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The Effect of Discovery Learning Model Assisted by Vee Map on Inference Skills and Learning Outcomes Alternating Current Subject Matter

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Abstract

The discovery learning model, combined with the Vee map learning approach, has been found to be suboptimal in previous studies for enhancing inference skills and physics learning outcomes. This research is needed to investigate the effect of the discovery learning model, assisted by Vee Map, on the inference skills and physics learning outcomes of high school students in the context of alternating current material. Employing an experimental method with a posttest-only control group design, the study randomly selected a sample, assuming a homogeneous population. The population for this study was drawn from SMA Negeri Ambulu's Class XII. The sample was chosen randomly (cluster random sampling) under the premise of demographic homogeneity, yielding two classes: XII Science and Technology 1 as the experimental class and XII Science and Technology 2 as the control class. Data were gathered through posttests of inference skills and physics learning outcomes in experimental and control classes using alternating current material. Independent sample t-tests revealed a significant effect: inference skills showed a significance of 0.006 < 0.05, and physics learning outcomes had a significance of 0.000 < 0.05. These results validate the alternative hypothesis (Ha), confirming a notable difference in students' inference skills between the control and experimental groups, and refute the null hypothesis (H0), which posited no significant difference. Consequently, this study concludes that the discovery learning model, as facilitated by the Vee Map, improves high school students' inference skills and physics learning outcomes in the subject of alternating current.

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INTRODUCTION

Education in Indonesia still faces challenges in improving its quality, one of which is the relatively low quality of Indonesian education compared to other countries [1]. Improving the quality of education is necessary to address the maximum challenges of the 21st century. 21st-century learning equips students to face the rapid development of science and technology [2]. Physics learning invites students to investigate natural events and phenomena in everyday life [3]. Physics learning aims to improve students' ability to think systematically, objectively, and creatively [4]. Based on interviews with physics teachers at SMA Negeri Ambulu, physics learning in the classroom primarily focuses on Theory, resulting in a teacher-centered approach to learning. Furthermore, the learning methods applied have not been fully utilized in overcoming student difficulties, particularly in the subject matter of alternating current. Alternating current is one of the physics concepts that can be abstract, so it requires student understanding through appropriate learning activities [5]. Frans & Wasis (2022) in their research stated that many students still do not understand the material about electricity despite its prevalence in everyday life [6]. Alik *et al.*, (2023) revealed that the use of inappropriate turning models resulted in passive learning. Based on this description, the learning methods implemented in schools are still not student-centered, which means they are not optimal in overcoming student difficulties and enhancing student thinking skills in alternating current material [7].

Inference skills are critical thinking skills that students must develop in 21st-century learning. Inference skills still receive insufficient attention from students and teachers. This is because the implementation of the learning model only focuses on learning objectives and cognitive learners, resulting in low inference skills [8]. This research aligns with the findings of Wijayanti and Siswanto (2020) , which indicate that the indicators of students' inference skills remain relatively low, at 39.17 [9]. Arif *et al.*, (2019) revealed that inference skills consist of making deductions and creating deduction results, making inductions and creating induction results, and designing and considering the value of a decision [10]. Low student learning outcomes can be attributed to ineffective learning models. This is supported by the statement Aprilia *et al.*, (2020), which states that less diverse learning models result in relatively low student physics learning outcomes, leading to less active students and difficulty understanding physics concepts [11]. Students' inference skills and learning outcomes are still relatively low in physics material due to the use of learning models that have not been effective, so students cannot maximally understand the physics material.

The independent curriculum is a curriculum that demands independence from students and provides freedom of thought [12]. Based on the objectives of the independent curriculum, teachers have the freedom to determine the appropriate model to use in the classroom, including the discovery learning model. This model emphasizes discovery through investigation, allowing students to explore and discover various new concepts [13]. The application of this model is student-centered, allowing students to be actively involved in their learning [14]. The stages of the discovery learning model include stimulation, problem identification, data collection, data processing, verification, and conclusions [15]. According to Fahlevi *et al.*, (2023) , their research reveals that learning discovery learning models still have weaknesses, namely being limited by certain homogeneous physical materials, having a limited time frame, and students remaining passive, as well as having low student understanding of physical materials. Based on this, an alternative approach is needed to effectively implement the discovery learning model, supporting the learning model [16].

