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The Effectiveness of Problem Based Learning Models (PBM) to Improve Students' Ability to Think Smoothly on Redox Reaction Material

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Figuring out the effectiveness of Problem Based Learning model to increase the smooth thinking of Redox reaction material is the goal of this research. State senior high school of 1 Tulangbawang, especially XI IPA students (Science major at twelve grade), becomes the population in this research on the second semester of 2017/2018. The sample class is divided into two groups namely; experimental class in XI IPA 3 and control class for XI IPA 4 by applying cluster random sampling as the technique to take the sample. It is a quasi-experiment research by involving the design of pretest-posttest control group. N-Gain scores' average on current students' thinking skill is used to show and measure the effect of problem based learning model. The outcomes of this research on the experimental class shows that the n-Gain average value on students' thinking skill is at high criterion by 0.88. Regarding to the results in this research, it can be inferred that the problem based learning model can increase students' thinking skill on material of Redox reaction.

Key words: *Redox Reaction, Thinking Smoothly, Problem Based Learning*.

Introduction

It is hoped that the 2013 curriculum can be implemented in 21st century learning. It goes to the demands of a rapidly competitive era. 21st Century learning reflects four things, namely (Kemendikbud, 2013) : (1) Creativity and Innovation; (2) Critical Thinking and Problem Solving; (3) Collaboration; (4) Communication. In the 21st century, various complex challenges are faced by people. It can be seen from the ease of accessing all types of information as its availability anywhere and any time (Wijaya, Sudjimat & Nyoto, 2016). In the 21st century, it is necessary for them to cope with at least some competencies such as;

creative and innovative thinking skill (Sharon & Key, 2010; Bramwell-Lalor & Rainford, 2014). Active atmosphere creates active instructional strategies (Priyono, 2018). It is expected that students are able to create new things and solve various problems (Mawaddah, Kartono & Suyitno). To deal with these problems, education can be believed as a vehicle to improve the ability to think creatively and solve problems in building high-quality and high-quality human resources (Marjan, Arnyana & Setiawan, 2015; Kearney, Treagust, Yeo & Zadnik, 2001; Beta, 2012). The learning fulfilment on the roadmaps and designing the experience gained by students increases their self -educational to be ready within the activities (Andreeva et al, 2018).

The results of observations and interviews with teachers and students obtained information that the majority of students are not interested in chemistry lessons, and tend to be lazy to learn. This caused the low ability to think smoothly in students. One of the thinking skills that can be developed in students is the ability to think creatively. The skill to generate new ideas through developing, changing and combining existing ones is done by creative thinking (Anwar, Aness, Khizar, Naseer & Muhammad, 2012; Anwar, Shamin & Haq, 2012). The skill of thinking creatively consists of: (1) Fluency Thinking; (2) Flexible thinking; (3) genuine thinking; (4) Elaboration; (5) Valuing (Anwar, Shamin & Haq, 2012; Fauziah, Marmoah & Murwaningsih, 2020). In this study the ability to be investigated is the ability to think fluently (fluency).

Problem-based learning model, hereinafter written PBM, (Nagarajan & Overton, 2019) is done by developing the skill to solve the problems coming from their own thinking resulting in creative thinking to perceive new knowledge based their own experiences (Riyanto, 2010; Raiyn & Tilchin, 2015). It is based on the real problems confronted in their daily life leading to discussions and go for some solutions (Cari, Pratiwi, Aminah & Nugraha, 2019; Pratiwi, Cari, Aminah & Affandy, 2019; Affandy, Aminah & Supriyanto, 2019). Therefore, by applying the PBM model, it can produce quality human resources, so that they are able to solve existing problems in life (Yazar, 2015). Referring to the description above, it will be described the effectiveness of problem-based learning models (PBM) in improving students' ability to think smoothly on the redox reaction material.

Methodology

This is a research by using a quasi- experiment as the method by using the pretest-posttest control group by a non-equivalent design (Fraenkel, Wallen & Hyun, 2012; Sugiyono, 2013). All of the students in class XI of SMA Negeri 1Tulangbawang Regency, in the 2017/2018 academic year become the population in this research consisting of five classes. The technique applied is a cluster of random sampling by taking the samples from XI IPA 3 for the control class and XI IPA 1 as the experiment class. There are 5 problem descriptions as the instrument in the pretest- posttest reflecting students' worksheets and dynamic thinking skill through the model PBM. Moreover, in addition, it also includes teachers' assessment sheet to know its feasibility in managing PBM- class.

