Enhancing students’ reasoning ability and learning outcomes in the topic of petroleum by using problem-based learning model

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Abstract. This study aims to determine the reasoning abilities and learning outcomes in petroleum material and obtain an overview of students’ responses through the problem-based learning (PBL) model. This research was a quasi-experimental method conducted in a private Islamic Senior High School. The subjects of the study were two groups of students from different classes. Data were collected by written using questions about pre-test, post-test and questionnaire responses of students’ pre-test, post-test, and N-gain the control class obtained values 40.5, 68 and 44.26 respectively, while the experimental class scored 44.67, 80.33 and 63.19 apiece. The reasoning ability of students showed a difference. The students from the experiment class scored higher than the students from the control group. Also, vast majority of students respond positively to PBL learning models.

1. Introduction

Based on Curriculum 2013, the integrated learning process includes of graduate competencies, adequacy materials, learning process revolutions, and reforming assessments [1]. Also, the active learning process can improve the students’ mindset [2]. In that way, the success learning activities leads to self-reliance students in gaining the learning goals [3]. In fact, most students gain low assessments results. Chemistry is one of the fields of study of natural sciences which is learned by students ranging from secondary schools to universities, but there are still many who consider chemistry difficult. This difficulty affects the students’ understanding of various chemical concepts [4]. The petroleum is one of difficult concepts according to many students at high schools.

This difficulty also occurred in the MAS Darul Ihsan Aceh Besar. Based on observations, the chemical value of petroleum material is still low, and this is seen from the average daily exam value of students in the last three years starting from the 2015/2016 academic year up to 2017/2018, which is 50, 50 and 55. Based on these data, it revealed that the average daily exam value of students in the last three years on petroleum material is 51.67. The data show that the daily exam value of students cannot reach the minimum completeness criteria. The minimum completeness criteria on chemical subjects in MAS Darul Ihsan is 65.
Referring to the national examination scores of the high school/MA in the academic year 2015/2016, 2016/2017, 2017/2018 MAS Darul Ihsan also scored low in the concept of petroleum, respectively 20.00, 20.00 and 26.09 [5]. Furthermore, the author also interviewed the chemistry teacher at the school, aimed at finding out the problems or obstacles during the learning process, which resulted in low daily exam and national examination scores. The teacher states that students experience difficulty in understanding chemical material including petroleum. Students face problems in understanding petroleum material due to teacher-centred learning which decreases student learning motivation, lack of interest and less concentrated in the classroom. The students also unable to express their learning and reasoning ability. The reasoning ability is one of the goals in the learning process especially in petroleum material because it can train students and reasoning ways of thinking to conclude.

The reasoning ability has a significant position in learning chemistry and can help students understand the object of learning chemistry well [6]. Besides, reasoning can also have a positive effect on student learning achievement [7]. Reasoning ability can increase by applying a learning model. One of the learning models that can improve reasoning ability is problem-based learning (PBL).

Learning carried out by giving a problem to students can improve learning skills and reasoning [8]. The PBL model can stimulate students to have excellent reasoning skills [9], encourage lifelong students [10] and can improve learning outcomes significantly [11] and can make students critical and creative thinking [12]. PBL is an active learning process so that students can develop the ability to create, analyse and evaluate and be able to provide an opportunity for students to improve their scientific work skills [13].

PBL model was developed based on the theory that a student can obtain a new science by applying existing knowledge [14]. The approach to solving a chemical problem can provide reinforce of understanding of chemical concepts and can train student’s reasoning skills [6]. Reasoning can also reduce misconceptions in chemical matter with concept-based maps [15]. Teaching carried out by applying the PBL model is more effective and can create creative thinking [16], contributing to the development of student’s thinking skills [17], able to link disciplinary knowledge to the problems that exist in real-world [18] and able to increase student’s interest and activeness [19]. Besides PBL learning models are also able to improve a student's scientific skills [20].

The PBL model has several advantages, namely providing a problem solving that is challenging, arousing a critical thinking ability of students, finding the knowledge that is new, fun and preferred, able to increase the activities of students and provide an opportunity to apply the knowledge they have [4]. Learning outcomes of students using PBL learning models were higher than those who did not use PBL [21].

