Implementation of The Discovery Model with a Differentiation Approach to Improve the Learning Outcomes of Higher Order Thinking Skills (HOTS) of Students on Acid-Base Chemistry High School Material

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Abstract- In applying discovery learning model by adjusting the characters and needs of students, the approach of differentiating students' learning styles is appropriate. The expected learning outcomes of students today are that apply HOTS. This study aims to describe the implementation, students' activities, improvement of students' HOTS learning outcomes, and students' responses to the application of the discovery learning model with a differentiated approach to acid-base material. The research methodology applied in this study was pre-experiment with One Group Pretest Postest Design. The results obtained are the application of the discovery learning model with a differentiation approach implemented because the results of learning implementation get mode 3 to 4 with good to very good categories in each aspect. On the results of student activity, students are said to be active during learning because they get a percentage of 97% to 100% based on the student activity observation sheet. Then focusing on the progress of student HOTS learning outcomes, the results of a significant value is a 0.000, which means is an influence in improving learning outcomes HOTS. Students' responses are said to be good to very good because the results obtained reach 75% to 100%.

Keywordss- Acid-Base, Discovery Learning, Diferensiasi, Higher Order Thinking Skills (HOTS).

I. INTRODUCTION

Currently, many schools have implemented the independent curriculum, where this curriculum provides intracurricular learning in various ways to improve conceptual understanding and improve student competency [1]. In implementing this independent curriculum, the learning conducted matching the character and requirements of students, this application contributes positively to students, students learn without being burdened by monotonous learning and even not in accordance with their interests. Acid-base material should be material that is quite easy to understand because it is often encountered in everyday life, but in reality students still find it difficult to understand the concept in this material. This was stated in a study conducted by Ref [2], students only focus on remembering a concept without understanding the concept. Students cannot detect acid-base indicators due to their inability to classify the characteristics of acidic or basic solutions. This happens because the teacher has not placed enough focus on the concept. Additionally, concerning the pH concept in environmental contexts, students are not yet capable of connect it to the application of acid-base solution concepts in daily life, which makes it challenging for them to grasp the idea.

The characteristics of acid-base indicator material in the chemical understanding element are being able to use acid-base concepts such as analyzing the properties of acid or base solutions using acid-base indicators. It is important to apply an effective learning model that highlights concept understanding, so students can more effectively grasp the concept of acid-base indicators which can later elevate the quality of student learning outcomes. The right learning model to apply is the discovery learning model. The discovery learning model is a learning model that is oriented towards investigation to find concepts or understanding of material independently by collecting various information. This kind of learning process can give the impression that students can more easily accept and understand the concept of acid-base indicators. In the learning process with this model, it can be done with the right approach. Investigations in this discovery learning model can be done by searching for information from various media by adjusting the diverse students' individual learning preferences, indicating a differentiated method of delivering process and content based on those styles [3].

The process differentiation approach based on the students' learning styles that vary from one another is a learning process for students that is different based on their learning styles [4]. This approach is very much needed to accommodate the diversity of students' learning styles. However, unfortunately in some schools there are still many teachers who have not implemented this learning. After conducting an interview with one of the chemistry SMA Negeri 1 Menganti's teachers on May 22, 2024, it was said that the chemistry SMA Negeri 1 Menganti's teachers was familiar with differentiation learning, but its application had not yet been carried out. So from this statement it can be said that learning at SMA Negeri 1 Menganti, especially in chemistry learning, has not yet implemented differentiated learning. This affects students' understanding of chemical concepts. Students' difficulty in understanding chemical concepts or their applications makes their learning outcomes quite low.

In The Regulation of the Minister of Education, Culture, Research, and Technology Number 5 of 2022 regarding Graduate Competency Standards at the secondary education level specifies that students should be able to analyze intricate problems, conclude their findings, and support their ideas with arguments based on precise data. However, in reality, many students still do not have learning outcomes with these skills. This can be proven by the outcomes of an initial research conducted at SMA Negeri 1 Menganti on May 16, 2024, where almost all students who worked on 6 questions with 3 HOTS Indicators, namely C4, C5, and C6, students had difficulty in working on them. The results obtained were still less than 50% of students who were able to work with answers and explanations correctly. In order to improve academic results that reflect higher-order thinking skills, an educational model is required to be applied with the right approach. With reference to the existing problems and prior investigations regarding the discovery learning model and the differentiation approach, the application of the discovery learning model with this differentiation approach is expected to boost the effectiveness of learning, especially in HOTS students in high school chemistry subjects on acid-base material.

