

Discovery Learning: Its Impact on Mathematical Computational Thinking Ability and Self-Confidence of Senior High School Student

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Article Info

Article History:

Received Jun 12, 2024

Revised Mar 20, 2025

Accepted Mar 26, 2025

Keywords:

Discovery Learning,
Computational Thinking,
Self Confidence.

Kata Kunci:

Discovery Learning,
Berpikir Komputasional,
Kepercayaan diri.

ABSTRACT

Computational thinking is the ability to think about solving problems the way a computer works. This ability is very important in the 21st century, so it needs a teacher's attention when teaching mathematics. This study aims to explore and analyze the impact of discovery learning on students' mathematical computational thinking abilities and self-confidence. The research was carried out at a private high school in Bogor for the 2023/2024 academic year. This research uses a quasi-experimental method with a randomized posttest-only control group design. The research sample consisted of 28 students using the discovery learning model and 26 students using the conventional model. Data collection instruments are tests and questionnaires that have been tested for validity and reliability. The research results show that the average mathematical computational thinking ability taught using the discovery learning model is higher than the conventional model class. The average self-confidence of experimental class students is higher than that of the control class. The discovery learning model influences students' mathematical computational thinking abilities and self-confidence.

ABSTRAK

Berpikir komputasional merupakan kemampuan berpikir dalam memecahkan masalah sebagaimana cara kerja komputer. Kemampuan ini sangat penting di abad 21, sehingga perlu menjadi perhatian guru dalam pembelajaran matematika. Studi ini bertujuan mengeksplorasi dan menganalisis dampak pembelajaran *discovery* terhadap kemampuan berpikir komputasional matematis dan kepercayaan diri siswa. Penelitian dilaksanakan pada SMA Swasta di Bogor tahun pelajaran 2023/2024. Penelitian ini menggunakan metode kuasi eksperimen dengan desain *randomized posttest-only control group design*. Sampel penelitian yakni 28 siswa menggunakan model *discovery learning* dan 26 siswa menggunakan model konvensional. Instrumen pengumpul data berupa tes dan angket yang sudah diuji validitas dan reliabilitasnya. Hasil penelitian menunjukkan rata-rata kemampuan berpikir komputasional matematis yang diajarkan menggunakan model pembelajaran *discovery* lebih tinggi daripada kelas model konvensional. Rata-rata kepercayaan diri siswa kelas eksperimen lebih tinggi daripada kelas kontrol dengan besar. Model pembelajaran *discovery* berpengaruh terhadap kemampuan berpikir komputasional matematis dan *self confidence* siswa.

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How to Cite

Windari, I., Fatra, M., & Diwidian, F. (2025). Discovery Learning: Its Impact on Mathematical Computational Thinking Ability and Self-Confidence of Senior High School Student. *JNPM (Jurnal Nasional Pendidikan Matematika)* 9(1), 51-65.

Introduction

In the 21st century, the development of Science and Technology (Science and Technology) brings rapid changes that result in changes in the learning framework contained in the curriculum, media, and technology (Azizah et al., [2023](#); Rahayu et al., [2022](#)). These changes require the readiness of teachers and students to learn. Teachers as facilitators in learning have the responsibility to direct and guide students so that goals are achieved. Among the objectives of mathematics, lessons are understanding mathematical material, using reasoning, performing mathematical manipulation, compiling evidence, and making generalizations (Kemendikbudristek, [2022](#)). The learning objectives of mathematics in the independent curriculum are closely related to computational skills.

