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Ratu Betta Rudibyani, and Ryzal Perdana

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Enhancing Higher-order Thinking Skills using Discovery Learning Model's on Acid-Base pH Material

Ratu Betta Rudibyani[1,a)], Ryzal Perdana[2,b)]

[1,2] *Teacher Training and Education Faculty of Lampung University, Jl. Prof. Dr. Soemantri Brojonegoro No. 1, Bandar Lampung, INDONESIA*
[2] *Doctoral Program of Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta, INDONESIA*

E-mail : [a)] ratu.betta.r@gmail.com, [b)] ryzalperdana2009@gmail.com

Abstract. This study aims to describe the practicality, effectiveness and effect size of the discovery learning model in enhancing students' higher-order thinking skills. Population in this research is all student of class X in senior high school in Metro, Indonesia. The method in this research is pre-experimental design with one group pretest-posttest design. Sampling was chosen randomly by cluster random sampling technique to get 2 experimental class that is class X.5 and X.8 which was treated by using learning model of discovery learning. The results showed that the implementation of the discovery learning model and the ability of teachers in managing the learning of "high" category, the response and the student activity during the learning category is "very high". The students' high-order thinking skills in both experimental classes increased with respect to the average n-Gain obtained, which was categorized as "medium". The discovery learning model has an effect on the improvement of students' higher-order thinking skills, as evidenced by the result of effect size test that is "high" in both experiment class. The results of this study can be concluded that the discovery learning model on acid-base pH material is practical, effective and has a large effect size in enhancing students high-order thinking skills.

INTRODUCTION

In the century of knowledge, the 21st century, high-quality, skilled human resources are required to work together, to high-order thinking, to be creative, to be skilled, to understand cultures, to communicate, and to learn lifelong learning [1-2]. In the century of knowledge, intellectual capital, especially high-order thinking, is a necessity as a reliable workforce [3]. Graduates from college to university, in addition to having vocational skills must also have the thinking skills, so that the Indonesian nation does not become a nation of "laborers" [4]. All the opinions of these scholars support the opinion of [5] who from the outset expects students to be taught thinking skills. However, until now, this thinking skill has not been handled sincerely by teachers at school.

Students 'thinking can be trained by applying the 2013 curriculum to chemistry learning. The 2013 curriculum is developed with the implications of the students' mindset that is the original teaching-centered learning pattern of the teacher to become a student-centered learning and learning pattern that passive students previously become active, critical and creative student learning [6].

In order for students to actively participate in learning, and can train students in the process of concept discovery and problem solving, it is necessary to apply a model of learning in accordance with the goals or competencies to be achieved. The expected learning model is an innovative learning model that is the basic learning model philosophy is constructivism [7]. According to [8] constructivism learning is suitable for use in science learning. One model of constructivism learning that leads to the process of conceptual discovery and problem solving is the discovery learning model.

Discovery learning model is a learning model recommended by the curriculum 2013. The use of discovery learning model in the learning process aims to train students to perform various activities, namely observation, investigation, experiments, comparing findings with each other, ask questions and seek answers to questions [9].

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According to [10], discovery model can provide opportunities for students to be more active in the learning process and application of discovery model can improve students' creative thinking ability. The research that has been done concluded that the discovery learning model is effective in improving the generating capability of both electrolyte and non-electrolyte solution materials [11]. Concluded that the discovery learning model is effective in improving the flexible thinking ability of reaction rate material [12]. In addition, stated that the application of discovery learning model succeeded in improving student's learning achievement of cognitive and affective aspects on buffer solution material [13].

High-order thinking skills (HOTS) is the ability to think and reason to answer complex questions and or solve a case or problem [14]. Teachers are responsible for training high-order thinking skills students because only with high-order thinking skills that students can use to live their lives after completing their education and students with good high-level thinking skills will have high cognitive abilities[15-16]. Low-level thinking is only useful for answering test questions or exams that may not necessarily be used in real life after school. The ability of teachers to make inquiries and in preparing the design of Lesson Plans (RPP) that contain elements of high-order thinking skills is something that absolutely must be had. Skilled teachers make inquiries and are skilled at making RPP with high-order thinking skills able to get their students to solve problems in their lives after they complete their education.

The results of interviews with chemistry teachers in high school can be concluded that chemistry teachers have not been able to train high-order thinking students. This can be seen from the RPP and the questions made by teachers have not contained elements of high-order thinking skills. Therefore, it is necessary for the teacher to apply a learning model that can solve the problem.