The Vee map tool is one of the solutions that can facilitate the discovery learning method. The Vee map becomes a valuable step in solving problems by constructing student knowledge [17] . This finding aligns with the results of Indahsari *et al.*, (2020) , who explain that applying the Vee map to the guided inquiry model can enhance scientific thinking skills in physics [17] . Based on this description, a plan for implementing the discovery learning model is needed, specifically with a Vee map, to ensure learning runs effectively and encourages active student participation during the learning process.

Research on discovery learning models and Vee maps in physics learning has been conducted in previous studies. The findings of Amini *et al.*, (2018) suggest that the discovery learning model is the most effective approach for enhancing students' inference skills and concept mastery [19]. Other research shows that inference skills improve after applying another learning model, namely the guided inquiry model [20]. he results of research by Afiesta *et al.*, (2022) indicated that students' critical thinking skills showed a significant improvement after learning with the discovery learning model [21]. The findings of Pardede *et al.*, (2023) stated that the use of discovery learning models combined with mind maps led to high student physics learning outcomes [14]. Pascaeka *et al.*, (2023) noted that a vee map can encourage active students to find physics concepts [22]. Adawiyah *et al.*, (2022) found that the use of a vee map as a learning tool has a significant impact on students' critical thinking skills and student learning outcomes in physics material [23]. Based on this explanation, the discovery learning model, combined with the use of a Vee map, can help construct students' understanding, thereby enhancing their critical thinking skills and improving their physics learning outcomes. The appropriate learning model can improve students' inference skills. Based on this description, research on the effect of combining the discovery learning model with the Vee map learning approach on inference skills and physics learning outcomes remains suboptimal.

Based on the problems described, further research is needed to examine the inference skills and physics learning outcomes of students. Previous research has shown that the discovery learning model, vee map, and the application of the right learning model in previous studies have proven to improve inference skills and student physics learning outcomes. Therefore, this study was conducted under the title "The Effect of Discovery Learning Model Assisted by Vee Map on Inference Skills and Physics Learning Outcomes of High School Students on the Subject of Alternating Current."

RESEARCH METHODS

The research conducted was an experimental study with a posttest-only control group design. The research design is presented in Table 1 as follows.

Table 1. Posttest Only Control Group Design

Class	Treatment	Posttest
Experiment	X	O_1
Control	-	O_2

Description:

X : Treatment given to the experimental group (discovery learning model assisted by vee map)

O_1 : Posttest in the experimental class

O_2 : Posttest in control class

The population in this study consisted of students in Class XII Science and XII Soshum 3 Ambulu in the odd semester of the 2024/2025 academic year. The total population consists of 140 students, specifically those in class XII at SMA Negeri Ambulu, which is used as the population because it offers physics subjects. The sample is determined by the cluster random sampling method if it is deemed homogeneous. This method was chosen due to its large population, making it more efficient in terms of both cost and time. Additionally, random sampling allows researchers to randomize at the group level, ensuring comparable experimental and control groups from the outset of the study. The sample for this research was divided into two groups: the experimental class, which received the treatment of the discovery learning model assisted by Vee Map, and the control class, which did not receive treatment.

The research began with the preparation of the article, followed by observations and interviews with physics teachers, and then determining the population and sample. The observation was conducted to obtain supporting information related to physics learning in class at SMAN Ambulu. Meanwhile, interviews were conducted with physics teachers of class XII at SMAN Ambulu, and data were obtained, which were used as study materials in the research. Furthermore, the test instruments and teaching module instruments to be used in the study have been checked, considering that they are clear, relevant, and appropriate sources. The sample was divided into two classes, namely the control class and the experimental class, through a homogeneity test using Lavene's Test to analyze the data of the mid-semester test scores of physics subjects in class XII at SMAN Ambulu. The implementation stage involves conducting learning activities using the usual methods employed by teachers in the control class, as well as implementing learning activities with the discovery learning model, assisted by a Vee Map. This stage also includes collecting data on the posttest results of learning outcomes and inference skills of students. The data collection technique utilizes primary data in the form of posttest results on inference skills and student learning outcomes related to the subject of alternating current. Supporting data are collected through observation, interviews, and documentation. The last stage is managing and analyzing data, compiling results, conducting discussions, and drawing conclusions. The initial stage in data analysis is to conduct a normality test using the Kolmogorov-Smirnov test on inference skills data and physics learning outcomes. This study employs the independent sample t-test, assuming that the data are typically distributed. Still, the data is not normally distributed. In that case, it uses the Mann-Whitney U-test to examine the hypothesis regarding whether the discovery learning model assisted by Vee Map affects the inference skills and physics learning outcomes of high school students in alternating current material. The data were analyzed using IBM SPSS software version 23. The research stages are illustrated in Figure 1.