Computational thinking is a necessary skill to be developed in the 21st century (Irawan et al., 2025; Jamna et al., 2022). Computational thinking involves cognitive aspects in mathematics learning to train students' skills for higher-order thinking (Christi & Rajiman, [2023](#)). Computational thinking is defined as a comprehensive ability to design systems, solve problems, and analyze one's behavior based on basic concepts of computer science (Khine, 2018; Nurlaelah et al., 2024; Salwadila & Hapizah, 2024; Wing, 2006). Another definition states that computational thinking is a series of abstract behaviors consisting of reasoning processes such as abstraction, decomposition, pattern mapping, pattern recognition, algorithmic thinking, automation, modeling, simulation, assessment, testing, and generalization (Angeli et al., 2016; Città et al., 2019). The characteristics of computational thinking skills are: (1) Formulating problems using computer algorithms, (2) Managing and analyzing data logically, (3) Representing data through abstractions such as modeling and simulation, (4) Automating answers through algorithmic thinking, (5) Identifying, analyzing, and applying goal-based solutions with efficient and effective combinations of steps and resources, (6) Generalising and transferring problem-solving processes to various problems (Dagiene et al., [2017](#); Kalelioğlu, [2018](#)).

Students' mathematical computational thinking skills are still relatively low. This is evidenced by the PISA results in 2022 at levels 4, 5, and 6 showing that almost no students in Indonesia were the best performers in mathematics with an average of less than 9% (OECD, 2022). Another study showed that only 1 out of 20 students fulfilled all indicators of computational thinking ability (Jamna et al., [2022](#)). One study showed that the challenges in achieving higher scores, particularly in pattern

recognition, were caused by students' misconceptions arising from their interpretation of reading questions, which led to incorrect answers. In addition, the study also found that a lack of habitual problem-solving practice in computational thinking was another contributing factor (Hapizah et al., 2024). This is in line with research, which found that mathematical computational thinking skills in solving contextual-based problems were low. Students were only able to solve problem based on indicator decomposition (Syari et al., 2024). The low computational thinking ability is because students' mathematical skills are rarely honed, and the a lack of teacher creativity in designing lessons (Ni'am et al., 2022).

Apart from the cognitive aspects, mathematics lessons also aim to train dispositional aspects, one of which is self-confidence. Self-confidence is an affective aspect that has an impact on student success in learning mathematics (Fardani et al., 2021). Another scholar defines self-confidence as a person's belief in their ability to identify, motivate, and use the necessary resources, and then apply them to actions tailored to the given assignment (Hendriana et al., 2021). Self-confidence supports the ability to think computationally when facing complex problems and provides experience in dealing with problems (Ansori, 2020). One of the keys to success in learning mathematics is that students must believe in their abilities and have self-confidence. With self-confidence, students believe in their ability to solve problems (Dewi et al., 2020). In line with the results of research (Yakpi et al., 2023) students who have high self-confidence, have good cognitive abilities, and students who have low self-confidence, their cognitive abilities are also low.

In fact, students still lack confidence in learning mathematics. As the results of the TIMSS (Trends in International Mathematics and Science Study) study in 2015 stated 23% of Indonesian students have high self-confidence, 53% of students have a moderate level of self-confidence, and 24% of students have low self-confidence (Mullis et al., 2015). Ramlan's research results show that in students' self-confidence in solving mathematical problems 56 students only 6 students with a high level of confidence, 24 students with a medium level of confidence, and 26 students with a low level of confidence (Ramlan et al., 2021). (Muningsih, 2020) states that the lack of student confidence is due to the learning process still tending to be passive and still teacher-centered so students are less actively involved in learning.

Efforts that can be made to train, generate, and activate the problem-solving aspect include applying the discovery learning model. Research (Rustamana, 2020) states that discovery learning can improve 21st-century thinking skills. This learning model pressures students to play an active and enthusiastic role in classroom learning, learn to identify patterns in concrete and abstract situations, choose questioning strategies in solving a problem, improve concept skills and more

meaningful learning principles (Muhammad & Juandi, 2023; Sidiq et al., 2021). The main purpose of the discovery learning model is to get students maximally involved and hone their confidence in the discoveries they design during the learning process (Nurlina et al., 2021; Syolendra & Laksono, 2019). The discovery learning model has six stages, namely: stimulation, problem statement, data collection, data processing, verification, and generalization (Hayati et al., 2020; Syolendra & Laksono, 2019).