Based on the above description, this article will describe the practicality, effectiveness, and effect size of learning discovery learning model in improving students' high-order thinking skills on acid-base pH material. This application uses student worksheets (LKS) and knowledge base assessment instruments based on discovery learning.

METHOD

Sample Research

The population of this study is all students of class X in SMAN 6 Metro consisting of eight classes. Sampling was done randomly by using cluster random sampling technique, so that obtained class X.5 which amounted to 23 students and X.8 which amounted to 26 students as experimental class.

The data used in this study is primary data, in the form of test results before the application of learning (pretest) and after the application of learning (posttest). It also uses secondary data that is observation sheet of discovery learning model implementation, student response questionnaire, teacher's ability observation sheet in classroom management, student activity sheet during the learning progress, and practice skills appraisal sheet. The data source of this research is all students in experiment class 1 and 2.

The research method used in this research is pre-experimental design with One Group Pretest-Posttest Design [17]. The design of this study looked at the differences in pretest and posttest in the class under study. This study was conducted by giving a treatment to the research subjects of two sample classes then observed.

Validity and Reliability Analysis

Validity and reliability test is done by using SPSS statistic 17.0. The valiestity test is applied by using the product moment parson correlation formula compared to the r_{valeu} and r_{table}, it is valid if it counts r_{table} with 5% significance. The reliability test was performed using the Cronbach Alpha formula which was then interpreted using the reliability scale (r_{11}) of evaluation tools according to Guilford [18] and is listed in Table 1.

TABLE 1. Criteria of reliability tool reliability scale

Reliability scale (r11)	Criteria
0,80< r11≤ 1,00	Very High
0,60< r11≤ 0,80	High
0,40< r11≤ 0,60	Medium
0,20< r11≤ 0,40	Low
0,00< r11≤ 0,20	Not Reliability

Practicality Data Analysis discovery learning model.

The practicality of learning discovery learning model is determined from the achievement of the discovery learning model measured through the evaluation of the implementation of RPP. The formula used by [19] is:

$$\%J_i = \frac{\sum J_i}{N} \times 100\% \quad (1)$$

$\%J_i$ is the percentage of the ideal score for every aspect of observation at the meeting (i), ΣJ_i is the sum of the scores of each observation aspect at meetings (i) and (N) is the maximum score. Then the results obtained data interpreted with the percentage value in Table 2 [20].

TABLE 2. Percentage value interpretation

Percentage	Criteria
75,1% - 100,0%	Very Good
50,1% - 75,0%	Good
25,1% - 50,0%	Pretty Good
0,0% - 25,0%	Poorly

Practicality is also determined from the point of view of the learning model measured through the student response questionnaire given at the end of the meeting. The questionnaire consisted of 13 positive and 13 negative statements. The student responds positively if the student responds to a positive statement and responds to a negative statement. Questionnaire response student is calculated by the formula:

$$\%X_{in} = \frac{\sum S}{S_{maks}} \times 100\% \quad (2)$$

$\%X_{in}$ is the percentage of students' response answers to the attractiveness of the discovery learning model, ΣS is the total score of answers, and S_{max} is the maximum score [19].

Data Analysis Effectiveness Model discovery learning

The effectiveness of the learner model of discovery learning is determined from the teacher's ability to manage the learning using the discovery learning model measured by the observation sheet. The formula used is the same as the extent of RPP according to [19].

The effectiveness of the learning discovery learning model is also determined by the improvement of students' high-order thinking skills, as measured by the n-Gain value with the following formula:

$$n-gain = \frac{\%posttest - \%pretest}{100 - \%pretest} \quad (3)$$

Criteria [21] are shown in table 3.