The SPSS version 17 is used to analyse instruments' reliability and validity for Windows software. The comparison of rtable and rcount values becomes the basis to define the questions' validity. The criterion is that if rtable <counts, the problem is valid. Cronbach's Alpha is taken to define its reliability. Table 1 shows the reliability degree criteria (r11) according to Guilford.

Table 1: Degree of Reliability Criteria

Degree of reliability (r11)	Criteria
$0,80 < r11 \leq 1,00$	Very high
$0,60 < r11 \leq 0,80$	High
$0,40 < r11 \leq 0,60$	Moderate
$0,20 < r11 \leq 0,40$	Low
$0,00 < r11 \leq 0,20$	Not reliable

The effectiveness of PBM learning models in improving students' ability to think smoothly on the redox reaction material is perceived by pretest and posttest grades. It was subsequently analysed by calculating the n-gain and converted into student scores. N-Gain value is the difference between the posttest and pretest scores. It is applied to determine the improvement of occurred value. The n-Gain Formula is as follow;

$$n - Gain = \frac{\% postest - \% pretest}{100 - \% pretest} \quad (1)$$

The n-Gain (Hake, 1998; 2012) criteria is given in Table 2.

Table 2: N-Gain Score Criteria

Score n-Gain	Criteria
n-Gain > 0,7	High
0,3 <n-Gain ≤ 0,7	Moderate
n-Gain ≤ 0,3	Low

The effect size of using PBM models in improving students' ability to think smoothly on the redox reaction material is taken the t test value. Before the t test was performed, the normality and homogeneity test of the pretest, posttest, and n-Gain tests was done by applying windows operation system of SPSS software 17th version. The Samples meet the normal distribution and homogeneous variance by the sig. value > 0.05. If the sample comes to the prerequisite above, the 17th version of SPSS is used to test its parametrical statistic for independent sample t test and n-Gain value for both classes. H0 is accepted if sig. value (2-tailed) > 0.05 meaning that the average n-Gain of students' smooth thinking skills by PBM models is lower than the average of n-Gain by conventional learning and reject H0 if otherwise. Furthermore, it meets the criteria of H0 if the value of sig. (2-tailed)> 0.05 meaning that the pretest value has no change or the same as the posttest value and it rejects H0 if vice versa. The t- value resulted from the independent sample t-test on both classes is continued by its size effect calculation by using the following formula (Jahjouh, 2014).

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

With the size effect criteria as in Table 3, the following (Dincer, 2015).

Table 3: Effect Size Criteria

Effect size (μ)	Criteria
μ ≤ 0,15	Very small
0,15 < μ ≤ 0,40	Small
0,40 < μ ≤ 0,75	moderate
0,75 < μ ≤ 1,10	Great
μ > 1,10	Very large

To show that the instructional process by using PBM model is done by assessing the PBM learning model feasibility through observation sheet. The formula below is applied to calculate its achievement percentage (Sudjana, 2005).

$$\%Ji = \frac{\sum Ji}{N} x100\% \quad (3)$$

Table 4: Criteria for Performability

Size effect (μ)	Criteria
80,1% - 100,0%	Very high
60,1% - 80,0%	High
40,1% - 60,0%	moderate
20,1% - 40,0%	Low
0,0% - 20,0%	Very low

Data obtained from the analysis of the feasibility of the PBM model are then interpreted based on the criteria for the level of feasibility as in Table 4 above according to Ratumanan (Sunyono, 2015).

Results and Discussion

This research explores the effectiveness of the PBM model in improving students' ability to think fluently in redox reaction material. The effectiveness of this PBM model is done by considering any improvement on the value of n-Gain students' average of thinking skills fluently in the end of teaching learning process. The distinctive feature of the PBM model is to bring up laziness regarding to daily life, and get way out in groups assisted by teacher in an experimental way. The instruments test are used to evaluate students' learning abilities, especially on smooth thinking as the main focus to be measured in this study.

Validity and Reliability

The results of the calculation on multiple choice questions' reliability and validity by applying Iteman 4.3 software are given in table 5.

