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THE EFFICACY OF DISCOVERY LEARNING IN ENHANCING THE CONCEPTUAL COMPREHENSION OF IMPULSE AND MOMENTUM AMONG CLASS X STUDENTS IS EXAMINED

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ABSTRAK

Abstrak: Materi Impuls dan Momentum adalah salah satu materi Fisika yang diajarkan di SMA. Penelitian ini bertujuan untuk mengevaluasi dampak positif pembelajaran discovery learning dalam meningkatkan pemahaman konsep peserta didik kelas X terhadap materi Fisika, khususnya impuls dan momentum di tingkat SMA. Metode penelitian yang digunakan adalah desain true experimental dengan pretest-posttest control group design. Analisis data melibatkan uji prasyarat analisis data, analisis deskriptif, dan uji hipotesis. Berdasarkan hasil penelitian dan pembahasan sebelumnya, dapat disimpulkan bahwa hipotesis nol (Ho) ditolak dan hipotesis alternatif (Ha) diterima. Hal ini dilihat dari nilai t-hitung sebesar 3,66 yang melebihi nilai t-tabel sebesar 1,67. Dengan demikian, dapat disimpulkan bahwa pemahaman konsep siswa yang menggunakan model pembelajaran *Discovery Learning* lebih baik daripada siswa yang menggunakan model pembelajaran konvensional. Nilai rata-rata hasil belajar untuk kelas eksperimen adalah 61,26, melebihi nilai rata-rata kelas kontrol yaitu 55,25. Hasil ini menunjukkan bahwa pemahaman konsep peserta didik yang mengikuti pembelajaran dengan model *Discovery Learning* lebih baik dibandingkan dengan mereka yang menggunakan model pembelajaran konvensional.

Abstract: *Impulse and momentum material is one of the Physics materials taught in high school. This study aims to evaluate the positive impact of discovery learning in improving the concept understanding of grade X students on Physics material, especially impulse and momentum at the high school level. The research method used is true experimental design with pretest-posttest control group design. Data analysis involves data analysis prerequisite tests, descriptive analysis, and hypothesis testing. Based on the results of the research and the previous discussion, it can be concluded that the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted. This can be seen from the t-count value of 3.66 which exceeds the t-table value of 1.67. Thus, it can be concluded that the concept understanding of students who use the Discovery Learning learning model is better than students who use the conventional learning model. The average value of learning outcomes for the experimental class was 61.26, exceeding the average value of the control class which was 55.25. This result shows that the concept understanding of students who follow learning with the Discovery Learning model is better than those who use the conventional learning model.*

A. INTRODUCTION

Impulse and Momentum material is one of the Physics materials taught in high school (Defrianti et al., 2021; Eksanita et al., 2021). In studying this material, students also often make mistakes in working on questions related to the material. Students must have a thorough understanding of existing concepts to be able to solve Momentum and Impulse questions correctly. Most of the concepts in Physics have clear meanings because they are agreed upon by physicists, but the interpretation of Physics concepts can vary between one student and another.

Physics is a subject that demands quite a high level of intelligence so that most students have difficulty studying it (Kawuri et al., 2019). As a result, it often causes problems during the physics learning process. This can cause the expected physics learning outcomes to be difficult to achieve (Bao & Koenig, 2019).

The identification results from research conducted Haqqo et al., (2023) of 34 students, 29 students experienced misconceptions, 4 students experienced a lack of understanding of the concept, and 1 student experienced understanding of the concept in the material of momentum, impulse and collision. The percentage of misconceptions experienced by students is 42.86% and the causes of misconceptions are dominated by false negatives and associative thinking. The highest misconception occurred in the questions about analyzing phenomena with conservation of energy and momentum in collisions of 35.29%.