TABLE 3. n-gain score critarion

n-gain score	Criteria
n-gain > 0,7	High
0,3 < n-gain ≤ 0,7	Medium
n-gain ≤ 0,3	Low

Data Analysis Influence Size

The effect size of the discovery learning model on the improvement of students' high-order thinking skills is determined based on t test value. Until the t test is applied, first a n-gain test is used to measure the n-gain value using SPSS statistic 17.0. The normality test is performed by one-sample kolmogorovsmirnov test, in which the sample is normally distributed when the Asymp value. Sig. (2-tailed) obtained by >0.05. Furthermore t test is applied to the mean difference of n-gain of high-order thinking skills between posstest value and pretest. The level of trust used $\alpha = 0.05$. The formula used in the t test according to [19] as follows:

$$t = \frac{\bar{X}_2 - \bar{X}_1}{\sqrt{\left(\frac{(n_1)\sigma_1 + (n_2)\sigma_2}{n^1 + n_2 - 2}\right)\left(\frac{1}{n_2} + \frac{1}{n_2}\right)}} \quad (4)$$

Furthermore, the calculation is done to determine the measure of effect size with the formula according to [22]:

$$\mu^2 = \frac{r^2}{r^2 + df} \quad (5)$$

μ is effect size, t is t_{count} from *t* test, and *df* is scale of fredom (n-1) [23] shown in table 4.

TABLE 4. Effect size criteria

Effect Size (μ)	Criteria
$\mu \leq 0{,}15$	Verry Small
$0{,}15 < \mu \leq 0{,}40$	Small
$0{,}40 < \mu \leq 0{,}75$	Medium
$0{,}75 < \mu \leq 1{,}10$	Big
$\mu > 1{,}10$	Verry Big

RESULT AND DISCUSSION

Validity and Reliability

Based on the analysis of the validity of the problem with the software SPSS version 17.0 Corrected Item-Total Correlation value that shows the value of the validity of items as in table 5.

TABLE 5. The validity of the item test result

Quetion number	Corrected Item-Total Correlation	dk	r_{Tabel}	Category of validity
1	0,638	19	0,433	High
2	0,516	19	0,433	Medium
3	0,488	19	0,433	Medium
4	0,640	19	0,433	High
5	0,718	19	0,433	High

The Corrected Item-Total Correlation value indicates that the value of $r_{valeu} > r_{table}$,. This indicates that the five items are declared valid. Reliability analysis problem with SPSS obtained Cronbach's Alpha value that shows the overall test reliability value of 0.770 which means the test instrument as a whole has a high degree of reliability criteria. This calculation also yields Cronbach's Alpha if Item Deleted value indicating the reliability value of the item as presented in Table 6, as follows:

TABLE 6. Result of item reliability test

Quetion number	Cronbach's Alpha if Item Deleted	dk	r_{Tabel}	Category of validity
1	0,768	19	0,433	High
2	0,745	19	0,433	High
3	0,749	19	0,433	High
4	0,697	19	0,433	High
5	0,657	19	0,433	High

The value of Cronbach's Alpha if Item Deleted shows that the value of $r_{valeu} > r_{table}$, so that the five items are declared reliable. Based on the results of validity and reliability test, the test question is valid and reliable, so that the test instrument can be used to measure the thinking ability of high level.

Practical data of discovery learning model

1. Implementation of discovery learning model

The results of the implementation of the discovery learning model ae shown in Table 7.

TABLE 7. Data of observation result of the implementation discovery learning model.

Aspect of observation	Average persentage of implementation (%)			
	Meeting 1	Category	Meeting 2	Category
Syntax	82	Very high	80	High
Social system	78	High	85	Very high
Principle of reaction	75	High	78	High
Average of each meeting	78.33	High	81	Very high
Average		79.67		

Based on the data contained in Table 7, the average implementation of discovery learning model is "high" which means the implementation of learning discovery learning model has high practicality in improving students' high-order thinking skills. This is in accordance with the statement put forward [24] that the effectiveness of the learning model is closely related to the achievement of learning objectives and a model of learning is said to have a high practicality, if the level of implementation of learning in the class categorized high.

2. Positive response of student

Overall towards the implementation of learning with discovery learning model shown in table .8

TABLE 8. Data on student response results implementation of learning

No.	Aspect		Persentage positive respons of student (%)	Criteria
1	Feeling of pleausre towards	Learnig topics	98	Very high
		Student worksheet	93	Very high
		Visual media	90	Very high
		Learnig atmosphere	59	Medium
		How teacher teach	98	Very high
		Teacher responds	95	Very high
2	Students' opinions about newness	Learnig topics	95	Very high
		Student worksheet	88	Very high
		Visual media	73	High
		Learnig atmosphere	54	Medium
		How teacher teach	68	High
		Teacher responds	73	High
3	Students' interest in learning		95	Very high
4	Student's opinion on students' worksheet and media	Understanding of language	98	Very high
		Interest in the performance of students' worksheet	83	Very high
		Train high-order thinking skills	93	Very high
		Make it easy to learn the topics	98	Very high
		Interest in webpage / weblog utilization	95	Very high
5	Students' opinions about the learning discovery learning model	Match on topics	98	Very high
		Activation of activity in class	78	High
		Development of flexible thinking skills	80	High
		Ease in interpreting a picture, story, or problem	80	High
		Application of the concept of electrolytes in everyday life	68	High
		Learning is more interesting, fun, and easy to understand	95	Very high
Average			85,21	Very high