II. RESEARCH ELABORATIONS

A. Discovery Learning Model

Discovery Learning model represents a pedagogical strategy that can encourage students to ask questions, formulate temporary answers, and conclude general concepts based on examples or practical experiences that they can find independently. This learning model can develop a learning environment characterized by more students centerd. Where students are required to stay actively involved in finding understanding or concepts that they learn independently based on established research procedures so that the understanding or knowledge can persist cognitively [5].

B. Differentiation Approach

Differentiated teaching methods can be utilized to fulfill the learning requirements of students, so teachers must identify appropriate learning needs [6]. Student learning needs can be classified based on at least 3 aspects, including: 1) Student learning readiness, each student has the ability to learn new material. 2) student interest, which is associated with student motivation to be actively involved in learning, 3) student learning style, which is associated with learning style by grouping visual and auditory skills and kinesthetic learning style [7].

C. Higher Order Thingking Skills (HOTS)

HOTS refer to sophisticated cognitive skills that involve critical, creative, and analytical processes when processing information and data to solve problems. Bloom states that thinking falls within the cognitive framework segmented into six progressive stages: knowledge, comprehension, application, analysis, evaluation, and creation [8]. The core purpose of HOTS is to strengthen students' advanced cognitive abilities, notably their capacity to think critically when encountering various forms of information, to apply creative thinking in resolving problems using prior knowledge, and to make informed decisions in challenging situations [9].

D. Acid-Base Material

Acid-base indicators are frequently utilized to determine pH levels due to their ability to exhibit a color change within a specific, narrow pH range. This color shift occurs as a result of an equilibrium between the acidic form and the basic form of the indicator, each displaying a distinct color. The acidic form is denoted as *In*, whereas the basic form is represented as In^- [10]. This natural indicator can be obtained by extracting compounds derived from plants that produce dyes. These compounds include anthocyanins, betalin, bixin and brazilin [11]. In this artificial indicator there are litmus paper indicators and also universal indicators. This litmus paper acid-base indicator can only be observed for its color change which can only indicate whether the solution is acidic or basic. This universal indicator is composed of various indicators that can determine the pH of a solution based on its color change [12]. This acid-base indicator solution is an acid-base indicator as a solution including phenolphthalein, bromthymol blue, methyl red, and so on. This indicator will show a color change based on the pH trajectory of each indicator [13].

III. METHODS

This study adopts a pre-experimental research approach, characterized by the absence of a control class. The design implemented is the One Group Pretest-Posttest Design. The trial of this study was conducted at SMAN 1 Menganti, Menganti District, Gresik Regency. The trial from this study was held in the even semester of the 2024/2025 Learning Period. This study used research subjects, namely 33 students of class XI-2 SMAN 1 Menganti. This research seeks to explain the implementation of learning, student activities, HOTS learning outcomes of students, and student responses by implementing learning by means of the discovery learning model with a differentiation approach in acid-base material. Data collection techniques, instruments and data analysis techniques in each aspect are as follows.

A. Validation of Research Instrument

The research instrument was validated using a dedicated validation sheet, and the process of validation was conducted by 3 validators, namely 2 expert lecturers and 1 high school chemistry teacher. Validation data was analyzed by determining the score mode. The score mode obtained will assess the validity of the research instrument according to the validity category table as follows.

Table 1. Validity Likert Scale

Scale Value	Category
1	Very Invalid
2	Invalid
3	Valid
4	Very Valid

Source: Riduwan 2015

B. Learning Implementation

The technique of collecting data concerning the execution of learning by applying the discovery learning approach integrated with a differentiation approach to acid-base material was carried out plying the observation instrument in order to evaluating the implementation of learning. This observation sheet was filled in by 3 observers during the learning process. Implementation data was analyzed by determining the score mode. The data was utilized to identify the practice of learning by applying the discovery learning model with a differentiation approach to acid-base material according to the following categories:

Table 2. Learning Implementation Category

Scale Value	Category
1	Bad
2	Enough
3	Good
4	Very Good

C. Student Activity

The data from the student activity sheet is used to determine the student activities that are seen during learning using a discovery learning approach supported by differentiation to strengthen students' performance in HOTS pertaining to acid-base concepts. The data from this observation will be analyzed by calculating the time used to carry out an activity.

$$\%Student\ Activity = \frac{the\ time\ of\ student\ activity\ that\ appears}{total\ learning\ time}\ x\ 100\%$$

Students are said to be active during learning as long as the percentage of appropriate student activities is higher than the percentage of inappropriate ones, namely when relevant student activities are ≥ 61% [14].

