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The Effect of the Discovery Learning Model on Students' Cognitive Learning Outcomes in Acid-Base Material

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Abstract: *This study aimed to determine the effect of the Discovery Learning model on students' cognitive learning outcomes in acid-base chemistry at SMA YPK Oikoumene Manokwari. A quasi-experimental method with a Control Group Pretest-Posttest design was employed. The sample consisted of 40 Grade XI science students divided into an experimental class (n = 20) and a control class (n = 20). The experimental class was taught using the Discovery Learning model, while the control class received conventional instruction. Data were collected through pretests and posttests and analyzed using descriptive statistics, paired-sample t-tests, N-Gain analysis, and effect percentage calculations with SPSS version 27. The findings revealed that the experimental class's mean score increased from 49.00 to 74.50, whereas the control class's mean score increased from 53.00 to 59.00. The experimental class achieved a moderate N-Gain category, with an effect percentage of 50%. Furthermore, the t-test results indicated a statistically significant difference ($p = 0.001 < 0.05$). These findings suggest that the Discovery Learning model significantly improves students' cognitive learning outcomes in acid-base chemistry compared with conventional instruction.*

Keywords: *discovery learning; cognitive learning outcomes; acid-base; chemistry education; quasi-experimental research.*

INTRODUCTION

Chemistry is a mandatory subject taught and developed at the Senior High School level. It encompasses a body of knowledge regarding the composition, structure, properties, and transformations of matter. Consequently, chemistry instruction not only fosters the mastery of knowledge. There are comprising facts, concepts, and principles, but also constitutes a process of understanding the subject itself (Silitonga, 2024).

Observations at SMA YPK Oikoumene Manokwari indicate that students perceive chemistry as a difficult and unappealing subject, a view that contributes to poor academic performance in the course. The

school largely relies on conventional pedagogical methods; teachers typically employ lectures to transmit knowledge, while students play a passive role as attentive listeners. Students are rarely given the opportunity to express themselves freely in class, which hinders them from reaching their full potential and renders the learning process unengaging.

The learning process can be viewed as a deliberate effort by the instructor to modify student behavior, evidenced by improved learning outcomes. Learning is a cognitive process involving the utilization of educational resources through dynamic interaction between educators and students, aimed at achieving specific objectives (Tobamba et al., 2019). The cognitive domain is a component of learning evaluation that can be measured through tests, whether written or oral. This is supported by Magdalena et al. (2020), who define the cognitive domain as a set of thought processes, in other words, an individual's ability to evaluate, connect, and consider events or occurrences. As cognitive abilities improve, students find it easier to grasp broader knowledge. Student learning outcomes can be enhanced by employing diverse learning models tailored to the specific subject matter being studied (Muhammad et al., 2023).

According to Adla & Maulia (2023), one solution to address low learning outcomes is the use of the Discovery Learning model. Discovery Learning is an instructional model in which students independently grasp concepts, meanings, and relationships through a process of understanding, ultimately leading to a conclusion. Mukaramah et al. (2020) note that the Discovery Learning model offers several advantages: it improves student learning outcomes, strengthens understanding, fosters independent learning and collaboration, generates a sense of enjoyment, and aids in memory retention. The Discovery Learning model can help students improve their learning outcomes because, regarding cognitive learning indicators, students are required to identify problems within existing concepts. Therefore, implementing the Discovery Learning model is an appropriate strategy to improve the low cognitive learning outcomes of students (Hanum et al., 2019).

Based on these issues, the researcher deemed it necessary to conduct a study titled "The Effect of the Discovery Learning Model students' cognitive learning outcomes in the acid-base material for XI science class at SMA YPK Oikoumene Manokwari."

The objectives of this study are as follows:

1. To determine whether there is a significant difference in the students' cognitive learning outcomes in the acid-base material for XI science class at SMA YPK Oikoumene Manokwari before and after the application of the Discovery Learning model.
2. To determine the percentage (%) of the effect of using the Discovery Learning model students' cognitive learning outcomes in the acid-base matetrial for XI science class at SMA YPK Oikoumene Manokwari.

