


## Reviving Algebra: Enhancing Student Outcomes Through Discovery Learning in Secondary Education

Muhamad Saleh<sup>1\*</sup>, Khairul Asri<sup>2</sup>, Nova Vembera<sup>3</sup>

Universitas Serambi Mekkah, Aceh, Indonesia

msalehginting@gmail.com<sup>1\*</sup>; khairul.asri3@gmail.com<sup>2</sup>; Shafaboby@icloud.com<sup>3</sup>

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### ABSTRACT

Many students struggle to understand mathematics due to its abstract nature, particularly in algebraic operations. This difficulty often leads to disinterest and passive learning behaviors, negatively impacting academic outcomes. Addressing this urgent challenge, the current study investigates the effectiveness of the Discovery Learning model in improving student learning outcomes in algebra. Using a quantitative pre-experimental design, data were collected from 60 eighth-grade students at SMP Negeri 14 Banda Aceh through tests, observations, and interviews. The findings indicate that the Discovery Learning model significantly enhanced students' understanding and engagement. Statistical analysis confirmed a notable improvement in learning outcomes, with  $t(29) = 5.92 > t\text{-table} = 2.05$ , indicating the model's positive effect at a 5% significance level. Moreover, the model fostered students' critical thinking, collaborative problem-solving, and peer learning, as evidenced by teacher and student interviews. This study contributes to the growing body of research supporting student-centered instructional strategies and offers practical insight into implementing Discovery Learning in mathematics education. The novelty lies in applying this model to abstract algebraic material in a secondary school context, demonstrating that it not only improves comprehension but also stimulates student motivation and classroom participation. These findings underscore the need to shift from traditional to active learning models to meet students' cognitive and emotional needs effectively.

**Keywords:** Discovery Learning, Middle School, Algebraic Operations

### ABSTRAK

Banyak siswa yang kesulitan memahami matematika karena sifatnya yang abstrak, terutama dalam operasi aljabar. Kesulitan ini sering kali menyebabkan kurangnya minat dan perilaku belajar pasif, yang berdampak negatif pada hasil akademis. Untuk mengatasi tantangan yang mendesak ini, penelitian saat ini menyelidiki efektivitas model Discovery Learning dalam meningkatkan hasil belajar siswa dalam aljabar. Dengan menggunakan desain pra-eksperimental kuantitatif, data dikumpulkan dari 60 siswa kelas delapan di SMP Negeri 14 Banda Aceh melalui tes, observasi, dan wawancara. Temuan menunjukkan bahwa model Discovery Learning secara signifikan meningkatkan pemahaman dan keterlibatan siswa. Analisis statistik mengonfirmasi peningkatan yang signifikan dalam hasil belajar, dengan  $t(29) = 5,92 > t\text{-tabel} = 2,05$ , yang menunjukkan efek positif model pada tingkat signifikansi 5%. Selain itu, model tersebut mendorong pemikiran kritis siswa, pemecahan masalah kolaboratif, dan pembelajaran antarteman, sebagaimana dibuktikan oleh wawancara guru dan siswa. Penelitian ini berkontribusi pada semakin banyaknya penelitian yang mendukung strategi pengajaran yang berpusat pada siswa dan menawarkan wawasan praktis dalam menerapkan Discovery Learning dalam pendidikan matematika. Kebaruannya terletak pada penerapan model ini pada materi aljabar abstrak dalam konteks sekolah menengah, yang menunjukkan bahwa model ini tidak hanya meningkatkan pemahaman tetapi juga merangsang motivasi siswa dan partisipasi di kelas. Temuan ini menggarisbawahi perlunya beralih dari model pembelajaran tradisional ke pembelajaran aktif untuk memenuhi kebutuhan kognitif dan emosional siswa secara efektif.

**Kata kunci:** Discovery Learning, Sekolah Menengah, Operasi Aljabar

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## Introduction

Education is a process of developing the potential of a person to become the capital of a nation's progress. Every individual has an instinct and tendency to be inquisitive about a phenomenon. Through education, it is expected that a person will develop better behaviors and intelligence, including in the capacity of mathematics theoretically and practically. Meanwhile, learning is an interactive process between students and educators as well as learning resources in a learning environment (Ow-Yeong et al., 2023). Learning is assistance that educators provide so that students can acquire knowledge, master skills, develop characters, and form attitudes and beliefs in students. In other words, learning is a process to help students learn well. The learning process is experienced throughout the life of a human being and can apply anywhere and anytime. Learning has a similar meaning to teaching although it has a different connotation (Komalasari, 2015; Sagala, 2013; Kemendikbud, 2014). However, in mathematical learning, abstract concepts and materials are often used, requiring extra efforts to help the students absorb the learning process optimally.