D. HOTS Learning Outcomes of Students

In this aspect, data collection techniques are used by conducting pretests and posttests using pretest and posttest sheets. Analysis of the gathered data was accomplished by utilizing SPSS Kolmogorov-Smirnov Normality Test and Paired Sample t-Test.

E. Student Response

The findings gathered from the students' responses were analyzed through a quantitative descriptive approach. Based on the questionnaire, the students' responses were in the form of positive and negative statements. Scoring was conducted in accordance with the following Guttman scale score:

Table 3. Guttman Scale Criteria

Answer Option	Score	
	Positive	Negative
Yes	1	0
No	0	1

Source: Riduwan 2015

The collected data will be analyzed using the following formula:

$$\%Response = \frac{Total\ score\ for\ each\ statement}{Number\ of\ respondents}\ x\ 100\%$$

Findings from the response questionnaire will serve as a basis for determining students' opinions and interests in the application of the discovery learning model with a differentiated approach to improve students' HOTS learning achievement in acid-base material employing the score interpretation shown below.

Table 4. Criteria of Student Response Quesionnaire Score

Persentage	Criteria
0 - 20	Very Bad
21 – 40	Bad
41 – 60	Fairly
61 – 80	Good
81 – 100	Very Good

Source: Ridwan 2015

IV. RESULT AND DISCUSSION

A. Validation Research Instrument

Table 5. Validity Instrument

Validity	Research Instrument						
	Worksheet 1	Worksheet 2	Teaching Module	Learning Implementation observation sheet	Student Activity Observation Sheet	Student Response Sheet	Pretest Posttest Sheet
Content Validity	3	4	4	4	4	4	4
Construct Validity	4	4	4	4	4	4	4

Based on Table 5, the validity data of the research instrument is obtained. After obtaining the validation results that have been given by three validators as in Table 5 based on theory, the instrument and media are said to be valid if the score is at least 3 [15]. The media and research instruments that have been compiled are said to be valid to very valid because they have a score mode of 3 to 4.

B. Learning Implementation

Table 6. Learning Implementation observation data

Meeting	Aspect									
	Introduction	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Closing	Time Management	Conditioning Class
1	4	4	3	4	3	4	4	4	4	4
2	4	4	4	4	4	3	3	4	4	4