LITERATURE REVIEW

According to Parwati et al. (2023), learning is a process and activity aimed at acquiring knowledge, improving behavior, enhancing skills and attitudes, and strengthening personality. The process of gaining knowledge transforms into personal experience. Furthermore, Paling et al. (2024) define learning as a process of behavioral change, example: encompassing the elements of intellect, emotion, and volition (or the cognitive, affective, and psychomotor domains) resulting from personal experience and environmental interaction in the pursuit of meeting life's needs.

Learning outcomes are defined as the capabilities possessed by students following their engagement in learning experiences. The learning process requires students not only to attend to the material presented by the teacher but also to participate actively by asking questions, responding to the material,

interacting, and expressing opinions thereby influencing their learning outcomes. Hezmua states that learning outcomes are reflected across three domains: cognitive, affective, and psychomotor; these outcomes manifest across all three domains simultaneously (Dakhi, 2020).

Cognitive learning outcomes among students can be improved by employing varied learning models tailored to the specific subject matter (Muhammad et al., 2023). One effective model is Discovery Learning. According to Ozdem-Yilmaz and Bilican (2025), Discovery Learning is a concept introduced by psychologist Jerome Bruner in 1961. In this teaching method, students are not presented with the final version of the lesson material; instead, they are expected to organize the information themselves. Teachers engineer specific problems to prompt students to analyze situations and draw conclusions. Teachers must utilize stories, games, visual aids, and engaging techniques to stimulate student curiosity. Furthermore, teachers guide students toward new ways of thinking, acting, and reflecting. Discovery Learning can be implemented either individually or in groups. Group-based learning can take various forms, such as discussions, projects, simulations, or experiments. In contrast, independent learning involves providing students with relevant resources and materials—such as readings, videos, or specific simulations.

Discovery Learning empowers students to take the lead in their own learning process, while the facilitator or teacher acts as a guide or support system. This approach encourages creative thinking, resilience in the face of challenges, and learning from personal experience; these elements foster a deeper understanding of the work, enhance practical skills, and prepare students to navigate the complexities and changes of the work environment. In student training, Discovery Learning can be implemented through methods such as case studies, simulations, problem-based projects, role-playing, or experiments.

According to Budiastuti et al. (2023), the learning steps in the Discovery Learning model include stimulation, problem statement, data collection, data processing, verification, and generalization. (1) Stimulation: At this stage, students are confronted with something that provokes curiosity or confusion; no immediate generalization is provided, thereby fostering a desire to investigate independently; (2) Problem Statement: The teacher gives students the opportunity to identify as many problem issues relevant to the lesson material as possible. Subsequently, one problem is selected and formulated as a hypothesis; (3) Data Collection: During the exploration phase, students are given the opportunity to gather as much information as possible to test the validity of the hypothesis. This stage serves to answer questions or verify the hypothesis; students gather relevant information by reading literature, observing objects, interviewing sources, conducting their own experiments, and so forth; (4) Data Processing: This involves processing the data and information obtained by the students. Processing methods include interviews and observations; the data is organized, sorted, classified, tabulated, calculated if necessary, and interpreted at a specific confidence level; (5) Verification: Students carefully examine their findings—linked to the data processing stage—to determine the validity of the established hypothesis. Verification ensures the learning process is effective and creative, particularly when the teacher allows students to discover concepts, theories, rules, or understandings through examples encountered in their daily lives; (6) Generalization: This is the process of drawing a conclusion that serves as a general principle applicable to all similar events or problems, based on the verification results. The principle underlying the generalization is formulated based on this verification.

METHODS

This study employs a quantitative approach using a quasi-experimental method with a Control Group Pretest-Posttest design. The study population consists of all Grade XI Science students at SMA YPK Oikoumene Manokwari. The sample comprises two classes selected through purposive sampling. An experimental class using the Discovery Learning model and a control class using conventional instruction with 20 students in each. Multiple-choice questions were used as the instrument to measure cognitive learning outcomes. Data analysis involved descriptive statistics, normality and homogeneity tests (as prerequisite tests), a paired t-test to examine significant differences, N-Gain calculations to determine the improvement in learning outcomes, and the calculation of the percentage of influence to assess the learning model's effectiveness, all facilitated by SPSS 27 software.