The results of research conducted Liwanag et al., (2022) analyzed multiple choice tests with open reasoning, totaling 20 questions, there were 16 questions that had misconceptions and 4 questions that were mastered by students well. In question number 12, the majority of students (69%) mastered the concept well. Students have misconceptions about all the concepts tested, namely momentum, impulse, the relationship between momentum and impulse, the law of conservation of momentum, collisions. The number of students who experienced misconceptions about each question item was 31% - 97% out of 32 students. On the concept of momentum, 91% of students have misconceptions, on the concept of impulse, 87% of students have misconceptions, on the concept of the relationship between momentum and impulse, 75% of students have misconceptions, on the concept of the law of conservation of momentum, 91% of students have misconceptions, on the concept of collisions, 97% students' misconceptions.

Based on observations and interviews conducted at SMAN 1 Gondanglegi. The learning used still uses conventional learning or teachers still tend to use the lecture method. This is seen as not being in line with what is expected by the Indonesian education curriculum. And in this learning, students feel they are still unable to express what they want to say because the center of learning is still focused on the teacher. In several classes, many students say that physics is a subject that is very difficult to understand with many formulas that have to be memorized so that they tend to get bored and become lazy in studying physics. As a result, when taking exams, students feel confused and are unable to answer questions correctly so that the learning outcomes obtained by students are relatively low. For this reason, it is necessary to use more effective learning methods.

There are several learning methods that can be used by teachers in teaching and learning activities, including the discovery learning method. Discovery learning is a way of teaching that involves students in the process of mental activity through exchanging opinions, discussions, reading on their own, and trying for themselves so that children learn on their own (Susilawati et al., 2022; Yuberti et al., 2019).

The advantage of this learning model is that it encourages students to think and work hard on their own initiative. According to Rahmah et al., (2023) the discovery learning model (learning through discovery) is a learning theory which is defined as a learning process that occurs when students are not presented with lessons in their final form, but are expected to organize their own learning. Also encourages students to think intuitively and formulate their own hypotheses. Provide decisions that are intrinsic, and create a more stimulating learning situation. Through this learning, students can learn more independently and construct knowledge obtained from the results of thinking and be trained in solving the problems they face.

Defrianti et al. (2021) found that implementing discovery learning had a significant impact on students' proficiency in understanding physics subjects. This is seen by the rise in the mean level of concept mastery among students instructed via discovery learning, which surpasses that of those instructed through traditional learning. The focus of this study is to investigate the impact of discovery learning on enhancing the conceptual understanding of impulse and momentum among students in class X.

B. RESEARCH METHOD

This research method uses research methods true eksperimental designs. The research design is described as follows.

Table 1. Research design

Group	Pre-test	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Information:

X: learning treatment with learning models

O1: pre-test score of the experimental group before being given treatment
O2: post-test score of the experimental group after being given treatment
O3: control group pre-test score before treatment
O4: post-test score of the control group after being given treatment

The population under study consists of 10th-grade students from SMAN 1 Gondanglegi during the second semester of the 2022/2023 academic year. This study focuses on the concepts of impulse and momentum, relevant to the Science curriculum for 10th-grade students. The sample includes students from class X Science, selected purposefully to align with the research objectives. The experimental group was taught using the Discovery Learning model, while the control group received traditional instruction. Both groups underwent pre-tests and post-tests, including a learning motivation questionnaire and a learning accomplishment exam.

The research instruments include treatment and measurement tools aimed at assessing students' understanding of physics concepts. The treatment instruments are the Learning Implementation Plan (RPP) and Student Worksheets (LKPD). The measurement instruments consist of observation sheets for both Discovery Learning and conventional learning implementations and tests for understanding physics concepts. Observation sheets rated the implementation on a scale from poor to very good.

Instrument validity was verified through several stages. Content validity was ensured by consulting physics education professors, and construct validity was assessed using an instrument grid with input from experts. Empirical validity was checked by comparing criteria with research findings. The Pearson Product Moment Correlation method was used to test item validity using SPSS 24 for Windows. Of the 22 questions tested, 16 were valid. Invalid items were excluded from the comprehension exams. Reliability was determined using Cronbach's Alpha via SPSS 24, indicating a reliable tool with a coefficient value exceeding 0.05.

