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The Effect of Problem Based Learning (PBL) Learning Model on Students' Learning Outcomes in Buffer Solution Materials

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Abstract:The Effect Of Problem-Based Learning (PBL) Learning Model On Students' Learning Outcomes In Buffer Solution Materials . This study aims to change the effect of the Problem Based Learning learning model on learning outcomes and find out which cognitive domain is the most developed Problem Based Learning learning model in the application of buffer solutions in class XI MIPA. Samples were taken randomly as many as 36 students in class XI MIPA SMA Negeri 5 Medan. The instrument used in this study is a test instrument. The instrument test was carried out 2 times, namely pre-test and post-test. The instrument test used was an objective test with a total of 30 questions to test the level of students' cognitive abilities, namely C1 (knowledge), C2 (understanding), and C4 (analysis). PBL results show that there is an increase in test scores. Where the average pretest score is only 62.94 while the average post test score is 80.42. Based on this, learning using the Problem Based Learning model is able to increase knowledge of the buffer solution material in class XI MIPA students at SMA Negeri 5 Medan.

Keywords: Problem Based Learning (PBL), Buffer Solutions, Chemistry Skills

Abstrak:Pengaruh Model Pembelajaran Problem Based Learning (PBL) Terhadap Hasil Belajar Kimia Siswa pada Materi Larutan Penyangga. *Penelitian ini bertujuan untuk mengetahui pengaruh pembelajaran model Problem Based Learning terhadap hasil belajar dan untuk mengetahui ranah kognitif mana yang paling berkembang melalui penerapan model pembelajaran Problem Based Learning pada materi larutan penyangga di kelas XI MIPA. Sampel diambil secara acak sebanyak 36 siswa di kelas XI MIPA SMA Negeri 5 Medan. Instrumen yang digunakan pada penelitian ini adalah instrument tes. Instrument test dilakukan sebanyak 2 kali yaitu pre-test dan post-test. Instrument test yang digunakan adalah tes objektif dengan jumlah soal sebanyak 30 butir untuk menguji tingkat kemapuan kognitif siswa yaitu C1 (pengetahuan), C2 (pemahaman), dan C4 (analisis). Hasil PBL menunjukkan bahwa terjadinya peningkatan nilai tes. Dimana nilai rata – rata pretes hanya sebsar 62,94 sedangkan rata – rata nilai post-test sebesar 80,42. Berdasarkan hal tersebut maka pembelajaran dengan menggunakan model Problem Based Learning mampu meningkatkan pengetahuan materi larutan penyangga pada siswa kelas XI MIPA SMA Negeri 5 medan.*

Kata kunci: *Problem Based Learning (PBL), Larutan Penyangga, Kemampuan Kimia*

▪ INTRODUCTION

Quality education is education that is able to support development in the future. According to Desnylasari et al (2016) that Education is one way to improve the quality of Human Resources. So that education is very important in the survival and development of a nation.

The process of learning chemistry is an attempt to improve the cognitive and metacognitive aspects of the teaching and learning process. This learning focuses on scientific conceptions and attitudes through interactions between students and mediators or teachers. Chemistry learning is very important because it requires high attention to the characteristics of chemistry. Chemistry processes and produces products, both covering the skills and attitudes of scientists to acquire and develop knowledge, as well as a set of chemical facts, concepts and principles. Because it is very important for students to master chemistry learning materials, such as understanding concepts and calculations which are prerequisites for understanding chemistry learning materials. Learning that is integrated with practice will make students understand chemistry material not only by memorizing theory but students also need it in relation to everyday life (Wardani et al., 2016).

Based on the results of observations made at SMA Negeri 5 Medan, there are several things that make it difficult for students to understand chemistry, namely: 1) the lack of learning resources that students have. The learning resources used are only in the form of textbooks 2) the learning approach used by the teacher tends to be teacher-centered by using the lecture and question and answer method. Teachers rarely use a variety of learning methods. Students only rely on teachers in obtaining information. According to Oktaviana et al, (2016) learning like this causes students to be less enthusiastic, less active and less honed in their thinking skills. As a result, students are less interested in the material, passive in discussions, and their mastery of concepts and critical thinking skills is low (Kristina in Rudibyani et al, 2021). One of the material that was considered difficult for students to understand was the material about Buffer Solutions. Buffer solution materialis a very complex material with concepts that are difficult for students to understand. In understanding buffer solutions, students are required to provide basic concepts of acid and base matter in chemical equilibrium (Syafaatunniyah et al., 2018).