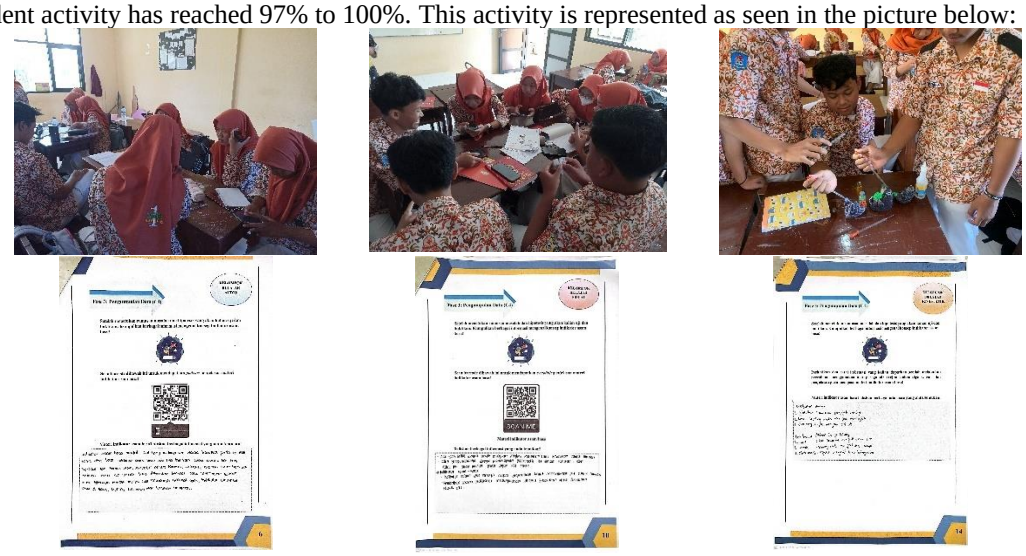
Based on Table 6, the learning implementation score data is obtained. After getting the results of the score mode for each observed aspect, the implementation data results are obtained. Based on the theory, this data is ordinal data whose determination is carried out by score mode. Where if the score mode obtained is at least 3, it can be stated that it has been implemented and is in the good to very good category [15]. So based on this theory, in the preliminary aspect of the first and second meetings, overall, the score mode is 4, which is in the very good category. In the main activities of phases 1 to 6, the first and second meetings, the score mode is 3 to 4 with a good to very good category. In the closing aspect of the first and second meetings, the score mode results are 4, which is part of the very good category. And in the classroom management aspect, the first and second meetings get a score mode of 4, which is in the very good category. This is in line with the study that has been carried out by Ref [16] about the act of putting into practice learning process utilizing the discovery learning model with a differentiation approach. This is supported by the results obtained in the study in cycles I and II which are said to be very good because they achieve indicators of learner implementation with a very good category. Based on the score mode obtained at the first and second meetings, which is 4, it can be said to be implemented very well because it has achieved the learning implementation indicator, namely a score of 4.

C. Student Activity

Table 7. Student Activity Observation Data

Learning Style	Meetings	Aspect						Average
		Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	
Audio	1	100%	100%	100%	100%	80%	100%	97%
	2	100%	100%	100%	100%	90%	100%	98%
Visual	1	100%	100%	100%	100%	100%	100%	100%
	2	100%	100%	100%	100%	90%	100%	98%
Kinesthetic	1	100%	100%	100%	100%	100%	100%	100%
	2	100%	100%	100%	100%	90%	100%	98%

Based on Table 7, data on student activity during learning with the discovery learning model with a differentiation approach is obtained. According to the theory, students can be said to be active during learning, depending on the percentage of relevant student activity is greater than ≥ 61% [14]. This agrees with the findings of research that has been executed by Ref [17] regarding student activity, namely that student activity is seen to increase, it is said to increase when considering the enthusiasm of students throughout their learning activities because the learning used is in accordance with what students want. Based on relevant theory and research, in this study students are described as active in implementing learning by implementing the discovery learning strategy together with a differentiation approach to acid-base material because relevant student activity has reached 97% to 100%. This activity is represented as seen in the picture below:



(a) Audio learning style students (b) Visual learning style students (c) Kinesthetic learning style students

Figure 1. Student Activities According to Learning Style

D. HOTS Learning Oucomes of Student

The improvement of HOTS learning achievement of students .is shown by the comparison of pretest and posttest results. After obtaining the score data from both the pretest and posttest of class XI-2 students of SMAN 1 Menganti. To assess normality, the data was analyzed with SPSS with the Kolmogorov-Smirnov Test. The following results were obtained.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Hasil	Pretest	.108	33	.200*	.956	33	.195
	Posttest	.116	33	.200*	.963	33	.316

Figure 2. Data Normality Test Result

According to the findings of the Kolmogorov-Smirnov Test, the pretest and posttest data in Figure 2 show a significant value of 0.200. After knowing the pretest and posttest data results, a Paired Sample t-Test was carried out. This a test was carried out to identify the effect on improving the results of the learning process of HOTS of students using the discovery learning model with a differentiation approach to acid-base material. This test was conducted using SPSS 16.0 with a significant rate of $\alpha = 0.05$ and degrees of freedom (df = n-1) with the testing criteria Ho is accepted when the significant value is > 0.05 and Ha is not accepted, and Ho is rejected if the significant value is < 0.05 and Ha is accepted [18]. The following results were obtained.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-35.212	13.131	2.286	-39.868	-30.556	-15.405	32	.000