The analysis included measuring discriminating power and difficulty levels. Data collection involved pre- and post-treatment concept knowledge tests. Data analysis employed prerequisite tests, descriptive analysis, and a right-sided t-test to compare the impact of Discovery Learning on students' conceptual understanding with that of traditional learning.

C. RESULT AND DISCUSSION

1. Description of Learning Process Implementation Data

Data on the execution of the learning process in both the experimental class and control class were acquired throughout the occurrence of the learning process. The experimental class in X-MIA-3 SMAN 1 Gondanglegi employs the Discovery Learning model for the learning process, whereas the control class in X-MIA-1 SMAN 1 Gondanglegi utilizes traditional learning methods. In all groups, there were a total of 3 sessions dedicated to learning about impulse and momentum, and 2 sessions for pre-test-post-test assessments. The learning implementation in both the experimental class and control class was derived from the observation sheet. Observations are conducted during the process of acquiring knowledge.

The physics instructor at SMAN 1 Gondanglegi and a physics student conducted observations.The degree of difficulty is determined by a difficulty index, which takes into account the number of participants that replied correctly. The subsequent data analysis encompassed preliminary data analysis tests, descriptive analysis, and hypothesis testing utilizing the right-sided t test to evaluate the impact and enhancement of students' comprehension of concepts between the group employing Discovery Learning and the control group employing conventional learning.

Table 2. Average Data on Learning Implementation for Experimental Class and Control Class

RPP	implementation (%)	
	Experiment	Control
Momentum	84	84
Impulse	84	83
Collision	84	83
Average	84	83

Table 2 reveals that the implementation procedure of the experimental class and control class is almost same, and the learning outcomes are likewise satisfactory. This is shown by the average percentage of learning implementation. The mean size among the experimental group is 84% while the control class is 83%.

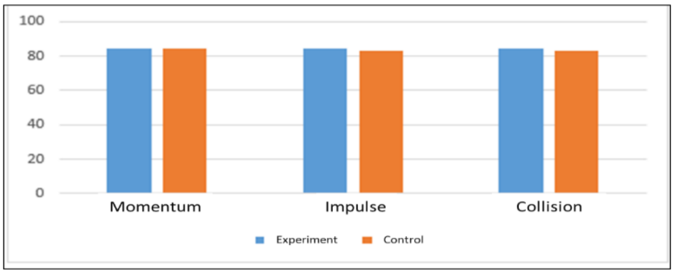

Figure 1. Graph of the Average Implementation of the Experimental Class and Learning Process Control Class

2. Data Description and Analysis of Students' Initial Concept Understanding

Information on the students' starting ability was acquired via the students' pre-test results on impulse and momentum material. A similarity test was conducted on the average beginning Concept Understanding scores of students to verify that both courses had identical starting Concept Understanding. Prior to conducting the similarity test, it is necessary to perform preparatory tests, namely the normalcy test and the homogeneity test. The statistics representing students' early conceptual grasp may be shown in Table 3.

Table 3. Description of Initial Concept Understanding data for Experimental Class and Control Class

Class	Experiment	Control
Number of Students	27,0	28,0
Lowest Value	20,0	20,0
The highest score	60,0	60,0
Average	38,0	40,7
Standard Deviation	10, 8	10,6

Based on Table 3, it can be seen that the initial conceptual understanding of students in the experimental class and the control class has an average difference. The average initial Concept Understanding score for students in the experimental class and control class was 38.0 and the control class was 40.7.

Figure 2 shows the histogram of the control class Pre-test values. The histogram can be seen if the value data is mostly below the normal curve line. Even though there is one part that is empty.

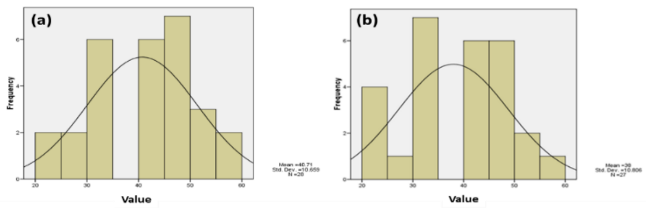

Figure 2. Histogram Description of Initial Concept Understanding data (a) Control Class, and (b) Experimental Class

Figure 2b shows the histogram of the control class Pre-test values from the histogram. It can be seen that most of the data values are below the normal curve line. Even though there is one part that is empty.