Choosing an effective and appropriate learning model is one of learning and good learning outcomes. The learning model is said to be successful if it can change students to be better than before so as to improve their learning outcomes. Problem-based learning can be made as an alternative way to improve the quality of a student's learning and their learning outcomes. The application of this PBL model carries out the learning stages for class XI students as follows: 1) basic concepts, 2) problem definition, 3) independent study, 4) group study and 5) assessment. At the basic concept stage, the teacher conveys the prerequisite material. (Armela et al., 2019), To improve their thinking skills, it is recommended that teachers develop and use HOTS questions in the learning and evaluation process, the results of which have a positive impact on their higher-order thinking skills (Misri and Kamelia, 2018)

The PBL model is a method of learning with students looking for a solution to a problem or task based on the concepts they learn. A learning method whose main center is the student or student-centered learning (Wibowo et al, 2021). This learning model is believed to provide many benefits to improve learning outcomes from the results of a mixture of buffer solutions (Buffer). The PBL model can help improve students' skills to think critically independently, by building a spirit (motivation) and developing higher skills. Learning with the PBL approach also teaches how to solve problems creatively and innovatively, and is able to motivate students to develop deeper mastery of the material.

According to Buheji and Buheji (2020), PBL is an educational strategy in which pertinent problems are addressed early in the instructional cycle to offer context and drive for subsequent learning. The PBL model is a method of instruction that has students learn about critical thinking and problem-solving techniques while also gaining information and understanding of the fundamental ideas of the subject (Aydin, 2014). The teacher actively and cooperatively conducts PBL learning activities to give students additional chances to discuss ideas and critique diverse viewpoints put forth by friends to address the issues at hand. Therefore, students can play a dual role, namely as students or as teachers (Tianto, 2007).

Studies show that Problem-Based Learning has a positive impact on the process of increasing learning outcomes from buffer solution material. According to a study by Al-Gazali, et al. (2020), PBL has been proven that there is an increase in learning outcomes from the results of understanding, namely the material of the buffer solution. With PBL, students are taught to better understand the concept as a whole by looking at the context of the situation, the underlying theory, and how to solve problems. Al-Gazali also found that this method can help increase student self-confidence and stimulate student motivation.

The purpose of this activity is to determine the effect of learning on the Problem Based Learning model on learning outcomes on buffer material in class XI MIPA and to find out which cognitive domain is most developed through the application of Problem Based Learning model learning in buffer solution material.

▪ METHOD

This research uses the Reeves model as a framework for conducting research (van den Akker, 2006). This research was conducted at SMA Negeri 5 Kota Medan in the 2022/2023 academic year with 36 students in class XI MIPA as subjects.

Research Instruments. The instruments used in this study consisted of test instruments. The test instrument is the results of students' chemistry learning, namely the pre-test and post-test. The pre-test is given to the sample before being given treatment (treatment) with the aim of knowing homogeneity and normality or the similarity of the characteristics of students' initial abilities. Post-test is given after completion of the treatment process (treatment) with the aim of knowing student learning outcomes. The test instrument is an objective test (multiple choice questions) with a total of 30 questions (before being validated) to test the level of students' cognitive abilities, namely C1 (knowledge), C2 (understanding), and C4 (analysis). Each question has 5 choices and each correct answer is given a score of 1 and an incorrect answer is given a score of 0. Before being tested, the instrument used is validated first by an expert validator. The tests are arranged based on Bloom's Taxonomy in the cognitive domain, namely C1 (knowledge), C2 (understanding), C3 (application), and C4 (analysis). Before the learning outcomes test is used, standardization of the instrument is carried out by testing the validity, level of difficulty, discriminating power and reliability testing.

- **Validity test**

Content validity is carried out by expert judgment (experts' considerations and suggestions). Then the researcher chose an expert validator, namely the chemistry lecturer at FMIPA Unimed to then be analyzed per item on the student learning outcomes test. This was done by researchers to obtain a valid test instrument. Content validity analysis criteria can be interpreted according to table 1.

Table 1. Classification of Content Validity Analysis

Value Range	Criteria
$0,81 < r \leq 1,00$	Very high validity
$0,61 < r \leq 0,80$	High validity
$0,41 < r \leq 0,60$	Enough validity
$0,21 < r \leq 0,40$	Low validity
$0,11 < r \leq 0,20$	Very low validity

A test item is said to be valid if the test item has a large carrying capacity for the total score which causes the total score to be high or low, in other words that the test item has alignment with the total score. To determine the coefficient of validity of the test used the product moment correlation technique with the formula:

$$r_{XY} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{\{N\sum X^2 - (\sum X)^2\}\{N\sum Y^2 - (\sum Y)^2\}}}$$

Description:
r XY = Correlation coefficient
X = Score of the item
Y = Total score of the items
N = Number of students

To interpret the significance of the question validity price, the price is consulted with the critical price r product moment with a = 0.05. If Thit > Itabel then the question is declared valid.

