low level of student success in solving systems of linear equations (Indrawati et al., 2019). Factors contributing to errors in students' responses to word problems include their mental abilities, such as a lack of understanding of the given information and questions in the problem, an inability to transform inquiry sentences into numerical models, a limited grasp of variables, and an insufficient understanding of solution techniques. These errors are also influenced by students' learning styles and environmental factors (Baskorowati, 2021).

Considering the identified challenges in the learning process related to systems of linear equations, there is a need for appropriate means to develop effective learning designs, especially at the vocational high school level. Preliminary research indicates that vocational school students exhibit a very low ability to solve problems within the system of linear equations. Addressing this issue requires exploring applying the aptitude treatment interaction model to linear equation systems material, aiming to make learning and teaching activities more meaningful and the presented material easily understandable for students.

The novelty of this research lies in developing a learning design using the aptitude treatment interaction model for vocational school students, focusing specifically on the subject of systems of linear equations. The term "learning design" represents a common approach to determining strategies for realizing student changes and abilities in the desired direction (Kurniawati, 2021). This article's selected material is confined to systems of linear equations, with a particular emphasis on designing mathematics learning subjects at

the vocational school level by applying the aptitude treatment interaction model. The choice of developing learning designs aims to facilitate teachers in executing each learning activity through structured planning, ensuring that the final learning goals are achieved, and students engage in meaningful learning. This study aims to explore how to design mathematics learning on the subject of systems of linear equations at the vocational high school level by applying the aptitude treatment interaction model.

Aptitude Treatment Interaction (ATI)

The Aptitude Treatment Interaction (ATI) learning model is a collaborative learning method developed by Slavin (Serlina & Leonard, 2020). The aptitude treatment interaction learning model is widely used to improve students' abilities. It is a learning model applying several effective learning strategies for students according to their abilities (Syafuruddin, 2005). Furthermore, the aptitude treatment interaction learning model is a learning model using certain effective treatments given to students depending on the student's individual ability level (Pirayanti, 2012; Fuchs, Schumacher, Sterba, Long, Namkung, Malone, & Chagas, 2014 in Saregar et al., 2017). Students' previous knowledge plays a role in compensating for deficiencies in teaching (Mayer and Sims, 1994 in Lehmann et al., 2016). The aptitude treatment interaction learning model shows that learning outcomes will be optimal if the instructions or treatment are adjusted to the student's talents.

In its application, ATI places greater emphasis on providing different treatments in learning; the treatment given is adjusted to the characteristics of each group of students, and with this grouping, it is hoped that it will produce optimal learning outcomes (Fitri, 2017). A teacher who applies the ATI model will try to find a treatment method that suits the differences (abilities) in students' abilities; namely, the treatment is applied optimally to students with different ability levels (Pamungkas & Afriansyah, 2017). Aptitude treatment interaction is a concept or model that includes several effective learning (treatment) strategies used for certain individuals based on their abilities.

The ATI model includes several learning strategies that aim to develop effective learning conditions for students with different ability groups, especially high, medium, and low ability groups (Kusumawati & Ruslan, 2016). Effective learning is needed to increase student creativity (Yeh & Lin, 2015). It was also explained that aptitude treatment interaction is used to optimize academic achievement, thereby creating a reciprocal relationship between the academic achievement achieved by students and the learning

conditions in the class (Herlina, 2015). Cronbach (1983:249) said that ATI tries to seek and find appropriate treatment for students with different abilities, where optimally effective treatment is applied to students who have different levels of ability.

During the learning process, the ATI model will create learning conditions that suit students' abilities. The ATI learning model includes several effective treatments for students based on each student's ability level (Saregar et al., 2017). To understand ATI as a whole, we need to understand one by one the meaning of talent, namely the abilities possessed by students, treatment, namely the learning given to students, and interaction as a service, or a form of motivation for students (Dirga, et al., 2019). Students' initial knowledge is a compensator to determine students' initial abilities before starting learning. A teacher's understanding of each student's initial abilities is paramount because, starting from this, a teacher can know the learning models that can be applied in learning activities so that the expected learning goals can be achieved, especially the goal of overcoming each student's difficulties in solving problems related to the system of linear equations.