3. Data Analysis Results of Students' Initial Concept Understanding

Table 4 displays the outcomes of the data analysis conducted on the first conceptual comprehension of students in both the experimental and control classes.

Table 4. Data Analysis Results of Initial Concept Understanding of Experimental Class and Control Class Students

Parameter	Control	Experiment	Information
Normality (Sig.)	0,066	0,200	Normal
Homogeneity (Sig.)	0,900		Homogen
Concept Similarity (t-value)	0.937 (2.005)		there is no difference

According to Table 4, the experimental class students' first conceptual comprehension data has a significance value of 0.200 and the control class data is 0.066. Thus, experimental and control class students' first Conceptual Understanding data is regularly distributed. Table 1 also shows that experimental and control class students' first Conceptual Understanding statistics had similar variances. The significance level is 0.900, above 0.050. Table 2 shows that the computed t-value is in the Ho acceptability region or between t(table), indicating that the control and experimental classes have similar conceptual comprehension.

4. Data Description and Analysis of Students' Final Concept Understanding

Post-test scores on impulse and momentum material following Discovery Learning provided final concept knowledge data. Table 5 shows students' ultimate conceptual knowledge of the experimental and control classes.

Table 5. Description of final concept understanding data for experimental class and control class

Class	Experiment	Control
Number of Students	27,0	28,0
Lowest Value	47,0	33,0
The highest score	87,0	73,0
Average	65,9	55,2
Standard Deviation	11,3	10,2

Table 5 shows a difference in average final conceptual knowledge between experimental and control students. The experimental class averaged 65.9 first Concept Understanding scores and the control class 55.2. Final Concept comprehension data was analyzed to see whether the experimental class treated with Discovery Learning had a greater concept comprehension than the control class treated with traditional learning. Analysis employs assisted right-hand Independent Sample t-Test. Before the right-side Independent Sample t-Test. Data was tested for normality and homogeneity.

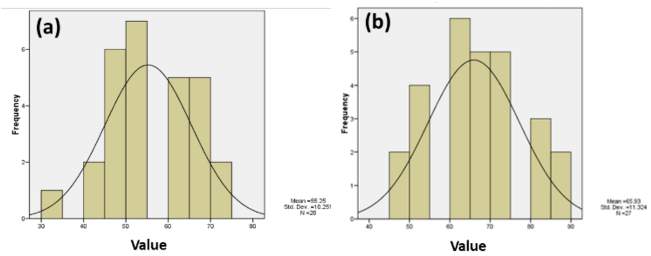

Figure 3. Histogram Description of Final Concept Understanding data (a) Control Class and (b) Experimental Class

The Histogram reveals that the post-test results data for both the control group and the experimental group mostly fall below the normal curve. Figure 4 displays the histogram of the post-test results for both the control class and the experimental class.

5. Data Analysis Results of Students' Final Concept Understanding

Table 5 shows the final Concept Understanding data normality test results for experimental and control students.

Table 6. Results of Data Analysis on Final Concept Understanding of Experimental Class and Control Class Students

Parameter	Control	Experiment	Information
Normality (Sig.)	0,086	0,158	Normal
Homogeneity (Sig.)	0,602		Homogen
Concept Similarity (t-value)	3,66	(1.67)	there is no difference

Table 2 shows that experimental class students' final Conceptual Understanding data has a significance value of 0.158 and control class data is 0.086. Conclusion: Experimental and control class students' final Conceptual Understanding data is regularly distributed. The final Concept Understanding data for experimental and control class students displays similar variation. The significance value is 0.602, above 0.050. Ho is valid if t_count < t_table. According to Table 2, students who use the Discovery Learning learning model have a higher conceptual understanding than those who use conventional learning models, as t_count is greater than t-table (1.67). Therefore, Ho is rejected and Ha is accepted. Experimental class averages 65.9 and control class averages 55.2.