This study provides additional information to explore and analyze the impact of Discovery learning on students' computational thinking ability and self-confidence in mathematics learning. In line with that, the two questions answered in this paper are (1) What are the mathematical computational thinking abilities and self-confidence of students?; (2) What is the effect of Discovery learning on the mathematical computational thinking ability and self-confidence of students?.

Method

This research uses a quantitative approach with a quasi-experimental method. The experimental group used the discovery learning model and the control group used the conventional learning model. This research is in the form of a randomized posttest-only control group design. The sample in this study came from the population of class X students at one of SMA in Bogor in the 2023/2024 school year consisting of four classes. The sampling technique used cluster random sampling and selected class X.2 as the experimental class and X.1 as the control class. The treatment in this study was conducted over a period of one month. The material taught focused on Linear Programming. In implementation, the researcher acted as a learning facilitator and provided direct feedback to the students, as well as observed the development of their computational thinking skills for the purpose of data analysis. The data collection technique used descriptive tests and questionnaires. The test was used to measure computational thinking ability and a questionnaire to measure students' self-confidence. The test instrument used has gone through a content validation process conducted by eight experts using the Content Validity Ratio (CVR) method based on Lawshe's criteria (Lawshe, 1975). The CVR results of 12 items ≥ 0.75 which indicates that all items are valid. For testing the feasibility of questionnaire instruments through empirical validity which is processed using SPSS 25. The results of this test show 20 valid items from 24 statements tested and high reliability. Data analysis techniques are descriptive and inferential analysis. Statistical tests used t-test and multivariate analysis of variances (MANOVA) using the Wilks' lambda formula. The effect size calculation criteria for the t-test are small effect: $0,01 < \eta^2 \leq 0,09$, medium effect: $0,09 < \eta^2 \leq 0,25$, large effect: $\eta^2 \geq 0,25$ (Kadir, 2019). For the MANOVA test, the small effect ($0,01 < \eta^2 \leq 0,09$), medium effect ($0,09 < \eta^2 \leq 0,25$), and large effect ($\eta^2 > 0,25$) (Kadir, 2019). The research hypotheses tested are:

- H1: There is a significant difference in the mathematical computational thinking ability of students taught using Discovery learning compared to the conventional learning model.
- H2: There is a significant difference in self-confidence of students who are taught using Discovery learning compared to using the conventional learning model.
- H3: There is an effect of the Discovery learning model on students' mathematical computational thinking ability and self-confidence.

Results and Discussion

Students' Mathematical Computational Thinking Ability

Mathematical computational thinking ability is characterized by four characteristics, namely problem decomposition, abstraction, algorithmic thinking, and debugging. Problem decomposition relates to the student's ability to decompose the problem into the information needed to solve the problem. Abstraction is a person's ability to take important parts by making representations in the form of mathematical models. Algorithmic thinking is the skill of using precise and sequential problem-solving steps. Debugging is the skill of identifying errors from a problem and correcting them. The following are the findings on students' mathematical computational thinking ability.

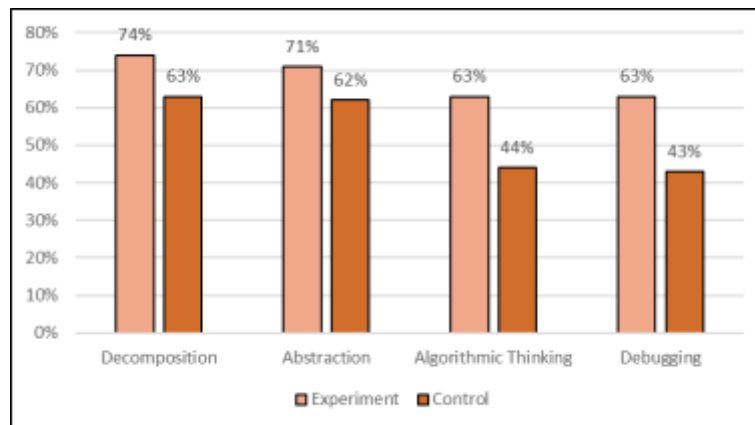


Figure 1: Students' Mathematical Computational Thinking Ability

Figure 1 shows that the highest mathematical computational thinking process is the ability to decompose the problem into the necessary information. And the lowest is the ability to identify errors and correct them. This condition occurred for both research groups. However, the mathematical computational thinking ability of students taught using the discovery learning model was better for all indicators than the conventional class. It can be interpreted that the discovery learning model has more influence on students' mathematical computational thinking ability. Discovery learning guides and trains students in finding problems and discussing

them to get solutions and solutions (Dewi et al., [2020](#); Ramadan et al., [2019](#); Saputri et al., [2019](#)).