Table 5: Criteria for Performability

Item Question	total Rpbis	Alpha	Description
1	0.448	0.554	Reliable and Valid
2	0.426	0.565	Reliable and Valid
3	0.420	0.562	Reliable and Valid
4	0.501	0.555	Reliable and Valid
5	0.410	0.588	Reliable and Valid
6	0.447	0.555	Reliable and Valid
7	0.510	0.543	Reliable and Valid
8	0.448	0.554	Reliable and Valid
9	0.438	0.557	Reliable and Valid
10	0.410	0.574	Reliable and Valid

The value of Corrected Item-Total Correlation calculated by 17th version of SPSS software presents value of validity shown in Table 6.

Table 6: Results of the reliability test items

Item Question	rcount	Dk	rtable	Criteria
1	0,793	19	0,444	Valid
2	0,696	19	0,444	Valid
3	0,785	19	0,444	Valid
4	0,696	19	0,444	Valid
5	0,660	19	0,444	Valid

The five description items have the value r count > r table, meaning that the five item description are declared valid as described in table 6.

The reliability calculation covering five descriptive questions are obtained from the Cronbach's Alpha result in the value of 0.764 meaning that there are five descriptive questions having high reliability (Arikunto, 2007; Mardapi, 2012). To be a good instrument, it has to come to be reliable and valid as the essential requirements (Arikunto, 2007, 2013; Mardapi, 2012). Five description questions and ten multiple choice questions as the tests' instruments meet the reliability and validity requirements which are stated to be appropriate in measuring students' current thinking skills on redox reaction material.

Effectiveness of Problem Based Learning Models (PBM)

Before the PBM model is effectively studied in improving students' ability to think smoothly, the teacher's learning management skill is first observed. There are two observers examining teacher's skill in learning management occurred through an observation sheet. The calculation shows the average ability of teachers in management of learning categorised as "very high" by achievement percentage of 78.43%. Teachers' skills to manage problem-based learning has run well which can be taken from preliminary observations, syntax, closing, and assessment aspects from the teacher.

The observations of the two observers on the teacher's ability to teach the PBM model on the redox reaction material are shown in Table 7.

Table 7: Teacher's Ability in Managing Learning

Meeting to-	Average percentage of teacher skills (%)				
	Observation aspect				Average of each meeting
	Preliminary	Syntax	Closing	Teacher assessment	
1	59.00	71.67	63.00	73.00	66.67
2	75.00	79.83	75.00	83.00	78.21
3	78.00	82.83	81.00	85.00	81.71
4	88.00	84.50	88.00	88.00	87.13
Average	75.00	79.71	76.75	82,25	78.43
Criteria	Very high	Very high	Very high	Very high	Very high

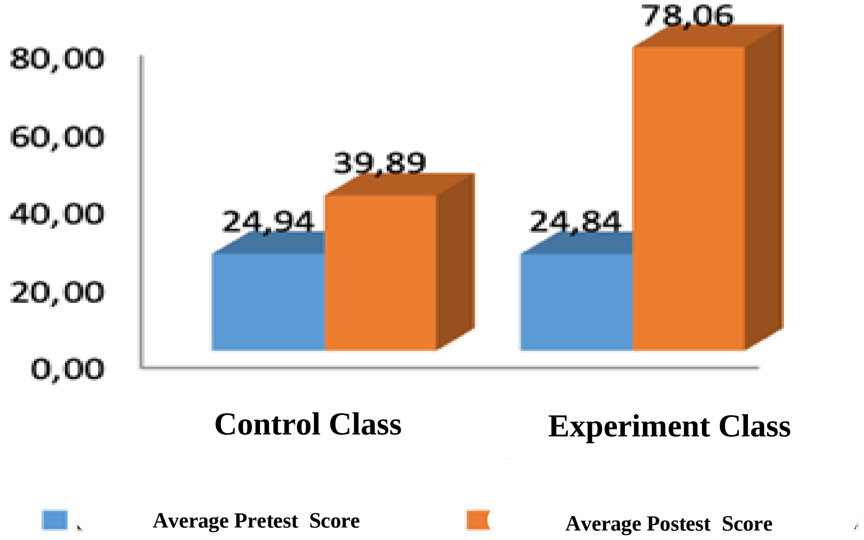
The results of observations and assessments on teacher's skill on learning management shows improvement for each meeting conducted. It can be captured from the way students are active during the instructional process as well to search the material by themselves or independent. It also leads them to be able to find solutions for problems in daily life. The results obtained are presented. Each meeting, students will be trained and become integrated steps of the PBM model.