Studying mathematics, in particular, is learning about how to communicate ideas and reasoning, an attitude of appreciating the usefulness of mathematics in life, and abstract things, including learning about quantitative concepts (Rohana et al., 2016). Meanwhile, learning outcomes are the results achieved by students during the learning process (Sudjana, 2017; Susanto, 2015; Saleh et al., 2021). A learning model is a form of learning that is illustrated from start to finish and is presented specially by the teacher. In other words, the learning model is a wrapper or frame for applying an approach, method, and learning technique (Fathurrohman, 2015; Andi, 2015; Al-Tabany, 2014).

People with hearing loss may perceive a bird song as an abstract concept, and many people with hearing ability may have never heard it. Thus, understanding how a bird song can be a challenging task for them (Cochran-Smith, 2004; Saleh et al., 2019; Saleh et al., 2018). One of the lessons taught at the school level is mathematics. Mathematics is a universal science that underlies the development of modern technology. It plays an essential role in various scientific disciplines and advances human thought (Nurikawai et al., 2021; Permita et al., 2022; Sarnawiah. & Nurul, 2019). Mathematics is not only a tool to understand mathematical concepts but also to comprehend other sciences, such as chemistry, physics, engineering, and pharmacy. Hence, mathematics plays an essential role in human's lives. It is one of the most influential subjects that correlate with other subjects.

Generally, mathematics is considered a less interesting subject by the students. This is due to the use of learning models that may not suit the students. They often learn by memorizing formulas and being passive learners, often not telling the teacher that they have not yet understood. Therefore, a learning model is needed to generate students' creativity and motivation to learn independently and in groups. Accuracy in choosing and using learning models that enhance students' participation can provide opportunities for students to develop their potential, indirectly affecting their learning outcomes (Rohana et.al, 2016; Susanto, 2015; Fitriawanawati et al., 2022).

Given the importance of strategy to reach the desired learning outcomes, teachers must continue to generate learning innovations as strategies to facilitate students' learning processes. Appropriate strategies can lead to more meaningful learning and increased participation. Similarly, a teacher as an instructor and a facilitator must pay close attention to the students' needs and abilities in the learning process (Saleh et al., 2018; Ansari & Saleh, 2019).

The discovery learning model is a model that provides experiences to students and requires students' engagement. Discovery learning is a cognitive learning model that requires teachers to be more creative in creating situations that stimulate students' activeness in discovering their knowledge (Yamashita et al., 2016; Oktari & Desyandri, 2020; Kemendikbud, 2014). Similar research conducted by Puspitasari & Nurhayati (2019) concluded that there was an influence of the discovery learning model on students' learning. This implies that it can generate better learning outcomes than the traditional learning models.

The claim was also reinforced by the finding of Ramadhani (2021) in which discovery learning affects students' learning outcomes positively. Its application can motivate students to learn independently and solve problems. Similar findings were also reported by a body of literature (Kaminski & Sloutsky, 2020; Saleh et al., 2021; Kodir, 2018). Hence, it can be said that the discovery learning model is highly appropriate to apply in classrooms. Through the discovery learning model, students can be closer to the source of their learning. Their confidence will also increase since their understanding is gained through their own efforts and discovery. Collaboration with peers will also increase and add to the experience of their students.

Discovery Learning is a model in teaching cognitive theory that prioritises the teacher's role in creating learning situations that encourage students to be active and independent. The discovery learning model is a teaching model that regulates teaching in such a way, making children acquire knowledge they did not previously know through notification, either partially or fully discovered by themselves. Discovery

learning activities are designed to allow students to find concepts and principles through their own mental processes. In finding ideas, students make observations, classify, make conjectures, explain, draw conclusions and so on to find some concepts or principles.