To test the difference between the two means using the t-test and Wilks' lambda test with a significance level of $\alpha = 0.05$. Before the test, the researcher had conducted normality and homogeneity tests which showed that the data had normal distribution and mathematical computational thinking ability had the same variance. The results of the mean difference test of the two research groups can be seen in Table 1 below.

Table 1. Results of Two Mean Difference Test

Class	\bar{x}	s	t	Sig. (2-tailed)	Partial Eta Squared
Experiment Class	67,63	13,15			
Control Class	53,21	14,47	3,839	0,000	0,221

The results of the Independent Sample T-test based on Table 1 obtained a sig value, 0.000 is smaller than the significance level = 0.05 ($0.000 < 0.05$) thus H_0 is rejected. This means that the discovery learning model has a significant effect on students' mathematical computational thinking skills. The effect of the discovery learning model on student's mathematical computational thinking skills is 22.1%, the rest is influenced by other factors not discussed in this study. Pedagogically, this indicates that the implementation of this model has a strong and significant influence in helping students decompose problems, think algorithmically, and make generalizations in mathematics. Teachers can use this finding to design more student-centered learning, provide space for exploration, and guide students to discover concepts on their own, thereby fostering higher-order thinking skills.

Students' mathematical computational thinking process is marked by several characteristics of the thinking process, namely problem decomposition, abstraction ability, algorithmic thinking, and making generalizations. The problem decomposition thinking process can be seen from the student's ability to know the problem and compile it into a more detailed form. Then the information is used as a reference to make the necessary representations and mathematical models. In the decomposition aspect, most students have been able to describe the problem correctly, completely, and precisely. For example, here is one of the students' answers that represents the problem decomposition indicator.

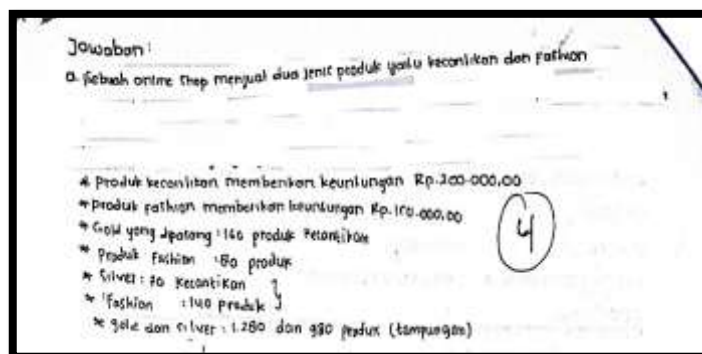


Figure 2: Students' Answers on Decomposition Indicator

Students in the experimental class are accustomed to working on the discovery learning model LKS at the stimulation and problem statement stages. They are accustomed to being given problems as stimulus to determine as many problems as possible formulate problems according to the problems given and then solve these problems (Kusumaningtyas et al., 2020; Widawati et al., 2020). Reinforced by research (HSB, 2021) which explains that the ability to solve mathematical problems using the discovery learning model has a significant effect.

The abstraction thinking process is related to a student's ability to take important parts by making data representations in the form of models, patterns, or images based on the problem. In this aspect, it can be seen that students have been able to make mathematical models correctly and completely. The discovery model learning has a data collection stage. In the data collection stage, students are directed to collect important data from various sources to solve problems (Ariyana et al., 2018). The findings of this study are in line with research conducted (Pramesty, 2022) which states that the discovery learning model affects students' mathematical critical thinking skills. Mathematical critical thinking ability and mathematical computational thinking ability have similar indicators of analysis and abstraction. The results of students' answers regarding the abstraction aspect can be seen in Figure 2.