RESULT AND DISCUSSION

1. Instrument Validity Test Results

The validity test is used to measure the accuracy and precision of a measuring instrument in performing its function. The instrument validity tests in this study covered the Lesson Plan (RPP), multiple-choice pretest and posttest questions, and Student Worksheets (LKPD). Validity testing involved two expert validators: a Chemistry Education lecturer from the University of Papua and a chemistry teacher from SMA YPK Oikoumene Manokwari. The validity test results were 3.75 (Highly Valid/SV) for the RPP, 3.75 (Highly Valid/SV) for the pretest and posttest questions, and 3.85 (Highly Valid/SV) for the LKPD; based on the instrument validity scale, these values fall into the "Highly Valid" (SV) category. These values represent the aggregated ratings from the two validators, divided by the total number of aspects and indicators for each instrument used (RPP, pretest-posttest questions, and LKPD).

2. Instrument Reliability Test Results

The reliability test in this assessment aims to determine whether an instrument is sufficiently reliable for use as a data collection tool. Reliability in this study was calculated using Cronbach's Alpha with the aid of SPSS 27 software. The calculation results for the pretest and posttest data using the Cronbach's Alpha formula (via SPSS 27) are presented in Table 1 for the control class and Table 2 for the experimental class.

Table 1. Reliability test results for pretest and posttest scores (control class)

Reliability Statistics			
Data	*Alpha Cronbach*	N	meaning
Pretest-Posttest	**0,58**	**20**	**moderate reliability**

Based on the data in Table 1, a reliability test using Cronbach's Alpha formula was conducted on the pretest and posttest data of the control class. The study fell into the moderate reliability category, yielding a value of 0.58; according to Sugiyono's (2018) reliability criteria, the result is falling within the range of $0.40 \leq 0.58 \leq 0.60$. It is indicates moderate reliability.

Table 2. Reliability test results for the experimental class pretest and posttest scores

Reliability Statistics			
Data	*Alpha Cronbach*	N	meaning
Pretest-Posttest	**0,69**	**20**	**high reliability**

A reliability test using Cronbach's Alpha formula was conducted on the pretest and posttest data from the experimental class. The study fell into the high reliability category, yielding a value of 0.69; based on Sugiyono's (2018) reliability criteria: where a result falling within the range of $0.60 \leq 0.69 \leq 0.80$ is classified as high reliability. It is mean, this value indicates high reliability.

3. Pretest and Posttest Descriptive Test Results

The pretest results represent the initial data obtained once prior to the commencement of the learning process in

both the control and experimental classes. The posttest results represent the data obtained once after the experimental class received the treatment using the Discovery Learning model and the control class received instruction using a conventional learning model (lectures and question-and-answer sessions). Descriptive data analysis was performed using SPSS 27 software. The pretest and posttest data for both classes are presented in Table 3.

Table 3. Descriptive Statistics for Pretest and Posttest

	N	Min	Max	Average	Standars deviation
Pre-Test Experiment	20	20	80	49.00	15,526
Post-Test Experiment	20	50	100	74,50	13,169
Pre-Test Control	20	30	80	53,00	13,803
Post-Test Control	20	40	80	59,00	10,712
Valid N (listwise)	20				

Based on Table 3, it is evident that the scores differ; the minimum and maximum pretest scores for both classes were lower than the minimum and maximum posttest scores.