The psychologist and proponent of cognitive learning theory, Jerome Bruner, was the first to explain the principles of discovery learning (Musrorah, 2018). It explains how a learner constructs knowledge based on prior knowledge or experience. Similarly, other cognitive learning theorists, such as John Dewey, Jean Piaget, and Lev Vygotsky strongly recommended using discovery learning because it can spur students to participate actively in learning activities or processes by exploring concepts and answering questions through their learning experiences. The discovery learning model teachers use to increase student activity is process-oriented, self-directed, self-seeking, and reflexive (Solikhah, 2017).

Below are examples of problems often encountered in everyday life:

#### Examples 1

Once upon a time, there was a conversation between Mr. Agus and Mr. Budi. They had just bought a book at a grocery store.

*Mr. Agus: "Mr. Budi, it seems you bought many notebooks."*

*Mr. Budi: "Yes, Sir. This is an order from my school. I bought 2 boxes and 3 books. What did Mr. Agus buy?"*

*Mr. Agus: "I only bought 5 books for my child in grade VIII of junior high school."*

#### Examples 2

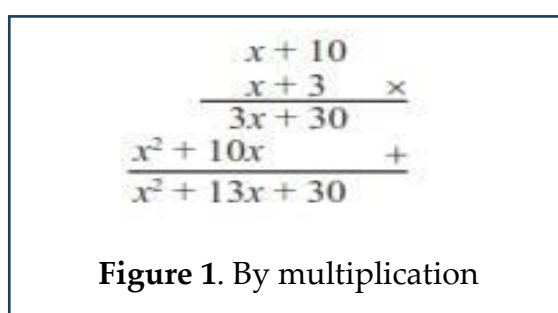
Mr. Tanto has a square-shaped apple orchard, and Mr. Sandi has a rectangular-shaped watermelon orchard. Mr. Sandi's watermelon orchard is 10 meters longer than the side length of Mr. Tanto's apple orchard. Meanwhile, the width is 3 meters longer than the side of Mr. Tanto's apple orchard. If the area of Mr. Sandi's orchard is 450 m<sup>2</sup>, determine the location of Mr. Tanto's apple orchard.

To solve this problem, you can take, for example, the length of the side of Mr Tanto's apple orchard with a variable, the variable  $x$ . The size of Mr. Sandi's watermelon orchard is 10 meters longer than the side length of the apple orchard, and you can write  $x + 10$ . Meanwhile, the width is 3 meters longer than the side length of Mr. Tanto's apple orchard, and you can write  $x + 3$ . As we know, the area of a rectangle is the length  $x$  wide. However, in the problem where the size of the side of the garden has to be determined, there is a little difficulty because what is being multiplied is an algebraic form. In this problem, the area of Mr. Sandi's watermelon orchard is the product of  $x + 10$  by  $x + 3$ .

The area of Mr. Sandi's watermelon orchard can be written in algebraic form as **Formula 1**:

$$\begin{aligned} \text{Area} &= \text{length} \times \text{width} && (1) \\ &= (x + 10)(x + 3) \\ &= x^2 + 3x + 10x + 30 \\ &= x^2 + 13x + 30 \text{ unit area} \end{aligned}$$

In addition to this method, we can determine the area of Mr Sandi's watermelon orchard by the following multiplication in **Figure 1**.



**Figure 1.** By multiplication

Hence, the area of Mr. Sandi's watermelon orchard is  $x^2 + 13x + 30$  area units. Please use the method you think is the easiest of the two ways. Let's observe the following illustration for more details on how to multiply these algebraic forms.

### Research Methods

The approach used in this research was quantitative. "Research is based on the philosophy of positivism, used to examine certain populations or samples. Data collection uses research instruments, while data analysis is quantitative/statistical in nature, intending to describe and test established hypotheses (Creswell & Plano Clark, 2011; Sugiyono, 2014). At the same time, the type of research used was pre-experimental research. "Pre-experimental research results are the dependent variable not solely influenced by the independent variable." The pre-experiment in this study was the discovery of learning models on algebraic operations material.

Population is a generalized area consisting of objects/subjects with certain qualities and characteristics determined by researchers to be studied and then concluded, the sample is part of the number and characteristics possessed by the population (Sugiyono, 2014; Creswell, 2010). A purposive sampling technique was used in this study, resulting in 60 students of VIII students of SMP Negeri 14 Banda Aceh for the 2021-2022 academic year.