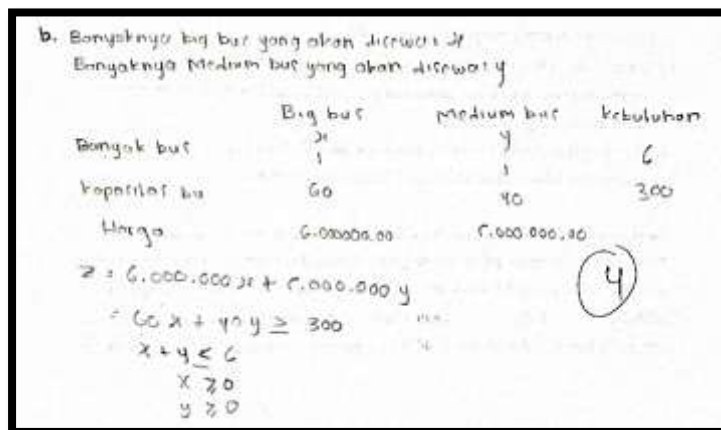


Figure 3. Students' Answers on Abstraction Indicator

Solving problems requires complete and systematic ways and stages, known as the algorithmic thinking process. The findings of this study show that most students have been able to use the steps correctly, completely, and sequentially. The following is an example of one of the students' answers that represents the indicator of algorithmic thinking.

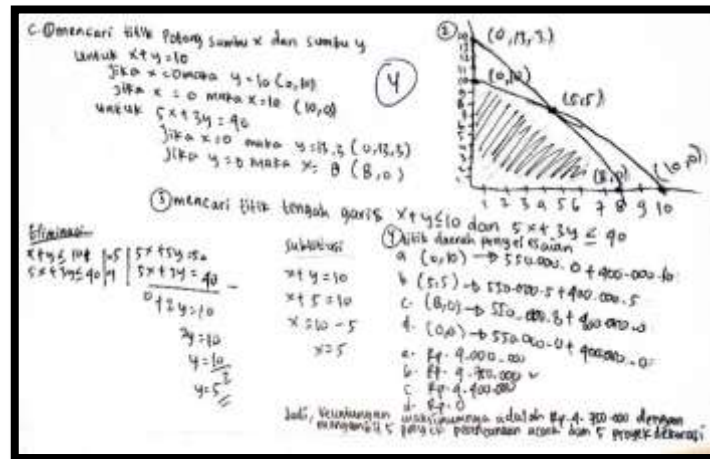


Figure 4. Students' Answers on Algorithmic Thinking Indicator

In discovery learning there are stages of data collection and processing. This stage trains students to find and collect information from various relevant sources and discuss to answer the problem formulation (Hayati et al., 2020). The data processing stage trains students to interpret data such as drawing graphs from the information that has been collected (Ariyana et al., 2018; Yanti, 2022).

Important aspects in solving problems include the ability to identify errors and correct them so that they can make conclusions and use the correct and complete method. The results of this study show that there are still many students who have not been able to identify errors using the right method but can only make conclusions. Here is one example of a student answer that represents the debugging indicator.

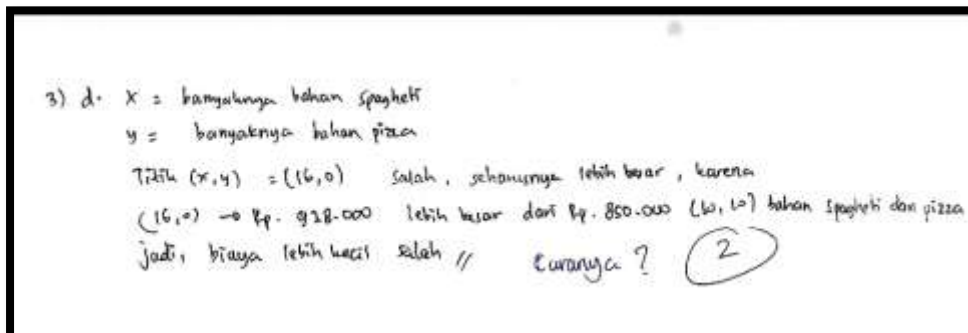


Figure 5. Student's Answer on Debugging Indicator

Discovery learning trains and guides students to verify and generalize. This verification stage trains students to re-examine the answers they have obtained by connecting the results of data processing (Hayati et al., 2020). The generalization stage trains students to make conclusions that are used as general principles for similar problems based on the results of verification (Hayati et al., 2020).