Teachers' skill to manage well prepared learning will lead to the successfulness of targeted learning goals (Rudibyani, 2018). Teachers 'ability to manage learning causes an increase in students' fluent thinking. PBM syntax can be applied to the thinking skills smoothly as found in the second to third stages. In the second stage there is organising students to learn. The teacher helps students to define and organise learning tasks related to problems. In the third stage the teacher guides students individually and in groups. In this third syntax the teacher helps students to gather appropriate information, carry out experiments to get explanations and problem solving.

Thinking Smoothly Ability

To measure the effectiveness of the PBM model on students' achievement on current thinking skills, it can be obtained from the calculation of the average pretest and posttest scores (Figure 1). The difference in the average n-Gain value is shown in Figure 2.

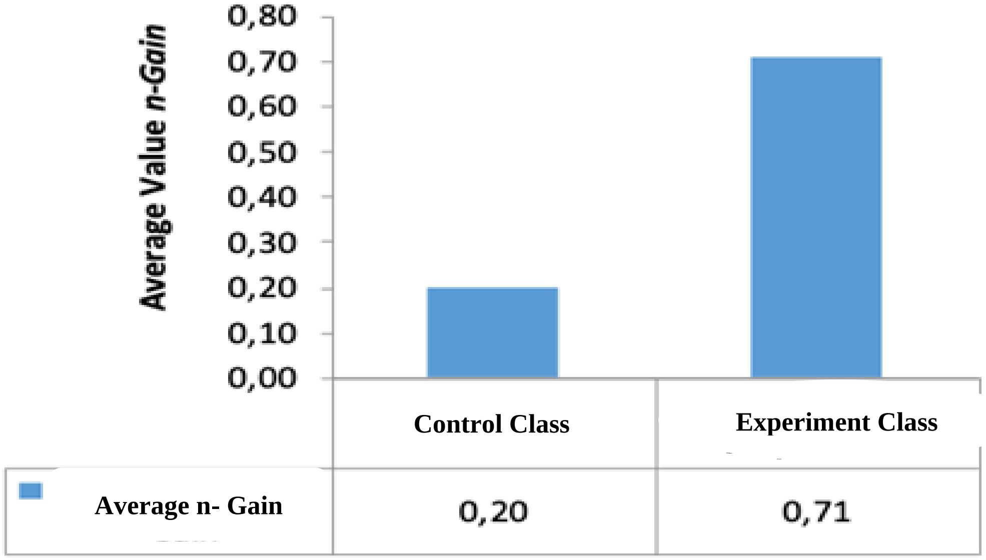
Figure 1. Average pretest posttest scores



It can be seen on figure 1 that the average pretest scores in the experimental and control classes are in the range of 24. It goes along with the researchers' basic hypothesis which is the same initial knowledge found on those samples. Moreover, it is also identified that there is an improvement on students' aspect of fluent thinking skills in both classes after appling the PBM Model. The result shows that both classes, control and experiment, improvement on the average value by greater achievement on experiment class as implemented the PBM Model. Thus, students' thinking smoothly skills after learning in both classes are applied better than before the learning is applied.

Increased students' ability to think fluently is demonstrated through the n-Gain value. This value is used to look carefully at the comparison between the difference between the value of pretest and posttest with the difference between the maximum value and the value of the pretest so that it can be seen the effectiveness of PBM models in increasing students' fluent thinking skills in redox reaction material (Figure 2).

Figure 2. Average n-gain values



The Figure above shows the average value n-Gain on students 'ability to think fluently in the experimental class by 0.71 into the criteria of "high" and the control class by 0.20 into the "low" criteria " for smooth thinking skill. It presents that the average value of n-Gain students' skill to think fluently in the class applied with PBM model is different in students' ability to think smoothly from the class applied conventional learning models on the redox reaction material. In short, students' fluency on thinking skill in experiment class is better than the control one.

Hypothesis testing

Test results on normality and homogeneous students' smooth thinking skill on both classes are described below.