Data collection used 3 instruments, namely: tests, observations and interviews. The test consisted of 10 questions with 30 minutes in the form of essay questions regarding algebraic operations, especially addition and subtraction of mathematical algebraic structures. Observations were made to find out students' attitudes in respecting friends' opinions during the teaching and learning process by applying the discovery learning model to algebraic operations material. Interviews were conducted with 1 teacher and 5 students with various abilities after the application of the discovery learning model. Furthermore, the data was processed with the t-test formula.

### **Result and Discussions**

Based on the research results, the lowest test score obtained by students was 59, while the highest score was 94, with a total value of 2452. Students' ability to answer questions concerning Algebraic Operations material using the Discovery Learning learning model showed that they understand the material better so that they can reach the expected learning outcomes. After applying the Discovery Learning model, based on the answers to the test questions given, the achievement of student learning completeness where there were 27 students or 90% of students had achieved a completeness score or obtained a score above the Minimum Completeness Criteria (KKM) score of 75 and only 3 students or 10 % of students who did not achieve mastery learning.

Based on the calculation results above, it can be seen that the calculated t value was 5.91667, while to figure the t table value, we first calculated the degree of freedom ( $df = N-1$ ) =  $30-1 = 29$ . Hence, with the degree of freedom (df) or degrees of freedom (db) of 29, then consulted with the t table at a significance level of 5% or 0.05, a t table value of 2.04523 was obtained. The calculated t value with the t table value were also compared, resulting in  $t \text{ count} > t \text{ table}$  ( $5.91667 > 2.04523$ ), then  $H_a$  was accepted at a significant level  $\alpha = 0.05$ . It can be concluded that the hypothesis proposed was accepted as accurate. In other words, the results of learning mathematics in algebraic operations material with the discovery learning model achieve completeness.

### ***Results of Interviews with Teachers before the Implementation of Discovery Learning***

The interviews with the teacher revealed that he has been teaching for 1 year. The learning outcomes of students in mathematics class were good. They could understand the material better even though the learning process in the classroom was complex. Activities must be planned and designed carefully to increase students' interest. In addition, practical learning activities were influenced by students' responses to education. There were times when learning activities did not go well because the students' answers were less enthusiastic due to inappropriate methods or other factors.

Based on the interview results, it was also known that there was a lack of students' enthusiasm for learning. At the same time, teachers had made some attempts to improve student learning processes and outcomes in mathematics. It was also found that the teacher has attempted to motivate students to show the importance of learning even in a pandemic condition.

Furthermore, it was discovered that the learning models the teacher knew were problem-based learning, discovery learning, NHT, open ending, etc. The learning model is a framework that provides a systematic description for carrying out learning to help students learn in a certain way. The learning model is a general description but still focuses on specific objectives. However, the teacher in the current research had never used the discovery learning model previously.

Moreover, the learning model often used by the teacher was problem-solving-based. One of the problem-based models is the Problem-Based Learning model, a learning approach that uses real-world problems as a context for students to develop critical thinking and problem-solving skills, as well as to acquire essential knowledge and concepts from the subject matter (Mariyati, 2018; Saleh et al., 2018; Saleh et al., 2019; Saleh et al., 2021). The interviewees also said that many students still have not yet understood, which may be caused by various factors, including the teacher's learning model (Cochran-Smith, 2004; Friani et al, 2017).

### ***Results of interviews with teachers after learning implementation***

Interview results with teachers after the implementation of discovery learning show that: 1) learning mathematics material for algebraic operations using the discovery learning model is highly appropriate as it can develop students' abilities; 2) the teachers stated that not all stages of the discovery learning process were easy for students to understand. As the discovery learning model requires students to actively discover answers, it focuses on students who have a significant role in learning activities. As a consequence, not all students' learning abilities can be improved; 3) each group possessed different ideas. Students discussed information they found from various sources with their group members for each assignment given by the teacher; 4) the teacher said that students became more critical. Learning with the discovery learning model increased their participation in the learning process and problem-solving skills. They also found ways to prevent the same problem from recurring; 5) students discussed with their group members to find new ideas, which was influenced by the teacher's guidance on how to conclude the findings, interpret problems, and present evidence to get an overview or answer to the problems faced by each group; 6) Students were more accustomed to solving critical problems with

different abilities; 7) the teacher perceived that the learning stages used the discovery learning model according to the steps suited students' thinking abilities.