The discovery learning model makes students play an active role in the learning process in the classroom which involves students finding a concept. Students are also enthusiastic about discussing with their groups to solve problems so that problems are easily resolved. This research is in line with the results of Novandri and Kurniawan who stated that discovery learning is feasible to be applied to mathematics learning because it has a positive effect on learning outcomes while motivating students to be more active in learning (Kurniawan et al., 2020; Novantri et al., 2020). In contrast to conventional learning, students only listen and imitate the teacher's ways of solving problems (Adila et al., 2020; Fatra, 2016).

Students' Self Confidence

To determine the difference in student self-confidence between the two research groups using a two-average difference test. In this study using the Independent Sample T test. The results of the calculation of the mean difference test can be seen in Table 2. below.

Table 2. Results of Two Mean Difference Test

Class	\bar{x}	s	t	Sig. (2-tailed)	Partial Eta Squared
Experiment Class	71,68	10,34			
Control Class	62,73	8,59	3,445	0,001	0,186

The results of the Independent Sample T-test are based on Table 2. obtained a sig value of 0.001, which means that the value is smaller than the significance level = 0.05 ($0.0005 < 0.05$) in other words H_0 . It can be concluded that the average student confidence using the discovery learning model is higher than the conventional learning model. The effect of the discovery learning model on students' mathematical computational thinking ability is 0.186. This means that 18.6% of student confidence is influenced by the discovery learning model in the medium category.

Believing in One's Own Ability

This study shows that students' self-confidence is quite good. Students who have good self-confidence then believe in themselves to overcome the problems that occur (Ganggi, 2018). Belief in one's ability is characterized by the ability to re-explain the mathematics material conveyed by the teacher to friends, confidence

that they can complete the mathematics assignments given by the teacher, confidence that they will get good grades in exams or tests on mathematics material, and not shy about asking questions. In discovery learning, students are given a stimulus to raise curiosity and conduct investigations independently (Hayati et al., [2020](#)). At the verification stage, students re-explain the material presented by the teacher with a presentation (Hartono, [2019](#)). At the conclusion stage as well, students can make conclusions from the material the teacher has presented (Hayati et al., [2020](#)).

Acting independently in making decisions is one of the characteristics of people who have high self-confidence. Students who have high self-confidence will choose everything for their own decisions, not following others (Hendriana, [2012](#)). Acting independently is characterized by students working on mathematics problems independently, easily finding mathematics material from various sources, not waiting for friends' help and not giving up in working on difficult mathematics problems. In the experimental class, students were directed to be independent in making decisions. In the discovery learning process, students are accustomed to seeking and gathering information from various sources and processing the data and information that has been obtained (Ariyana et al., [2018](#); Chairunnisa et al., [2022](#)).

In addition, students who have high self-confidence have a positive self-concept that is optimistic about themselves and others, both from views and actions (Ganggi, [2018](#)). A positive self-concept is characterized by being proud of the results of one's mathematical work, happy to be able to teach mathematical material to friends who are having difficulty, and doing the tasks given by the teacher. In discovery learning at the problem statement stage, students are allowed to identify and analyze problems, and then formulate problems as temporary answers (Chairunnisa et al., [2022](#)).