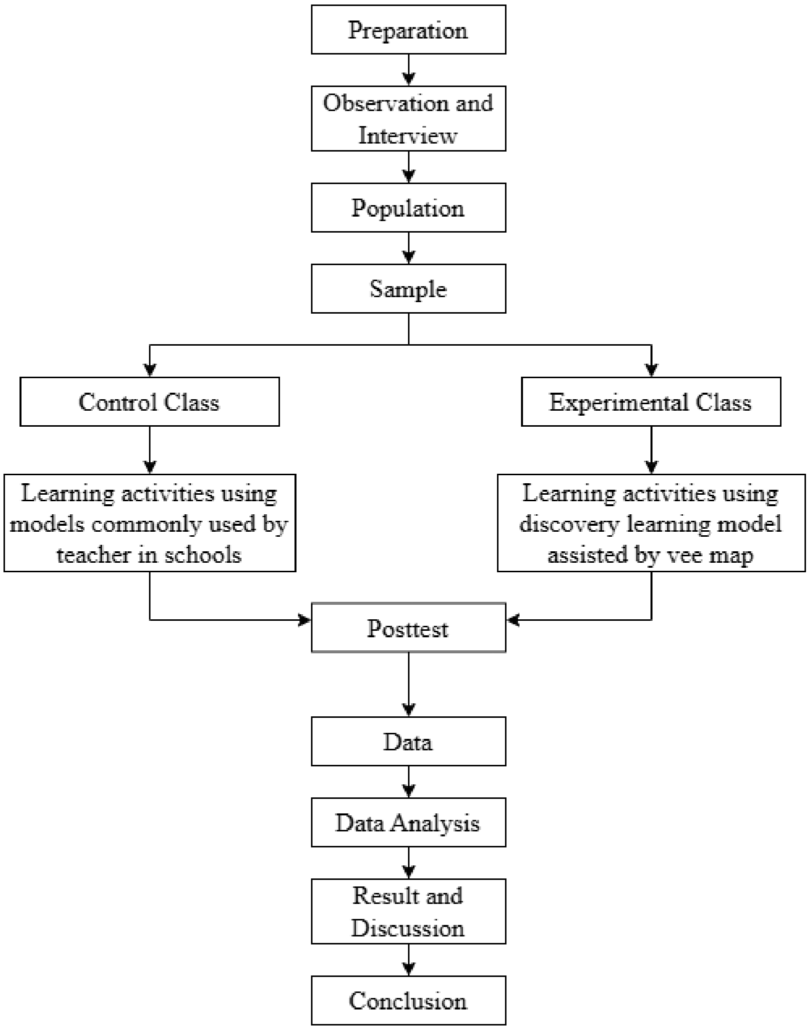

Figure 1. Chart of Research Procedure

RESULTS AND DISCUSSION

Population determination is performed using a homogeneity test based on physics UTS scores. The technique for the homogeneity test used Lavene's Test, and the result obtained was a homogeneity test with a significance value of 0.821 (0.821 > 0.05). , Thus, the area is homogeneous. Determination of research samples using cluster random sampling technique consisting of experimental and control classes. Thus, XII Science 1 was designated as the experimental class, and XII Science 2 became the control class. The learning process in the experimental class was implemented using the discovery learning model, assisted by a Vee map, whereas the implementation in the control class followed the model typically used in schools. The material taught in this study is Alternating current found in the odd semester. This research was conducted four times a meeting (4 JP) with a duration of 80 minutes at each meeting.

The Effect of Discovery Learning Model Assisted by Vee Map on Inference Skills

Students' inference skills are assessed through the posttest administered at the end of the learning period. This posttest activity aims to assess the development of inference skills, assisted by a Vee map, after learning with questions that refer to inference skill indicators. Inference skills data can be observed in Table 2 below:

Table 2. Data on students' inference skills

Class Type	N	Lowest Score	Highest Score	Average
Experiment Class	36	54.2	91.7	76.389
Control Class	34	50.0	87.5	68.871

The average value, as shown in the table above, indicates that the experimental class has a higher value than the control class. The recapitulation of the average data of inference skills on each indicator is as follows.