- **Problem Difficulty Level**

The number that indicates the characteristic (easy and difficult) of a question is called the Difficulty Index. The difficulty index of this item shows the level of difficulty of the item. The number that indicates the level of difficulty of a test item is called the Item Difficulty Index (P) which can be calculated by the formula:

$$P = B/T \qquad \text{(Silitonga, 2014)}$$

Table 2. Classification of the level of Difficulty of Test Items

P Price	**Categori**
0,00 - 0,30	Hard
0,31 - 0,70	Currently
0,71 - 1,00	Easy

- **Discriminating Power of Questions**

The discriminating power of the item is the ability of the item to distinguish between students with high abilities and students with low abilities. To calculate the discriminating power of questions can be seen from the following equation:

$$D = \frac{BA}{JA} \pm \frac{BB}{JB} = pA - pB$$ (Silitonga, 2014)

Description:
D = power of discriminating questions
BA = Many participants in the upper group answered correctly
Bb = Many participants in the lower group answered correctly
JA= Number of upper group participants
JB =Lots of lower group participants
Pa = Proportion of upper group participants who answered correctly
PB = Proportion of lower group participants who answered correctly

Table 3. Criteria for Discriminating Power of Test Items

Score	**Criteria**
0,00 - 0,20	Bad
0,21 - 0,40	Currently
0,41 - 0,70	Good
0,71 - 1,00	Very Good

- **Reliability Test**

Test reliability test is to see how far the measuring tool is reliable (reliable) and can be trusted, so that the instrument made can be accounted for in disclosing research data. Because the test used as a research instrument is a multiple choice question, the formula used is the Kuder and Richardson formula (K-R.20) and (K-R.21) as follows::

$$r_{11} = \left(\frac{n}{n-1}\right)\left(\frac{S_t^2 - \sum pq}{S_t^2}\right)$$

Description:
r11= Test reliability
p = Proportion of subjects who answered the item correctly
q = Proportion of subjects who answered the item incorrectly

N = Number of test items
S^2 = Variance of scores

Each proportion is calculated by the formula:

$$p = \frac{\text{the number of subjects whose score is 1}}{N}$$

$$q = \frac{\text{the number of subjects whose score is 0}}{N}$$

To interpret the reliability value of the question, the price is correlated to the product moment price table with a = 0.05 if it is a hit, then the test instrument is said to be reliable.

Table 4. Criteria for the degree of Reliability of a test

Score KR -20	**Level of Reliability**
0,80 - 1,00	Very high
0,60 - 0,79	High
0,40 - 0,59	Currently
0,20 - 0,39	Low
0,00 - 0,19	Very Low

▪ RESULT AND DISCUSSION

RESULT

This research was conducted in class XI IPA 2 SMA Negeri 5 Medan using a problem based learning model. In its implementation, the use of the problem-based learning model has phases that must be taken, namely first providing orientation on problems to students, organizing students to research, guiding student investigations independently and in groups, developing and presenting work as well as analyzing and evaluating problem solving process.

The use of this problem based learning model is accompanied by demonstrations. The next step is the researcher gives Problem Based Learning lessons in class for 3 meetings. Before and after the learning activities are completed, a test is then held to determine student learning outcomes. Based on the tests conducted, it was obtained that the average value of the pre-test of student learning outcomes was 62.94 while the average value of the post-test results was 80.42. Based on these results, it shows that the average post test that is taught with the problem based learning model is higher than the pretest average. This is also in accordance with Agustina's statement. et al, (2017), that there is an increase in student learning outcomes that have been taught using the problem based learning model.