The next aspect of self-confidence is the courage to express opinions. Students who have high self-confidence can express their thoughts or ideas through reality can be accepted by reason, and do not care too much about the bad rejection of others (Ganggi, [2018](#)). The characteristics of courage in expressing opinions in this study are marked by the ability to express opinions in discussions, ask friends who are presenting, and present discussion material in front of the class. In the experimental class, students were accustomed to a learning process that directed them to discuss by identifying as many problems as possible (Hayati et al., [2020](#)). At the verification stage, students in groups are directed to present discussion material in front of the class and other students give each other suggestions (Marisyah & Sukma, [2020](#)).

Test of Effect on Two Dependent Variables

Multivariate Analysis of Variances (MANOVA) test using Wilks's lambda is to determine whether there are differences in the average of more than one dependent variable and whether the assumption of homogeneity is met. The test results can be seen in Table 3 below.

Table 3. Multivariate Tests Results

<i>Effect</i>		<i>Value</i>	<i>F</i>	<i>Hypotesis df</i>	<i>Error df</i>	<i>Sig.</i>	<i>Partial Eta Squared</i>
Model	Wilks' Lambda	0,708	10,522	2,000	51,000	0,000	0,292

The MANOVA test results in the multivariate tests table found in the Wilks' lambda column obtained a p-value = 0.000 which means <0.05 or H_0 is rejected and H_1 is accepted. It can be concluded that there is a difference in the average mathematical computational thinking ability and self-confidence of students taught using the discovery learning model with the conventional learning model. The effect of the discovery learning model on students' mathematical computational thinking ability and self-confidence was 0.292 or 29.2% of students' computational thinking ability and self-confidence were influenced by discovery learning. The effect of discovery learning in this study is large.

This paper describes the difference in treatment using learning models that have an impact on mathematical computational thinking skills and students. Students who received the discovery learning model had better mathematical computational thinking skills and self-confidence. The discovery learning model encourages students to use their ability to find a problem creatively, critically, systematically, and logically so that they can formulate their knowledge with confidence. This is in line with research (Marjani et al., [2018](#)) which states that the application of the discovery learning approach to student self-confidence has increased. Furthermore, research conducted by (Sholehah & Marhayati, [2022](#)) also stated that the discovery learning model was able to increase students' self-confidence. Whereas in the control class with a conventional model where students tend to be passive and only listen to explanations from the teacher. Conventional learning models are less motivating for students and teachers do not involve students to be active in the learning process. This is in line with Gunawan's research which states that conventional learning models are more directed to the teacher as the center of learning, methods that are usually lectures, and less active students in learning because the delivery of material only relies on oral (Gunawan et al., [2020](#); Handoyono et al., [2020](#)).

The results of this study can be used as a reference to improve the quality of learning in schools, as the implementation of discovery learning can enhance students' computational thinking skills and self-confidence. However, several aspects need to be taken into consideration, such as designing the implementation of this learning model more effectively by paying attention to the stages of learning and time allocation, so that the learning process can run according to the predetermined schedule and produce more optimal outcomes. Future research is recommended to develop non-routine problems on systems of linear inequalities in two variables to assess more complex mathematical computational thinking skills, as well as to conduct studies on the discovery learning model in relation to other abilities, attitudes, educational levels, or mathematics topics.

Conclusion

Students' mathematical computational thinking skills in discovery learning are relatively better. Students' mathematical computational thinking processes in the aspects of decomposition, abstraction, algorithmic thinking, and generation are better with discovery learning. The average mathematical computational thinking ability of students in discovery learning is higher than in conventional classes. The influence of the discovery learning model on mathematical computational thinking ability is included in the moderate category. Likewise, the aspect of student self-confidence in the experimental class is higher than in the conventional class. The discovery learning model influences mathematical computational thinking ability and student self-confidence. This research shows that the discovery learning model has a positive effect on mathematical computational thinking ability and student self-confidence. Discovery learning provides space for students to explore concepts through various problems given. Students practice solving problems independently, discussing with friends and teachers. This activity makes mathematics learning more meaningful for students. This research has implications for educators to be able to apply the discovery learning model as an option in mathematics learning. Because this model can improve mathematical computational thinking skills and student self-confidence. Educators need to consider appropriate materials, time availability and a good understanding of learning models.

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