6. Discussion

a. Implementation of the Learning Process

Observations or learning observations might show research learning implementation. Each of the three learning meetings was observed. Learning observers from SMAN 1 Gonndanglegi physics instructors and students. Learning implementation averaged 84% for the experimental class and 83.3% for the control class. Several of the two courses' averages were not met or in compliance with the Learning Implementation Plan.

First experimental class meeting addressed momentum submaterial. The instructor greets pupils and records attendance before playing an appreciation film about busses and motorcycles driving down a hill. After the appreciation video, the instructor asks questions. After that, the instructor explains the learning goals and splits pupils into small groups. Students see a demonstration of halting people running and walking to understand a new occurrence. Students practice observation skills by watching the presentation.

The second step (manipulation) is that students identify the phenomena that have been given and connect them with existing concepts. When identifying the phenomenon of practicing observing, understanding and applying skills, this can be seen from the way students carry out experiments in accordance with procedures. In this step, what the teacher does is provide students with LKPD about momentum and encourage students to have group discussions and express opinions to each other. in his group. The experiment was carried out using the Phet "collision" application simulation to observe how the speed and direction of two colliding objects would be if they had the same mass, the same speed, different masses and different speeds.

The third step (Generalization) students analyze experimental data to develop principles that can explain the observed phenomena. The students' analysis skills in this step look good as evidenced by the way students discuss analyzing experimental data in the form of the direction of two balls in the Phet simulation and begin to connect it with existing concepts to solve problems in the experiment.

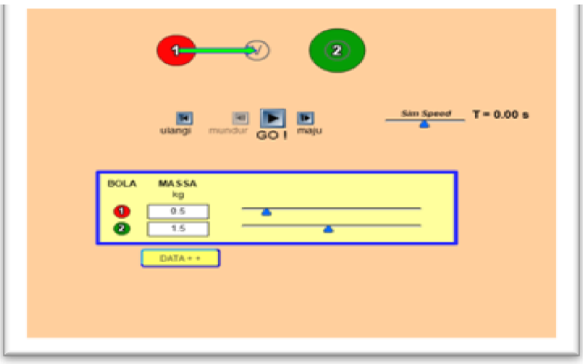

Figure 4. Momentum PhET simulation

Figure 5. Students discuss with groups

The fourth step (Verification) in this step, students present the results of their group discussion in front of the class to verify the correctness of the concepts used and compare with other groups. Each group got their part to present, the first group discussed the phenomenon of the collision of two balls of the same mass, the next group discussed the collision of two balls with the same speed, and the third discussed the collision of two balls with different masses. here the teacher's role is only as a facilitator who corrects inappropriate concepts.

The final step (Application) at this stage students conclude that what influences momentum is the speed and mass of the object. Students also concluded that the phenomenon being demonstrated would be more difficult to stop a person who is running than a person who is walking because the speed of the person running is greater.

According to the learning description, pupils comprehend momentum. Through methodical steps in the discovery learning model, students may build autonomous thinking and grasp momentum (Ndoa et al., 2022; Putra et al., 2019; Rahmah, 2023). Student participation affects concept knowledge (Purwaningsih et al., 2020; Rahayu & Kuswanto, 2021; Sukmadewi & Jumadi, 2023). Discovery learning helps kids grasp impulse and momentum. Students' activeness in discovery learning improves concept knowledge, according to Putra et al. (2019).

This second meeting discussed impulses, the meeting lasted 2 x 40 minutes. In this second meeting, students had read a little about impulse material. It was a bit different from the first meeting. The second meeting was opened with greetings by the teacher and then began to record student attendance. After that the teacher started showing a video about impulse, namely airbag simulation. Then the teacher asks the students several questions about the video. students are enthusiastic to answer.

The first step of learning (observation) through a video, the teacher begins to bring up cases of accidents that use airbags and those that don't use airbags. Guess who was more seriously injured using an airbag or not using an airbag. After seeing the video, students begin to observe (C1) this phenomenon. Next, the teacher instructs students to gather in groups determined at the previous meeting.