Table 5. Mean, Standard Deviation, Pre-test and Post-test Data

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Pre-Test (PBL)	36	50	73	62,94	5.519
Post-Test (PBL)	36	70	90	80,42	5.123

	N	Minimum	Maximum	Mean	Std. Deviation
Valid N (listwise)	36				

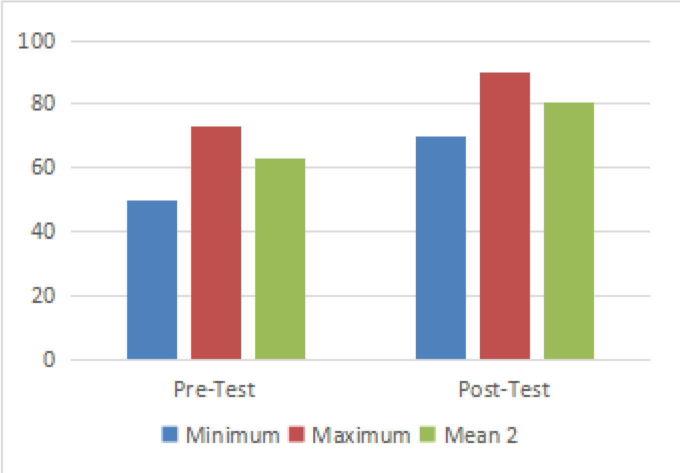


Figure 1. Mean, Standard Deviation, Pre-test and Post-test Data

1. Results of Data Analysis

Normality Test

The normality test is made to find out whether the data is normally distributed or not. Then, the samples come from the same population as well. To test normality, it can be obtained using the Kolmogorov-Smirnov approach to the SPSS 22.0 for windows program with a significance level of 0.05. The requirements of the Paired Sample t-Test test are to do the Normality test first. To see the results in pretest and posttest normality can be seen from the table 3 :

Table 6. Pre-test and Post-test Data Normality Test

Test of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Pre-Test	.135	36	.096	.954	36	.136
Post-Test	.123	36	.188	.946	36	.077

Based on the data normality test, it was carried out using the Kolmogorov-Smirnov approach in the SPSS 22.0 for windows program with a significant level of 0.05, that is, the value of Sig. for the pre-test 0.096 and post-test 0.188 where the class Sig value is greater than 0.05 (significance level), so it can be concluded that the research data above are **normally distributed**.

Hypothesis Test

- **Hypothesis 1**

After the data is processed, it is determined that it follows the normal distribution. Next, hypothesis testing is carried out. Therefore, this study used Paired sample t-Test to test the data, using SPSS 22.0 software for statistical analysis. Using a predetermined significance threshold of 0.05.

Table 7. Data From Hypothesis Testing on Learning Outcomes

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	Early Chemical Intelligence - Late Chemical Intelligence	-17.47222	6.34929	1.05822	-19.62051	-15.32393	-16.511	35	.000

In this study, statistical software SPSS 22.0 for Windows was used. The acceptance of the alternative hypothesis (Ha) is determined based on the provision that the significance level (Sig.) (2-tailed) is less than 0.05. If the significance level (2-tailed) is greater than 0.05, then the alternative hypothesis (Ha) is considered rejected.

The test findings shown in Table 4.4 show the results of the first hypothesis. The Sig. value obtained is 0.000, which is below the significance level of 0.05, and Table 4.4 shows that the t-count value = -16.511. t calculate this negative value because the average score of Pre Test learning outcomes is lower than the average Post Test learning outcomes.

In the context of such a case, a negative t-count can be positive. So the calculated t value becomes 16.511. Where t table is searched based on the value of df (degree of freedom) and the value of significance ($\alpha/2$). From the output above, it is known that the df value is 35 and the value of 0.05/2 is equal to 0.025.

We use this value as a reference base in finding the table t value in the statistical table t-value distribution. So find the table t value is 2.030. Thus, since the calculated value of t is 16.511> t table 2.030, then as the basis for making the above decision can be concluded that H0 is rejected and Ha is accepted.

Based on the existing evidence, it can be concluded that the first hypothesis is supported. This finding indicates a significant improvement in student chemistry learning outcomes after the application of the Problem-Based Learning (PBL) learning approach to the Buffer Solution material.

So it can be concluded that there is an average difference between Pre Test and Post Test learning outcomes, which means that there is an influence on the use of problem Based Learning (PBL) learning models in improving student chemistry learning outcomes on Buffer Solution material.

- **Hypothesis 2**

One-Sample Test

	Test Value = 75					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Kecerdasan Kimia Akhir	6.343	35	.000	5.41667	3.6831	7.1502

This study produced findings showing Sig. (2-tailed) of 0.000, leading to rejection of the null hypothesis (H0) and acceptance of the alternative hypothesis (H1). Research findings show that the average learning outcomes of students who use the Problem Based Learning approach are much higher than 75.