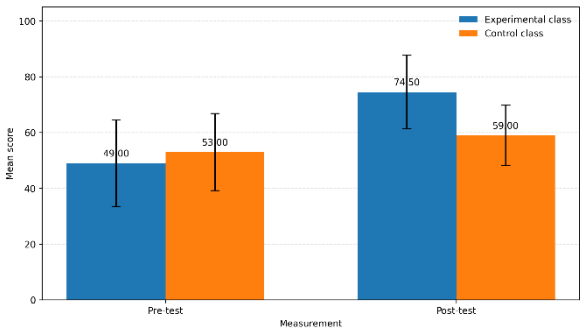


Figure 1. Comparison of Pre-test and Post-test Mean Scores

Figure 1. graphical representation of Table 3. The mean scores for the students' cognitive learning outcomes in both classes were also lower for the pretest compared to the posttest. The mean pretest score was 49.00 for the experimental class and 53.00 for the control class, while the mean posttest score was 74.50 for the experimental class and 59.00 for the control class. This discrepancy arose because, prior to the pretest, neither class had yet received instruction on the acid-base learning material. Before the posttest, the experimental class was taught using the Discovery Learning model, whereas the control class utilized a conventional learning model; consequently, the mean posttest scores differed, with the experimental class achieving a higher mean score than the control class. This indicates that the Discovery Learning model can help improve students' understanding of acid-base material.

4. Normality Test Results

The normality test used to analyze the pretest and posttest data for the experimental and control classes employed a significance level of 0.05, with the criterion that sample data are normally distributed if the significance value (sig) is greater than 0.05. The test results are presented in Table 4, generated using SPSS 27 software.

Table 4. Normality Test for Pretest and Posttest Scores: Experimental and Control Classes

Class	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-Test Experiment (DL)	,967	20	,681
Post-Test Experiment (DL)	,944	20	,291
Pre-Test control (conventional)	,950	20	,372
Post-Test control (conventional)	,926	20	,128

Based on Table 4.4, the significance (sig) values from the Shapiro-Wilk normality test were 0.681 for the experimental class pretest and 0.372 for the control class pretest. Meanwhile, the posttest significance values were 0.291 for the experimental class and 0.128 for the control class. These normality test results indicate that the pretest and

posttest data for both classes are normally distributed. According to Sugiyono's (2018) criteria, data are considered normally distributed if the significance value (sig) is greater than 0.05.

5. Homogeneity Test

The homogeneity test was conducted to determine whether the data variances from the sampled groups were homogeneous. The decision-making guidelines for the homogeneity test, as outlined by Usmadi (2020), are as follows:

a. If the significance value (sig) is less than 0.05, the variances of the two or more population groups are considered unequal (not homogeneous).
b. If the significance value (sig) is greater than 0.05, the variances of the two or more population groups are considered equal (homogeneous).

The pretest and posttest data obtained for both classes processed using SPSS 27 software are presented in Table 5.

Table 5. Homogeneity Test for Experimental Class and Control Class Posttest Data

Homogeneity Test	*Levene Statistic*	*d1*	*df2*	*Sig.*
Based average	1,571	1	38	,218
Based median	,983	1	38	,328
Based median & derajat degress of freedom	,983	1	35,961	,328
Based trimmed mean value	1,532	1	38	,223

Based on the homogeneity test results for the post-test of both classes (experimental and control) shown in Table 5, the significance value (sig) based on the mean was 0.218 (which is greater than 0.05); therefore, it can be concluded that the variances of the post-test data for the experimental and control classes are equal, or homogeneous.

Table 6. Homogeneity Test of Pre-test Scores for Experimental and Control Classes

Homogeneity Test	*Levene Statistic*	*d1*	*df2*	*Sig.*
Based average	,115	1	38	,736
Based median	,123	1	38	,728
Based median & derajat degress of freedom	,123	1	37,548	,728
Based trimmed mean value	,127	1	38	,724

Based on the homogeneity test results shown in Table 6 for the pretest data of both classes (experimental and control), the significance value (sig.) based on the mean was 0.736 (which is > 0.05). Therefore, it can be concluded that the variances of the experimental class pretest and the control class posttest are equal, or homogeneous.

6. Hypothesis Testing

Hypothesis testing was conducted after obtaining data from the normality and homogeneity tests. The results of the normality and homogeneity tests for the pretest and posttest scores of the experimental and control classes indicated that the data were normally distributed and homogeneous. Consequently, the analysis proceeded to a t-test, specifically the Paired Sample T-test. This test was performed to determine whether there was a difference between the two paired samples. The test was conducted using SPSS 27 software. The data are presented in Table 7.