METHOD

This study employed development research with learning design referring to the Instructional Development Model (MPI). The design was chosen because it is expected to address learning problems systematically by planning the learning materials and activities to be implemented, the use of learning resources, and the evaluation. The mathematical lesson plan was developed with a focus on the system of linear equations and adapted to the learning objectives to be used as a guideline for achieving success in mathematics.

RESULT AND DISCUSSION

This learning design was developed for Year 10 Vocational High School students. Preliminary research revealed a deficiency in most students' mathematical skills regarding systems of linear equations. This deficiency stems from students' preference for vocational subjects over general mathematics. The study of the mathematical equation system is a requisite for Year 10 Vocational High School students, emphasizing the need for a solid understanding and proficiency in solving problems related to the system of linear equations-three variables. While comprehension of concepts related to systems of linear equations is crucial for Vocational High School students, the reality falls short of optimal. Often, students merely memorize procedural steps without grasping the underlying meaning of the process (Rita et al., 2021). As discussed in the previous section and supported by the findings of previous researchers, students frequently struggle to

understand the given information, the questions posed, the transformation of sentence structures, the concept of variables, and the methods employed to answer questions related to systems of linear equations (Baskorowati, 2021).

Given the importance of linear equation learning systems and students who still have difficulty understanding the material, it is necessary to develop a learning model that includes several learning strategies by developing the following conditions: effective learning conditions for students with different skill groups: high, medium, and low (Kusumawati & Ruslan, 2016). The effective learning model that focuses on students' abilities is the ATI learning model, which contains several effective treatment methods applied to students based on their level of ability (Saregar et al., 2017). It is one of the effective learning models applied especially to the system of linear equations in vocational secondary schools because it focuses on providing effective solutions. The different treatment methods and the treatment given are adapted to the characteristics of each student group, so this grouping is expected to produce optimal learning outcomes (Fitri, 2017). The learning design developed in this study includes designing mathematical learning on systems of linear equations by applying the aptitude treatment interaction model. This learning aims to enable students to solve problems related to systems of linear equations. A summary of the activity plan of aptitude treatment interaction model application to design the learning material of the linear equation with the topic of the three linear variable equations for Year 10 is presented in Table 1.

Table 1: Learning design of linear equation system using aptitude treatment interaction model

Core activities	
1.	Students are divided into discussion groups with heterogeneous abilities based on assessments obtained at the pre-test. Students who meet high standards of creative thinking will be selected as tutors for other students. Students with average abilities will benefit from conventional learning as usual. In contrast, students with low criteria of creative thinking will be given homework and asked to observe and summarize the material to be discussed by providing a learning video link on the topic.
2.	Teachers guide students on the system of linear equations (two and three variables with a graphic method).
3.	Students watch a video learning how to use the GeoGebra application to determine the solution from SLETV, and students observe the linear system of equations on the student worksheet provided. They are invited to explore and solve the given issues based on the instructions of the student worksheet in groups.
4.	The teacher observes students and allows them to ask about problems they do not understand.
5.	Students of each group present the results of the discussion. Students of the other groups give their opinions, and the teacher gives reinforcement.

Learning Objectives

A series of learning objectives developed in dealing with linear equation systems, namely:

3.1.1 Recall the linear equation concept of two variables well.

3.1.2 Explain the various methods of solving linear equation systems correctly.

- 3.1.3 Describes solution for Systems of Linear Equations-Two variables using graphical methods accurately.
- 3.1.4 Describe for Systems of Linear Equations-Two variables using combination methods accurately.
- 3.1.5 Associates the understanding of the solution of a three-variable linear equation system based on an accurate understanding of a solution of Systems of Linear Equations-Two variables.
- 3.1.6 Modeling the problem presented into the Systems of Linear Equations-Three variables accurately.
- 3.1.7 Solving problems related to Systems of Linear Equations-Three variables.

Learning objectives were employed to assess students' learning outcomes. The objectives formulated for this learning design facilitate the observation of various ways students explain and apply the material during the learning process. Additionally, they allow for assessment based on the level of understanding exhibited by students.