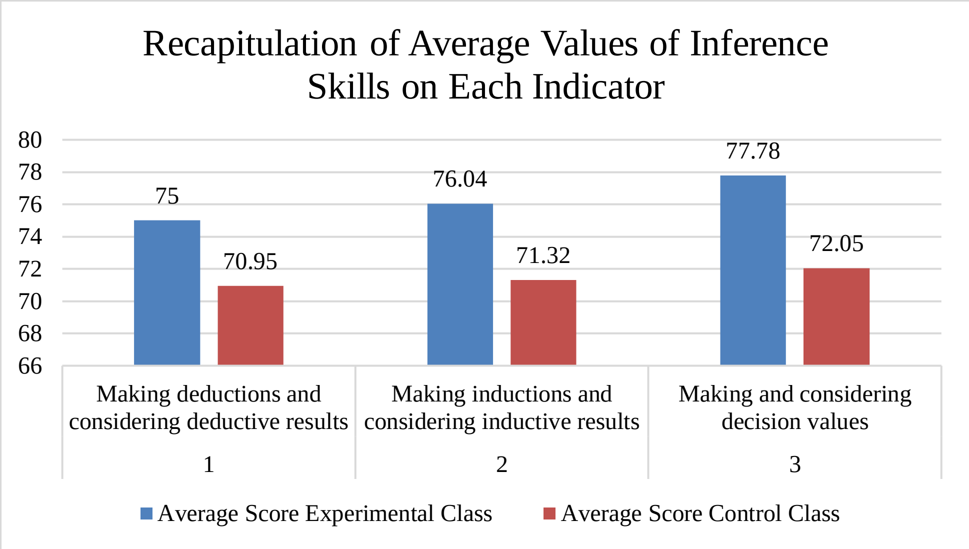

Figure 1. Recapitulation of Inference Skills for Each Indikator

Analysis of the Effect of the Discovery Learning Model Assisted by Vee Map on Inference Skills Using Normality Tests and t-Tests with SPSS 23. Based on the results of the normality test, it was found that the inference skills of both classes were normally distributed, with significance values of 0.069 in the experimental class and 0.200 in the control class. The results of the normality test for normally distributed inference skills data indicated that the independent sample t-test was then conducted. Hypothesis testing using the independent sample t-test technique yielded a Significant Result. (2-tailed) $0.006 \leq 0.05$. Thus, the null hypothesis $H0$ is rejected, and the alternative hypothesis Ha is accepted. This Ha hypothesis is defined when there is a difference in students' inference skills between the control class and the experimental class, while $H0$ is defined when there is no difference in students' inference skills between the control class and also the experimental class.

The primary objective of this research is to investigate the impact of the discovery learning model, combined with a Veea map, on students' inference skills. Students' inference skills were measured using a posttest instrument consisting of 6 essay-style questions, administered after learning in both the control and experimental classes. The posttest indicators used are those developed by Ennis (2011), specifically making deductions, inductions, and considering the value of decisions [24]. Based on the data generated, the average experimental class is greater than the control class. The results of the data analysis in this study were obtained through an independent sample t-test, indicating a significant difference in the average value of inference skills between the experimental and control classes. This shows that the use of the discovery learning model, assisted by the Vee map, has a significant impact on the inference skills of high school students.

The results obtained are based on Bruner's Theory, which explains that effective learning can be achieved when students actively participate in the learning process, allowing them to discover and understand concepts independently [25]. This Theory reveals that learners can construct new concepts or ideas from prior knowledge. These concepts can be visualized using tools in the form of Vee maps. According to Novak and Gowin (1984), the use of vee maps can strengthen students' understanding by providing structure to the information they learn [17]. Vee maps help students organize information and link Theory with practice, enabling their critical thinking skills to improve. Inference skills are one of the essential thinking skills, according to Ennis [24]. Students making inferences must follow steps from reasons to a conclusion through deductive thinking, inductive thinking, and considering the results of their decisions.

The discovery learning model encourages students to ask questions, make discoveries, and draw conclusions independently. This is explained by the Theory of Constructivism, which emphasizes the process of knowledge construction that requires students to be more actively involved in learning activities, formulate concepts, and understand the meaning related to the things they learn [26] . This process not only improves concept understanding but also trains critical thinking skills. Learning with the discovery learning model, assisted by a Vee map, encourages students to be actively involved in the process of concept discovery through observation, experimentation, and data analysis. This finding aligns with the results of Amini *et al.* (2018), which revealed that the discovery learning model is effective in enhancing students' inference skills [19]. The discovery learning model can integrate theoretical learning with direct experimental learning, thereby enhancing students' critical thinking skills [4].