Table 7. Hypothesis Testing

	Average	Differences partners Standard dvt | error	Confidence Interval 95% difference Low	High	*df*	*Sig. (2-tailed)*
*Pair Pre*Eks-1	-25,500	5,104 0,989	-27,889	-42,130	20	0,001
*Pair Pre*Kon-2	-6,000	5,026 1,140	-8,352	-3,648	20	0,001

Table 7 shows that for pairs 1 and 2, the obtained sig. (2-tailed) value is 0.001 (< 0.05); therefore, H_0 is rejected and H_1 is accepted, in accordance with the following hypothesis testing criteria:

a. If the sig. (2-tailed) value > 0.05, then H_0 is accepted and H_1 is rejected, indicating no significant difference in the use of the Discovery Learning model regarding students' cognitive learning outcomes.
b. If the sig. (2-tailed) value < 0.05, then H_0 is rejected and H_1 is accepted, indicating a significant difference associated with the use of the Discovery Learning model.

Thus, it can be concluded that there is a significant difference in students' cognitive learning outcomes, specifically between pretest and posttest scores for both the experimental and control classes. This implies that instruction using the Discovery Learning model influences students' cognitive learning outcomes regarding the topic of acids and bases.

7. N-Gain Standard

The N-Gain test assesses the N-gain value (or N-gain score). This test aims to determine the effectiveness of the Discovery Learning model versus conventional methods regarding students' level of understanding of the topic of acids and bases.

Table 8. Results of the standard N-Gain calculation for the experiment

Statistic	Value	Clarification
Standard N-Gain	**0,5**	**Medium**

Table 9. Results of the standard N-Gain calculation for the control

Statistic	Value	Clarification
Standard N-Gain	**0,1**	**Low**

Based on the standard N-Gain calculations are 0.5 for the experimental class and 0.1 for the control class.

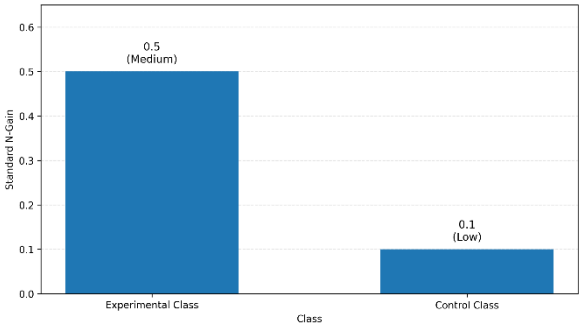


Figure 2. Comparison of N-Gain Scores between Experimental and Control Classes

Figure 2 It can be concluded that the experimental class falls into the medium category, whereas the control class falls into the low category. This indicates that the Discovery Learning model has a greater impact than conventional instruction on the understanding of acid-base concepts.

8. Percentage of Influence

The percentage of influence is calculated to determine the extent (%) to which the use of the Discovery Learning model affects students' learning outcomes.

$$\% \text{ influence} = \frac{\textit{Mean posttest-Mean pretest}}{\text{Nilai } \textit{Max} - \textit{Mean pretest}} \times 100\%$$

$$= \frac{74{,}50 - 49{,}00}{100 - 49{,}00} \times 100\%$$

$$= \frac{25{,}5}{51} \times 100\%$$

$$= 50\ \%$$

Based on the calculation of the percentage of influence, a value of 50% was obtained.

CONCLUSION

Based on the research results, data analysis, and discussion, it can be concluded that:

1. There is a significant difference in the students' cognitive learning outcomes in the acid-base material for XI science class at SMA YPK Oikoumene Manokwari before and after the application of the Discovery Learning Model. This is evidenced by the paired-sample t-test results for pairs 1 and 2, which yielded a sig. (2-tailed) value of 0.001 (< 0.05); consequently, H_0 is rejected and H_1 is accepted in accordance with the hypothesis testing criteria.
2. The use of the Discovery Learning Model influences the the students' cognitive learning outcomes in the acid-base material for XI science class at SMA YPK Oikoumene Manokwari regarding the topic of acids and bases. There is a significant influence, amounting to 50%.

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