One-Way Testing
For example: the average final grade of students is at least 75

H0 = $\mu_1 \geq 75$
H1 = $\mu_1 < 75$

df = n-1 = 36-1 = 35
Sig level = 0,05
C = 1- 5% = 95%
Za = 1,65

Uji Statitik :

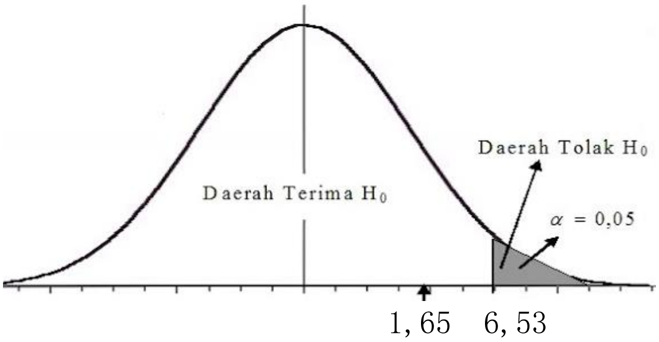
$$Z = \frac{\overline{(x)} - \mu 0}{\frac{s}{\sqrt{n}}}$$

$$Z = \frac{(80{,}42 - 75)}{\frac{5{,}123}{\sqrt{36}}}$$

$$Z = \frac{5{,}42}{0{,}83}$$

$$Z = 6{,}53$$

Menentukan daerah keputusan dengan nilai kritis Z = 1,65



Decision Making :

Z value (6.53) ,Located in the area not rejecting H0. This indicates that Ho is accepted and H1 is rejected. Thus, the average student score is greater than 75 so that 36 students meet the graduation requirements.

- **DISCUSSION**

Based on the research that has been done, the results of the first hypothesis test are obtained, where the Sig value obtained is less than 0.05, namely 0.00, so it can be concluded that the first hypothesis is accepted. This means that there is an increase in student learning outcomes taught using problem based learning models on buffer solution material. The second hypothesis is that the Sig value obtained is smaller than 0.005, namely 0.00. It can be concluded that the second hypothesis is accepted. The results of the analysis show that the average student learning outcomes after applying the Problem Based Learning learning model are significantly more than 75. This is in accordance with the results of Sholihah's research (2020) that the teacher's role in problem-based teaching is to present problems, ask questions, facilitate investigation and dialogue. Problem-based teaching cannot be carried out if the teacher does not develop a classroom environment that allows for an open exchange of ideas. In essence, students are faced with authentic and meaningful problem situations that students can challenge to solve. it can be said that problem-based learning provides students with the opportunity to learn how to learn (Hallinger & Bridges, 2017). Previous research also shows that the PBL modality fosters the students' creativity and critical thinking abilities throughout the learning process (Al-Fikry et al., 2018; Cahyo et al., 2018).

Although this research succeeded in improving student learning outcomes, individual completeness cannot be said to be 100% complete because there are several students whose post-test scores have not yet reached the KKM (minimum completeness criteria) score of 75 for the chemistry subject at the school. This can be related to the factors that cause students to be unable to fulfill the KKM according to Ariyo (2013), namely, aspects of complexity related to the level of difficulty of the subject matter being tested, aspects of supporting resources related to the facilities and infrastructure available at school and aspects related to the intellectual level of students.

Apart from that, there are internal and external factors that influence how well the PBL learning model performs in improving student learning outcomes in the buffer solution material. The extent to which students want to learn well, how motivated they are learning, and how much they want to succeed are all intrinsic aspects. Meanwhile, the rewards and the degree to which learning activities are enjoyable are extrinsic factors (Febrina & Airlanda, 2020; Utama & Kristin, 2020).

▪ CONCLUSION

Based on research that has been done that the Problem Based Learning learning model is able to improve students' thinking skills, this is evidenced by the increase in pre-test scores with an average of 62.94 to 80.42 during the post-test. The Normality Test is 0.096 and 0.188 where the Sig value of each test is greater than 0.05 (significance level), so it can be concluded that the research data above are normally distributed. Then for the results of hypothesis testing using the Paired Sample t-Test test, the significance value is 0.00, the Sig value is less than 0.05, so it can be concluded that the first hypothesis is accepted. This means that there is an increase in student learning outcomes taught using the problem-based learning model on buffer solution material at SMAN 5 Medan. The second hypothesis is that the Sig value obtained is smaller than 0.005, namely 0.00. It can be concluded that the second hypothesis is accepted. The results of the analysis show that the average student learning outcomes after applying the Problem Based Learning learning model is significantly more than 75%.

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