The results of interviews with 5 students show that: 1) two students said it was excellent. One student believed it could improve students' ability to think critically, while 2 perceived it was not attractive. In other words, 5 respondents who were interviewed gave different answers regarding the implementation of the Discovery Learning model in the learning. This was because students were not used to learning using the model; 2) three students stated that they were happy to participate in learning mathematics through the Discovery Learning model because they could work together in groups to solve problems in learning. However, two said they were unhappy and did not like participating in learning using the Discovery Learning model; 3) all respondents stated that they did interact with friends because they were both looking for solutions to answer problems or questions in mathematics learning; 4) on average, respondents stated that they could contribute to understanding and improving their friends' abilities through discussions in the LKPD (Student Worksheets); 5) all respondents stated that they shared their opinions in group discussions since each of them looked for solutions and suggestions in group discussions; 6) the average respondents stated that learning using the Discovery Learning model was interesting because it could help finding solutions to problems and exchange opinions with their peers; 7) all respondents stated that they had difficulty solving questions independently without explanation from the teacher first; 8) all respondents agreed that the model can help enhance students' engagement in learning both independently and in groups to find solutions to problems.

The results showed that the Discovery Learning model on algebraic operations material had a more positive effect on the completeness of students' learning outcomes. This can be seen from the administration of tests, where the totality of student learning reached 90%. Hence, it can be said that the learning process with the Discovery Learning model went very effectively and helped students complete the learning outcomes.

The model stimulated the students to be active, dynamic, and critical towards the mathematical problems given. The students were not presented with lessons in their final form yet were expected to organize themselves. Even though they were given the same material at the same time, in the recommended inquiry model, students were given case examples to train them to understand and solve the problems, so they would not only be fixated on the teacher's explanation and become are less active. The Discovery Learning model was designed to help students discover the answers to the problems by themselves. It is a student-centered learning model to allow them

understand the material through their own research. The teacher only serves as a facilitator. Such method accelerates the students' understanding of the concepts being studied through self- or collective discovery. It can liven up the atmosphere in the teaching and learning process so that it will not be boring and monotonous.

Regarding the application of the discovery learning model in improving student learning mastery, it is relevant to research conducted by Widyastuti (2014). In the process, this model will guide students to find and express their ideas related to the topic being studied so that it is very demanding for student learning activity both independently and in groups. Based on the interviews' results, the mathematics teacher at SMP Negeri 14 Banda Aceh considered the the Discovery Learning model as an excellent learning method because it could develop students' potential abilities. Students felt happy to participate in mathematics learning because they can work together in groups to solve problems. They seek solutions collectively to answer mathematical questions. After implementing the discovery learning model, students became active in learning and helped each other to answers problems in the LKPD. They also shared their opinions in group discussions and gave suggestions. When learning with the Discovery Learning model, the students had difficulties solving problems independently without having the teacher's explanation previously. However, the student agree that the model increased their classroom participation.

Based on the findings, it can be said that the Discovery Learning model had a positive impact on both the teacher and the students. It provided an experience for the teacher to develop more interesting learning. As for the students, they could understand algebraic operations, making learning more meaningful because the teaching emphasized the development of cognitive, affective and psychomotor aspects. The application of innovative learning models enhanced students' activeness and motivation in learning. The learning atmosphere became livelier because the students worked in groups actively and asked questions to teacher and their peers. Using this model, the students enjoyed the learning more than they did in the teacher-centred learning. Positive interactions between teachers and students can support students' social, emotional and cognitive needs. According to Damrongpanit (2022), good interaction between teachers and students can increase learning interest and opportunities because the learning opportunities provided by the teacher are more significant. The teacher supports students to actively participate in learning so that students can discuss with group teams to find new ideas.

## **Conclusion**

This study concludes that the Discovery Learning model significantly improves students' learning outcomes in algebraic operations. The results of hypothesis testing

demonstrate a statistically significant increase in student performance, indicating that the application of this model enhances both comprehension and mastery of algebraic concepts. Additionally, qualitative data from observations and interviews confirm that the model fosters student engagement, critical thinking, and collaborative learning. Students became more active participants in the learning process, while teachers observed higher levels of motivation and peer interaction. Therefore, the Discovery Learning model is an effective instructional approach for addressing students' difficulties with abstract mathematical content and should be considered a viable alternative to traditional, teacher-centered methods in mathematics education.

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