The research results obtained are in line with the findings of Anawati et al. (2020), which indicate that the implementation of the discovery learning model has a positive impact on students' critical thinking skills, including inference skills [27]. This finding is supported by Afiesta et al. (2022), who revealed that learning through the discovery learning model, which involves learning syntax, enhanced high school student's ability to think critically, as evidenced by an increase in test scores after the implementation of learning activities [21]. Vee maps can also hone students' critical thinking skills, which include inference skills. This research aligns with Adawiyah et al. (2022), who found that students' critical thinking skills improved after implementing learning using Vee maps through experimental activities [23]. The research results obtained indicate that the discovery learning model, assisted by the Vee Map, has a positive impact on students' inference skills in the subject of alternating current. The application of the discovery learning model, supported by the Vee map, can be an effective strategy for improving students' critical thinking skills, especially in the context of physics learning.

The obstacles identified in this study are the lack of student knowledge about Vee maps, which necessitates detailed explanations regarding their use in learning. Additionally, the research method faces obstacles, specifically the research design employed, which is a posttest-only control group design. Therefore, it is not possible to determine the initial differences between the control and experimental classes. Based on these constraints, the limitations of this study include the limited research time of only four meeting hours, which means that the long-term impact of the discovery learning model assisted by Vee Map on inference skills remains unknown. This study is also limited by the absence of other variables that can mediate the effect of the discovery learning model with Vee Map on inference skills, such as student learning styles and interests. Therefore, further research is needed to consider the long-term impact of the discovery learning model, assisted by Vee Map or other learning models. In addition, additional research is also required to mediate other variables that can affect students' inference skills. This research suggests that teachers can effectively apply the discovery learning model and Vee map approach in physics classes to enhance students' inference skills. In addition, teachers can also combine the discovery learning model with other methods, such as the VEE map or other learning models combined with the VEE map, in the context of learning, especially in abstract physics materials, such as alternating current.

The Effect of *Discovery Learning* Model Assisted by *Vee Map* on Physics Learning Outcomes

Data on students' physics learning outcomes were collected through the experimental class posttest and the posttest in the control class after the learning period. In the experimental class, the posttest was conducted after the implementation of learning using the discovery learning model assisted by a Vee map. The posttest in the control class was administered after implementing learning using the method commonly employed by physics teachers. The following are the results of the acquisition of physics learning outcomes data in the control class and experimental class.

Table 3. Data on Students' Physics Learning Outcomes

Class Type	N	Lowest Score	Highest Score	Average
Experiment Class	36	56	96	80,08
Control Class	34	50	90	70,41

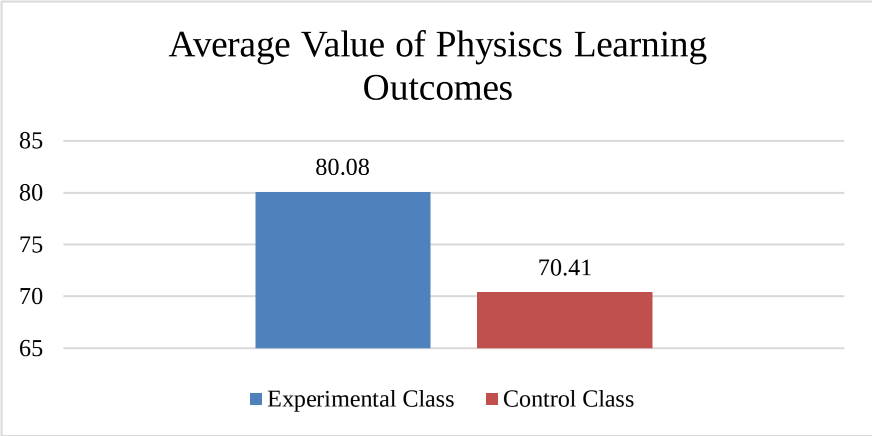

Figure 2. Recapitulation of the Average Value of Physics Learning Outcomes

The results obtained show a significant difference in the average value of physics learning outcomes for alternating current material between the control class students and the experimental classes, with the control class showing lower results compared to the experimental class. An analysis of the effect of applying the discovery learning model, combined with a Vee map, on students' physics learning outcomes is conducted using a normality test. A normality test was conducted in Class XII Science 1, yielding a significance value of 0.200 ($p > 0.05$), and in Class XII Science 2, yielding a significance value of 0.200 ($p > 0.05$), indicating that the physics learning outcomes data were normally distributed. Hypothesis testing using an independent sample t-test technique yielded a significant p-value. (2- tailed) $0.000 \leq 0.05$ so that$H0$is rejected and Ha is accepted.Ha is defined when there is a difference in student physics learning outcomes between the control class and the experimental class, while $H0$ is defined when there is no difference in student inference skills between the control class and the experimental class.