Applying an aptitude treatment interaction model will help develop students' understanding to reach their learning goals. The teaching-learning phase refers to the aptitude treatment interaction model, involving the provision of initial processing to encourage the development of student's creative thinking skills (Maskur et al., 2020). In addition, in the learning model aptitude treatment interaction, students will be grouped, and then teachers will perform therapeutic monitoring depending on each student's ability level. This is in line with Cronbach's (1983) view that ATI is trying to find appropriate treatment methods for students with different abilities, where the treatment method is effectively applied to students with different levels of ability.

How Learning Outcomes Support Every Objective

The following explains the relationship between the purpose of learning and the outcome. The learning activities on Systems of Linear Equations using the aptitude treatment interaction model are presented with the following steps.

1. Students can recall pre-conditional material (Systems of Linear Equation-Two Variables)

First, the teacher initiated the treatment by having the students review the material through a pre-test. Afterward, the teacher motivated the students by presenting the pre-test results and offering learning inspiration. Next, the students were reminded of the pre-requisite material through a presentation on the PowerPoint

slide. At this stage, teachers gathered data about the students' initial abilities, enabling them to provide follow-up treatment tailored to each student's ability level.

2. Describes the completion of Systems of Linear Equation-Two Variables using the graphical method

The subsequent activities involve students being grouped into discussion groups with heterogeneous abilities. Students with a high level of creative thinking were selected as peer tutors for other students. Those with average abilities benefited from regular or conventional learning as usual. Meanwhile, students with low creative thinking criteria were assigned homework and asked to observe and write a summary of the material to be discussed, providing a video learning link on the topic. Then, the teacher directed the participants to learn about Systems of Linear Equation-Two Variables using graphical methods. At this stage, there was also an interaction of question and answer between the teacher and the students until the concept of Systems of Linear Equation-Two Variables is understood, enabling students to build knowledge more easily. The model represents a problem necessary for problem-solving, serving as a "bridge" of longitudinal mathematical activity (Rahmawati, 2013).

3. Solving problems related to Systems of Linear Equation-Three Variables

Once students understand the concept of Systems of Linear Equation-Two Variables and the use of graphical methods in solving the system of linear equations, the teacher guided the students to understand the System of Linear Equations-Three Variables. The students watched a learning video about using the GeoGebra application to solve problems related to Systems of Linear Equation-Two Variables. They can apply the knowledge they have acquired to solve the problem presented.

Learning Instruction and Evaluation Activities

Proper learning development is done by detailing the teaching and evaluation processes (Roubides, 2015). Both are important to develop because, with good planning, teachers can carry out the learning well. Learning activities are more directed so they can be conducted according to the learning objectives. This article adopted the latest educational approaches, particularly the nine Gagne facts and general guidelines consistent with the educational model.

Instruction Activity

Brown and Green's Teaching Activity (2011) explained the importance of ordering teaching activities to create effective teaching, as proposed by Gagne. The teaching framework proposed by Gagne provides a series of well-organized and sequential processes and supports the possibility of implementing a good teaching process. For learning activities to be successful and effective (Good and Brophy, 1990), below are the nine steps of Gagne's pedagogy that the authors have modified to fit a student-centered approach better. Simultaneously, they support a cognitive constructivist approach to learning and teaching. An adaptation of Gagne's original nine-step guide is described as follows.

1. Attracting students' attention from the beginning, ensuring they are ready to learn, and encouraging them to participate throughout the learning process.
2. Informing students about learning goals and asking them to think about how learning goals can be achieved and why those goals are important to them.
3. Exploring previous knowledge.
4. Discussing the content of the lesson.
5. Facilitating student learning through discovery methods and enhancing their metacognitive skills.
6. Providing an opportunity to apply the concepts and skills learned in practice.
7. Giving me the appropriate feedback.
8. Evaluating student learning outcomes.
9. Improving the observance and transfer of science is the ultimate goal of educational activities, i.e., the concepts and skills learned can be applied to similar situations outside the classroom.

Learning Evaluation

Formative and summative evaluation are the tools used to evaluate teaching. Each step in the revised nine-step Gagne teaching method can provide an opportunity for formative assessment (Roubides, 2015). Summary assessment measures student abilities, such as conducting a quiz about a particular learning goal and seeing if the student has achieved the goal.