Figure 3. Paired Sample t-Test Result

Based on Figure 3, the significant value of the pretest and posttest is 0.000. Based on the basic testing criteria, it can be said that Ha is accepted or there is an influence in improving students' HOTS learning achievement by using the discovery learning model with a differentiation approach because it has a significant value of 0.000. This is in line alongside research carried out by Ref [19] in the study, the results showed that H1 was accepted, which means indicating the presence of an impact of the application of the discovery learning model on students' high-level abilities. Also in research conducted by Ref [20] the carrying out of the discovery learning model along with a

differentiated learning strategy can help students understand the material better. This is because the use of the discovery learning model combined with a differentiated strategy is learning that focuses on providing opportunities for students to undergo learning that matches the needs of students. Namely by carrying out various activities independently and in groups. This learning model also focuses on the process aspect. As well as in the research conducted by Ref [21] said that implementing the discovery learning model has the potential to enhance students' learning achievements, namely 20% in the medium category and 80% in the high category. In the research conducted by Ref [22] said that most students can develop their cognitive skills provided that learning is not boring.

E. Student Response

Table 8. Student Response Questionnaire Data

No	Statements	Persentage
1	I have a better understanding of the material if the learning implements study groups based on learning styles.	94%
2	I feel happy with the learning that uses a group discussion model to discover concepts.	97%
3	I feel more interested and want to know more about the concept of acid-base indicators when given an acid-base indicator phenomenon.	94%
4	Learning by formulating problems and hypotheses based on a phenomenon is very interesting.	76%
5	I enjoy searching for various information to find answers to the problems that have been formulated.	79%
6	Learning by adjusting learning media based on learning style makes it easier for me to understand the concepts I want to look for.	94%
7	I find it easier to remember a concept by discovering and understanding it myself based on the findings I get.	94%
8	Analyzing the information I get makes me more enthusiastic.	100%
9	Conducting proof of the hypothesis that has been made based on the information that has been analyzed makes it easier for me to remember the concept of acid-base indicators.	97%
10	Making conclusions based on findings and group discussions makes learning memorable and enjoyable.	94%
11	The worksheet provided really makes it easier for me to study.	88%
12	Learning the topic of acid-base indicators using the discovery learning method with a differentiation approach made me understand more about the concept and application of acid-base indicators in everyday life.	94%

In this study, the statements used are positive statements, so if you answer "Yes" you get a score of 1. Then the total score for each statement will be divided by the number of respondents and multiplied by 100%. As shown by the data obtained as in Table 8, student responses are recorded at a percentage of 75% to 100%. Based on the Guttman Scale, if the statement is positive, the answer "Yes" is worth 1. And the criteria for student responses to the application of the discovery learning model with a differentiation approach to improve students' HOTS learning achievements on acid-base material are said to be good to very good if a percentage of ≥ 61% is obtained [15]. In line with the research that has been conducted Rudibyani & Perdana (2018) in their research it was stated that the average student response rate was considered to be in the category of "very high" [19]. This shows that student responses to the application of the discovery learning model on the pH of acid-base solutions offer significant value in boosting students' higher-level thinking skills. The number of students who gave positive responses to learning shows that student are interested and interested in the learning that is carried out. Based on relevant previous theories and research, it can be said that students' responses to the application of the discovery learning model combined with a differentiated approach to enhance students' HOTS learning achievement on acid-base material are said to be good to very good because the results obtained reach 75% to 100%.

V. CONCLUSION

According to the results gathered from the study, it is concluded that utilizing the discovery learning model with a differentiation approach can boost the learning achievements of HOTS of students in the material of chemical acids and bases in high school. This can be seen from 4 aspects, namely (1) the aspect of implementation, the implementation of the discovery learning approach combined with a differentiation approach is said to be implemented well because the results of the learning implementation get a mode of 3 to 4 with a good to very good category in each aspect. (2) the aspect of student activity, in the results of student activity, students are said to be active during learning because they get a percentage of 97% to 100%. (3) In the aspect of improving HOTS students' learning achievement, a significant value of 0.000 is obtained, which means that Ha is accepted or there is an influence in improving HOTS learning achievement. (4) In the aspect of student responses regarding the implementation of the discovery learning approach combined with a differentiation approach, it is said to be good to very good because the results obtained reach 75% to 100%.

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