The second objective of this research is to investigate the impact of the discovery learning model, supplemented by Vee Map, on the physics learning outcomes of high school students in the context of alternating current material. The posttest contains six multiple-choice questions that assess cognitive aspects. The question indicators are aligned with the revised Bloom taxonomy by Anderson and Krathwohl (2001). The questions are derived from physics books and exercise books that have been modified. Posttest questions are adjusted to the cognitive domain starting from C1, C2, C3, and C5. Based on the data obtained, it is evident that the experimental class has a higher average value than the control class.

The results of the data analysis obtained in this study, using an independent sample t-test, indicated a difference in the average physics learning outcomes between the experimental and control classes. This suggests that the use of the discovery learning model, combined with the VEE map, has a significant effect on the physics learning outcomes of high school students. The results obtained are based on Ausubel's Theory, which emphasizes the importance of meaningful learning, where students combine new information with their existing knowledge. Optimal learning outcomes occur when students can integrate new concepts with relevant expertise to create a deeper understanding [28]. This is also supported by another Theory, namely Gagne's Theory, which emphasizes that effective learning occurs when students can process information correctly, involving the organization of data, solving problems, and developing concepts [29].

Organizing and integrating concepts can be facilitated through a Vee map in discovery learning. The Vee map, developed by Novak and Gowin, is a problem-solving problem-solving method based on scientific stages, and students are given the option to build their knowledge independently, which can positively impact students' cognitive learning outcomes [17]. The results of the study align with those of Adawiyah et al. (2022), which state that students are actively involved in the process of concept discovery, data collection, and knowledge organization through a Vee map [23].

Vee maps can encourage students to understand physics concepts deeply and apply them in solving problems, thus having a positive impact on learning outcomes. This finding aligns with the research of Usman and Samudra (2023), who found that the use of the Vee heuristic learning model with concept maps can improve learning outcomes and scientific attitudes among students in physics materials [30] . The results of this study are also in line with the research of Pardede et al. (2023), which revealed that learning physics with a discovery learning model assisted by mind maps can improve student learning outcomes [14] . In addition, Pascaeka et al. (2023) also found in their research that Vee maps can encourage active students to discover physics concepts, which in turn can improve students' conceptual understanding [22].

Several obstacles and limitations were encountered during the research process. The obstacle that existed during the learning process with the discovery learning model, assisted by the Vee map, was the difficulty in conditioning students. This is because students rarely use Vee maps in their learning, so many students are still confused about working on LKPD and following the learning process. The limitations of this study are primarily due to the research time, which is limited to four meeting hours in both the control and experimental classes. Additionally, this study only examines the effect of the discovery learning model, assisted by Vee Map, on learning outcomes for alternating current material. This limits the generalization of research results to other physics materials. Based on the provided description, the discovery learning model, assisted by the Vee map, has a significant impact on the inference skills and physics learning outcomes of high school students in the subject of alternating current. This finding suggests that the discovery learning model, assisted by a Vee map, can be used by teachers as an effective learning model to enhance the quality of physics learning, particularly in improving learning outcomes. Further research is needed to explore other learning models combined with the VEE map, aiming to gain a deeper understanding of student's abilities and skills and to provide insights into the effectiveness of discovery learning models and other learning models assisted by the VEE map in various educational contexts.

CONCLUSION

Based on the explanation provided, the discovery learning model, assisted by the Vee map, has a positive effect on the inference skills and physics learning outcomes of SMA Negeri Ambulu students in the subject of alternating current. Suggestions for schools, specifically learning models that incorporate discovery learning and Vee maps, which have not been previously applied, are expected to be considered as an option in physics learning and can enhance inference skills and improve student physics learning outcomes. For physics teachers, the discovery learning model, combined with Vee map tools, can be an alternative to traditional physics learning that is more active in concept discovery. For other researchers, applying or combining the discovery learning model with different methods or tools, such as Vee Map, and extending it to other subjects can serve as a reference for further research.

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