Table 8: Normality test results

Class	N	n-Gain	
		sig.	Criteria
Experiment	31	0,110	sig. > 0,05
Control	30	0,158	sig. > 0,05

It can inferred from table 8 that both classes reaching for the sig value referring to the normality test results by n-Gain values from Shapiro-walk by > 0.05 and to accept H0 and reject H1, which means that the population are distributed normally.

Table 9: Homogeneity Test Results

Class	N	n-Gain	
		sig.	Criteria
Experiment	31	0,77	sig. > 0,05
Control	30		

Table 9 presents the test results on homogeneity by the n-Gain value for both classes reaching for sig values. > 0.05, by decision to accept H0 and reject H1. It means that the variance values of both samples are homogeneous.

Difference Test Of Two N-Gain Averages

The two mean difference on n-Gain of students smooth thinking results on those both classes are given in table 10.

Table 10: Test the Difference of Two Averages

Class	N	Average	df	sig. (2-tailed)
Experiment	31	0,71	59	0.00
Control	30	0,20		

SPSS 17.0 program is used to have independent sample t-test with a significance level of 5% which was conducted to find the averages of test difference in which to accept H1 test's criteria if the value of sig. (2-tailed) to be equal <0.05 and accept H0 if vice versa. The difference of two n-Gain average test results on students' thinking skills on both classes indicate that the value of sig. (2-tailed) <0.05 by decision to accept H0 and reject H1. It means that the significant difference in the n-Gain scores for both classes especially on the experiment class applying PBM Model reaching higher achievement seen from the topic of redox reaction.

The two difference test averages and the teacher's skill for learning management exposes that PBM model implementation on learning has been performed better in improving students' ability to think smoothly. PBM is one of the innovative learning models that can provide active learning conditions for students. PBM is a learning model that involves students to solve a problem through the stages of the scientific method so that students can learn knowledge related to the problem and at the same time have the skills to solve problems.

Effect Size

The next step after completing the difference test of both averages on the n-Ganin values, is continued with figuring out the influence of PBM Model on its effectiveness by having effect size calculation. It is necessary to define its t value resulted from the test results by calculating its effect size to know the t value of the difference test results against those two classes. Tcount value obtained from the difference test taken from the average of pretest-posttest with independent sample t-test result in t value of 33,499 for experiment class and 8,658 in control class. The results of the calculation on effect size of smooth thinking for both classes is as follow.

Table 11: The value of effect sizes in the control and experimental classes

Class	N	Df	t count	sig.(2-tailed)	Effect Size	Criteria
Experiment	31	60	33.499	0,000	0.98	Big
Control	30	58	8.658	0,000	0.75	Medium

Based on Table 11, it can be concluded that Sig. value (2-tailed) to be less than 0.05 and accept H1 in two classes. It means that a significant difference in the average pretest-posttest scores among those two classes is available. The value of 0.98 is found at the effect size in the experimental class. According to Dincer criteria24 that value is in the range of $0.75 < \mu \leq 1.10$ defined to be "big effect" category. The control class reached the value of 0.75 for its effect size. According to Dincer criteria24, the value lies in the range of $0.15 < \mu \leq 0.75$ belonging to "medium" category.

The results of these calculations indicate that the influence of the PBM model is bigger in experimental class compared to control class on the redox reaction material. The increasing of students' fluent thinking skills in the 98% experimental class was influenced by the PBM model while 75% in the control class was influenced by the conventional model.

The results of effect size and effectiveness test above informs that the implementation of PBM models on the learning has a big influence to lift up students' thinking skills smoothly. This is supported by the results of Zalia's 2013 study that there is a simultaneous influence on the application of the PBM model to students' critical thinking skills, motivation and social studies learning outcomes of Grade VII students of SMPN 1 (Aikmel & Lasmawan, 2013). The results of other studies state that the PBM model can improve students' creative thinking abilities in the Stochiometry material (Rudibyani, 2018).

Conclusion

The PBM model is effective in increasing students' ability to think smoothly on redox reaction material. This improvement is evidenced from the activities of students who are relevant in learning management by teachers in the category of "very high". The greater average n-Gain value presents significant differences on control class compared to experiment class. The PBM model has a "large" measure of influence in improving students' fluent thinking skills on redox reaction material. To achieve optimal learning outcomes, learning with the PBM approach needs to be well designed starting from preparing problems that are appropriate to the curriculum that will be developed in the classroom, raising problems from students, equipment that may be needed, and assessments used.

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