Based on the data contained in table 9, the average percentage of student responses is categorized as "very high". This indicates that students 'responses to the implementation of learning discovery learning models on pH materials acid-base solutions have a very high practicality in improving students' high-order thinking skills. This is in line with [25] who argued that the number of students who responded positively to teaching showed that children were interested and interested in teaching that was implemented.

The effectiveness of discovery learning model

1. The ability of teachers in managing learning is shown in Table 9, as follows:

TABLE 9. Data on teacher ability observation managing learning

Meeting	Aspects of observation	percentage of achievement (%)	Category
I	**Introduction**	**84**	**Very high**
	Syntax		
	Stage I: Stimulation	75	High
	Stage II: *Problem Statement*	81	Very high
	Stage III: *Data Collection*	81	Very high
	Stage IV: *Data Processing*	79	Very high
	Stage V: *Verification*	75	High
	Stage VI: *Generalization*	81	Very high
	Closing	**81**	**High**
	Assessment of teachers		
	Time management Mastery of topic Appearence of teacher Use of language Open response to student	85	Very high
	Average	80	High
II	**Introduction**	**81**	Very high
	Stage I: Stimulation	75	High
	Stage II: *Problem Statement*	75	High
	Stage III: *Data Collection*	81	Very high
	Stage IV: *Data Processing*	88	Very high
	Stage V: *Verification*	69	High
	Stage VI: *Generalization*	81	Very high
	Closing	**81**	**High**
	Assessment of teachers		
	Time management Mastery of topic Appearence of teacher Use of language Open response to student	85	Very high
	Average	79,6	High

Based on the data contained in table 9, the average ability of teachers in managing learning meets the "high" criteria at meetings 1 and 2, said the ability of teachers in managing learning with the model of discovery learning is effective in improving students' high-order thinking.

2. High-order thinking skills

The average results of pretest and posttest from the class X.5 and X.8 are shown in Fig 1.

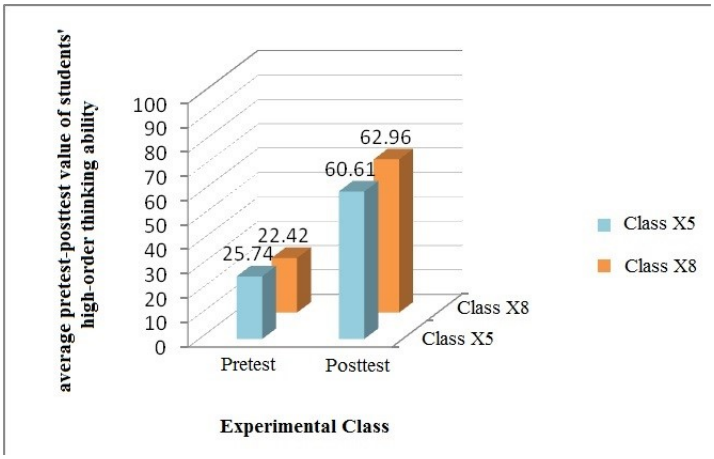

Figure 1. Average pretest and postes values high-order thinking skills students.

Based on Figure 1, it can be seen that there is an increase in the average student score between before (pretest) and after (posttest) implementation of learning with discovery learning model.

Based on the calculation obtained the average n-Gain high-thinking ability of students in class X.5 and X.8, as presented in Figure 2.