The second step (manipulation) is that students discuss with their groups to discuss the phenomena that have been presented and connect them with existing concepts. Students will be guided and directed to observe phenomena in order to find concepts, with the result that students will always be active until they find a correct conclusion. In this step students carry out the skills of observing (C1), understanding (C2), applying (C3) well. The teacher distributes LKPD about impulses, participants in each group observe the phenomenon on the LKPD. In this LKPD about impulses, students are asked to know the impact of impulses on accidents. Namely, the water safety bag uses the impulse principle $I = F\,\Delta t = \Delta P$. Step three (generalization) in this step students begin to analyze (C3) the data on the LKPD for application and connection with phenomena and impulse concepts. In this step, students are really required to use their own thinking skills. This will increase students' ability to understand concepts in analyzing physical phenomena.

In the verification stage, each group of students presents their findings and engages in a discussion with other groups in front of the class. In this level, the teacher's job is just that of a facilitator who verifies if there is any student who still lacks comprehension of the impulse notion. During the fifth phase, students determine the practical applications of the idea of impulse in their daily lives.

From the learning description, it may be inferred that pupils have acquired a grasp of the notion of impulse momentum. The influence of students' engagement in learning is the attainment of comprehension of the idea (Ointu et al., 2022; Sahrianti et al., 2021; Saputri et al., 2022). Discovery learning enhances students' comprehension of topics related to impulse and momentum. This is corroborated by a study done by Serevina & Luthfi, (2021), which demonstrates that students' engagement in discovery learning enhances their comprehension of topics.

This second meeting discussed impulses, the meeting lasted 2 x 40 minutes. In this second meeting the students had read quite a bit about impulse material. It was a bit different from the first meeting. The second meeting was opened with greetings by the teacher and then began to record student attendance.

The first step of learning (Observation) in this step the teacher brings a new phenomenon to the students. The teacher asked, "Have some of these students ever seen or played billiards?? What is the speed of the white ball after being hit? And what is the condition of the white ball and the ball that was hit by the white ball? The next step (manipulation) students begin to carry out a series of collision type experiments using the collision laboratory on the PhEt Colorado application. In this step, the skills of observing (C1), understanding (C2), and applying (C3) are carried out well, this is proven by following the practical procedures carried out by the students.

The third step (generalization) students analyze the data in the phet application in the form of the direction of the two balls after the collision and what the condition of the two balls was after the collision. From the data analyzed, students connect it with existing concepts. This proves good analytical skills (C4). The fourth step (verification) in this step, students represent their groups to express opinions from their respective groups about what types of collisions are and the characteristics of each type of collision. Here the teacher is only a facilitator who validates opinions that are not in accordance with the concept of collision.

The ultimate stage is the application phase, during which students put into practice the principles they have acquired during the learning process. During this stage, students demonstrate their proficiency in application skills (C3) by providing examples of various tasks that include the collision concept. Based on the provided learning description, it may be inferred that pupils possess the ability to comprehend the idea of momentum. Students' capacity for independent thinking may be cultivated via a structured progression in the discovery learning model, leading to a comprehensive grasp of the notion of momentum (Purwaningsih et al., 2020; Serevina & Luthfi, 2021). The influence of students' engagement in learning is the attainment of comprehension of ideas (Aliman & Astina, 2019). Discovery learning enhances students' comprehension of topics related to impulse and momentum. Research done by Simamora & Saragih (2019) demonstrates that students' engagement in exploration learning enhances their comprehension of subjects.

b. Students' understanding of physics concepts

According to Munawaroh et al. (2021), students' concept knowledge is judged by their ability to define (C1), identify (C2), and link (C3) ideas. Students averaged C1, C2, C3, and C4 cognitive skills after the post-test. A typical interpretation of experimental and control classes is as follows:

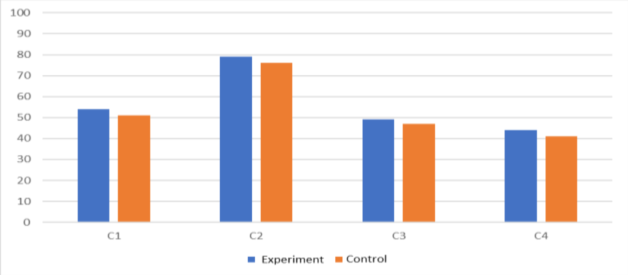

Figure 6. Graph of Average Gains for Each Cognitive Aspect C1 to C4 Experimental Class and Control Class

Comparing the mean values of the experimental class and control class, it is evident that the experimental class has greater values for C1, C2, C3, and C4 compared to the control class. The first cognitive talent is recall, when children possess the capacity to rearticulate the information they have acquired. The experimental class had higher average values of cognitive feature C1 compared to the control class. Discovery learning enhances pupils' observation abilities (C1), hence improving their memory.

The experimental group had a higher average value for the C2 cognitive feature compared to the control class, as shown by the findings. This is a result of manipulation and generalization. Students are expected to independently observe and examine the phenomena provided by the instructor. In the verification syntax, the instructor also affirms thoughts offered by pupils that are not suitable. The mean value of the C3 cognitive feature for the experimental group exceeded that of the control group. The reason for this is because discovery learning involves the use of an application syntax, where students express their ideas on everyday actions that demonstrate the concepts of impulse and momentum.

In addition, the experimental class had a higher average value for the C4 cognitive feature compared to the control class. This occurs due to the use of discovery learning methodology, whereby students examine empirical evidence and then establish connections with pre-existing ideas in order to address issues.

c. The Influence of Discovery Learning on Understanding the Concept of Impulse and Momentum Material

The impact of the discovery learning paradigm on students' conceptual comprehension is seen via the outcomes of hypothesis testing. The t-Test hypothesis test yielded a t-count value of 3.66, which exceeded the t-table value of 1.67. Therefore, it can be inferred that the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted. Consequently, it can be concluded that the conceptual understanding of students who utilize the Discovery Learning learning model is superior to that of students who employ conventional learning models. The mean learning outcome value for the experimental class is 61.26, surpassing the mean value for the control class of 55.25. According to Murillo-Zamorano et al. (2019), using discovery learning may enhance students' knowledge and comprehension, as well as promote intrinsic motivation. Discovery learning has the benefit of engaging pupils in active learning activities, resulting in a more enduring knowledge. This aligns with the assertion made by Rahmah et al. (2023) and Rodrigues et al. (2019) that effective learning occurs when individuals engage in direct experiential learning. The grammar of manipulation and generalization in the discovery learning paradigm contributes to enhancing the comprehension of ideas. Engeness (2021) suggests that engaging with the environment might enhance comprehension and enhance one's knowledge. Evrim and Dadli (2020) also highlighted that engaging in conversations with other students may enhance information acquisition and promote cognitive acuity.

This study aligns with the research conducted by Seprapti et al. (2023), which found that utilizing the guided discovery model for learning had a positive impact on students' conceptual understanding. The research demonstrated that students' engagement and performance during the learning process using the guided discovery model met high standards. Likewise, this is in line with research conducted by Lidiana et al., (2018) which concluded that discovery learning can increase understanding of dynamic electricity in the high category.

D. CONCLUSION AND SUGESTION

Based on the analysis and discussion of the research results, it can be concluded that the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted. The t-Test hypothesis test yielded a t-count value of 3.66, which exceeded the t-table value of 1.67. Consequently, it can be concluded that the conceptual understanding of students who utilize the Discovery Learning learning model is superior to that of students who employ conventional learning models. The mean learning outcome value for the experimental class is 61.26, surpassing the mean value for the control class of 55.25. Therefore, it can be concluded that students who learn using the Discovery Learning model have a higher conceptual understanding compared to students who learn using conventional learning models. The research findings suggest that this study solely focuses on evaluating students' comprehension of concepts taught through the discovery learning approach. Consequently, future researchers are encouraged to explore additional variables and investigate the advantages of implementing discovery learning.

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