Formative Evaluation

Formative evaluation is a process of collecting data and information to improve teaching effectiveness. Formative assessment is undertaken as a constructive process

without making decisions. However, it becomes necessary to determine whether the teaching is effective at some point. To reach that conclusion, a summary assessment is required. Through formative assessment, the teacher can examine how well his/her students master the material (Aji, 2016). The formative evaluation that can be applied in this learning design includes assessing students' completion of worksheets, evaluating students' performance in discussion activities, appraising students' ability to present discussion results, and assessing students' cooperation in the learning process. The following is an example of a problem on the student worksheet for formative assessment.

Table 2 Examples of questions on Student worksheet: Students are asked to find solutions to the problems presented

Problem:

Adi, Budi, and Citra bought some stationary in the school shop. Adi bought 2 notebooks, 1 pencil, and 1 pen at the price of Rp. 15,500,00. Budi bought 2 pencils and 1 pencil for IDR. 10,000,00. Citra purchased 1 book and 1 Pencil for IDR. 8.000,00. If the capital of the school shop to sell 1 writing book, 1 Pencil, and 1 Pen is IDR. 9.500,00. Then determine the profit obtained by the cooperative from selling 1 book, 1 pen and 1 pencil!

Summative Evaluation

Summary evaluation is collecting data and information to decide the achievement of a planned learning objective. Through summary evaluation, a learning design that is the basis of the decision of evaluation based on the effectiveness and efficiency in the teaching and evaluation of learning activities (Aji, 2016). Summary evaluation is directed at the success of achieving the goals set at the beginning, as demonstrated by the student's performance. If all objectives have been achieved, the effectiveness of implementing a particular subject learning activity is considered successful. Similarly, if student success is achieved within a relatively short period, then learning efficiency can be achievable.

Below are examples of summary assessments to assess the understanding of the system of linear equations and their relationship to the objectives and learning outcomes.

1. Recalling the concept of the system of linear equations-two variables by mentioning the variables provided.

Write the variables in the following system of linear equations:
$$\begin{cases} 3m + 5n = 15 \\ 6m + 10n = 30 \end{cases}$$

2. Explaining the number of methods that can be used in solving system of linear equations. Describing the method that can be used to solve problems related to the system of linear equations.
3. Determining the solution of the system of linear equations using the Graphic Method.

Determining the solution of the following system of linear equations-two variables

using the GeoGebra application:
$$\begin{cases} p + q = 8 \\ p - q = 4 \end{cases}$$

4. Determining the solution of the system of linear equations using the Combined Method.

Susi bought 2 kg of oranges and 3 kg of mango for IDR. 85,000, while Sari bought 1 kg of Oranges and 2 kgs of manga at IDR. 50,000.

5. Creating a mathematical model of the problem presented and determining the appropriate solution to solve the problem.

Asep has several sticks with three sizes: size a, size b, and size c. Asep aligns 3 sizes a, 2 sizes b, and 1 sizes c with a length of 390 cm. Write down the measurement in the mathematical equation and determine the method to determine the length of the three available sticks!

6. Determining the solution of the system of linear equations-three variables

Determining the solution of the following system of linear equations-three variables:

$$\begin{cases} a + b + 2c = -9 \\ 2a - b + c = -3 \\ 2a = b \end{cases}$$

CONCLUSION

Through the early stages of analysis, development, and evaluation, it is evident that the system of linear equations is one of the compulsory subjects for vocational secondary school students. The application of the aptitude treatment interaction model in developing the mathematical understanding of Year 10 students on system of linear equations-three variables was carried out in several stages. First, the teacher administered a preliminary treatment in the form of a pre-test to measure the initial ability of the student, which was then used to group the students in the second stage. Second, the students were grouped according to their creative thinking ability. The grouping of students is a crucial step because if the teacher makes a mistake in grouping the students, the treatment given would be inappropriate and meaningless. Third, the teacher conducted teaching or therapy based on students' abilities: students with high creative thinking were selected as peer tutors for other students; students with average abilities benefited from regular or conventional learning; students with low creative thinking criteria were given homework and asked to observe and write a summary of the material to be discussed by providing a learning video link on the topic.

The context used in each activity helps students in solving a given problem. The student's mathematical understanding develops according to student construction, which results in each learning activity using an aptitude treatment interaction model. Interactivity is well-embedded, which is demonstrated in the discussion activities.

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