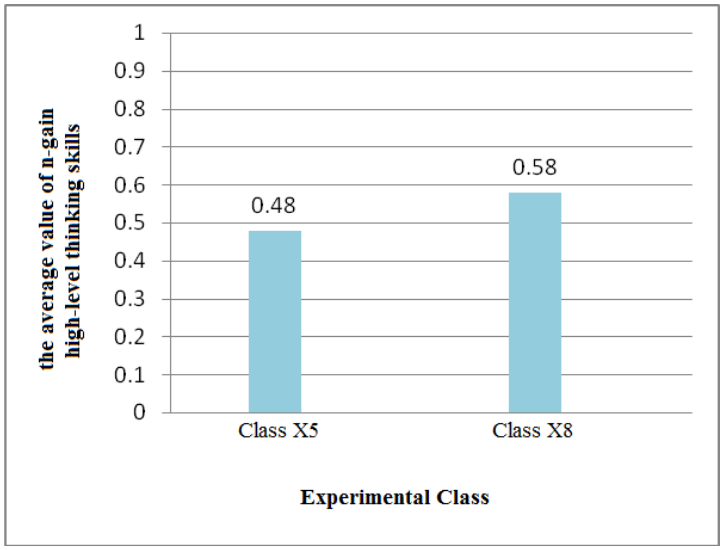

Figure 2. Average n-Gain students' high-order thinking ability.

Figure 2. Show the average difference of n-Gain class X.5 and X.8 with "medium" criteria which means learning with effective discovery learning model in improving students' high-order thinking skills on acid-base PH material.

Hypothesis testing and effect size (effect size)

1. Normality and homogenity test

The result of normality test to pretest and posttest value in class X.5 has sig value. 0.108 and 0.070 which means accept H_0 or the sample is normally distributed, while the pretest and postes values in class X.8 have sig values. 0.643 and 0.063 which means accept H_0 or the sample is normally distributed.

Homogenity test results on pretest and posttest values have value 0.190 and 0.918 which means accept H_0 or both classes have a homogeneous variance

2. Test the difference in pretest and postes averages

The result of Paired Sample T-Test is shown in table 10.

TABEL 10. T test of class X.5 dan X.8 results

Experimental Class	Average		Test *Paired Sample T-Test*		
	Pretest	Posttest	N	sig. (*2-tailed*)	Test criteria
Class X.5	25,74	60,61	23	0,000	sig. (*2-tailed*) > 0,05
Class X.8	22,42	62,96	26	0,000	sig. (*2-tailed*) > 0,05

Based on table 10, the results in both classes indicate H_0 is rejected, then H_1 is accepted which means the posstest value is better than the pretest value. Discovery learning has a positive effect on students' high-order thinking skills because the posstest value is better than the pretest value after the students are treated using the discovery learning model. Using the discovery learning model fosters a scientific attitude and a desire to investigate so that students can improve high-order thinking skills that are an important attribute to success in the 21st century [26-27]

The method of problem solving is an active thinking process based on the thinking process toward definitive conclusions [28-29] the discovery learning model facilitates students to solve problems through teacher guidance so that students will indirectly use the appropriate thinking skills with the teacher's direction. The role of students in the discovery learning model is not entirely as a locus of control because the teacher still guides and directs students to solve problems and draw conclusions from the results of the investigation [30-31]. An investigation conducted on the acid-base pH material requires the guidance of the teacher because in the fear of the students will be confused if not given guidance through questions or direct instruction by the teacher. Therefore, the discovery learning model is suitable for directing students on the acid-base pH material that requires high-order thinking skills.

3. Effect size test

Based on the effect size test, the value of effect size as shown in table 11.

TABLE 11. The effect size test results.

Experimental class	N	*df*	t_{count}	*Effect size value*	Category
Class X.5	23	22	12,30	0,93	Big
Class X.8	26	25	15,16	0,95	Big

The effect size values for both experimental classes (class X5 and X8) are "big", which means that the application of discovery learning model has a big effect on the improvement of students' high-order thinking skills on the acid-base pH material. Measurement of effect size is important because if the value of significance is not necessarily if its effect size will be big too, effect size aims to know how big influence from application of treatment to a variable [32-33].

CONCLUSION

Based on the discussion and research results found that the model of practical discovery learning in improving students' high-order thinking on the acid-base pH material. This is indicated by the average percentage of RPP is "high" categorization and average percentage of student responses categorized as "very high". The discovery

learning model is also considered effective in improving students' high-order thinking on acid-base pH material. This is demonstrated by the ability of teachers to manage "high" learning and the increase of pretest-posstest (n-Gain) values in both experimental classes meet the "medium" criteria. Then for the result of influence or effect size using discovery learning model in improving high-order thinking skills have criteria of "big" on acid-base pH material.

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