Learning models using PBL can make students have the skills to solve a proposed problem so that student learning outcomes can increase [22]. Based on existing statements, there is a close relationship between PBL models on reasoning abilities and learning outcomes of students. Therefore, research related to the application of the PBL model to petroleum material was carried out, in this case, what explored was the reasoning ability and learning outcomes of the students of MAS Darul Ihsan Aceh Besar.

2. Methods
This study employed TAM model, originally proposed by Davis in 1986. It is well known model and has proven to be a theoretical model to explain and predict use behaviour in the use of information technology.

The method employed in this study was a quasi-experiment. The research design used was a pre-test and post-test group. Research design can be seen in table 1 [23].
The population in this study is class XI MAS Darul Ihsan Aceh Besar, which consists of 5 classes with a total number of 182 students. Sampling in this study using purposive sampling, they were selected based on their daily quiz scores. The sample in this study is class XI-D and XI-E. Determination for the control and experiment classes was carried out using simple random sampling technique that is by lottery, to obtain the XI-D class as the control class and XI-E experiment. The procedure in this study was to provide a pre-test in the experimental and control classes. Then the treatment was used using the PBL model in the experimental class. The final stage was a post-test.

Data processing techniques include normality, homogeneity, and t-test. The N-gain test was conducted to determine the increase in reasoning ability in the control and experimental classes. The questionnaire test was conducted to determine the responses of students after learning using the PBL model.

### 3. Results and Discussion

The difference between the experimental and control classes lies in the learning model implemented, for the control class does not apply the PBL model when the learning process takes place while the experiment class uses the PBL model. In the teacher control class who are actively involved in learning, so the teaching and learning process is centred on the teacher, while in the experimental class, students are required to be active and solve problems. Both experimental and control classes use student worksheets. The initial stage is a normality test. The results of the calculations are performed using statistical product and service solutions (SPSS) version 20. Normality tests are conducted to find out the data obtained is normally distributed or not. The data distribution normality test of experimental and control class students was conducted using the one-sample Kolmogorov-Smirnov test through SPSS version 20 software with a significance level of 0.05. The pre-test and post-test scores are depicted in table 2.

| Data Source | Class     | Sig.  | Result |
|-------------|-----------|-------|--------|
| Pre-test    | Control   | 0.110 | Normal |
|             | Experiment| 0.476 | Normal |
| Post-test   | Control   | 0.187 | Normal |
|             | Experiment| 0.361 | Normal |

The results of the experimental and control class pre-test normality tests are 0.110 and 0.476 respectively, so it can be concluded that each class is normally distributed, this is due to the control and experimental classes significant > 0.05. Judging from the results of the post-test normality test of the control and experiment classes respectively 0.187 and 0.361, based on this it can be concluded that the control and experimental classes are significant > 0.05 so that each class is normally distributed. Then a homogeneity test was carried out, which was conducted to find out the data that we get between the control class and the experiment that has a homogeneous variance or not. This homogeneity test uses the Levene test (homogeneity of variances) test. The results of the statistical analysis of the pre-test and post-test scores of the control and experimental classes available in table 3.
Table 3. The homogeneity test result of pre-test and post-test

| Data Source | Class     | Sig.   | Result |
|-------------|-----------|--------|--------|
| Pre-test    | Control   | 0.700  | Normal |
|             | Experiment|        |        |
| Post-test   | Control   | 0.224  | Normal |
|             | Experiment|        |        |

The homogeneity test results of the pre-test control and experimental classes were 0.700, while the post-test homogeneity test was 0.224, so it could be concluded that the variance of the two samples was homogeneous, this was due to the control and experimental classes significant > 0.05. Data on student learning outcomes obtained are normally distributed and homogeneous, then t-tests were carried out using the independent sample test.

Table 4. Average difference test

| Data source | Class     | t-test | Sig.  | Result              |
|-------------|-----------|--------|-------|---------------------|
| Pre-test    | Control   | 1.572  | 0.121 | Insignificant differences |
|             | Experiment|        |       |                     |
| Post-test   | Control   | 5.999  | 0.000 | Significant differences |
|             | Experiment|        |       |                     |

The pre-test results in both classes were obtained sig. (2-tailed) 0.121, it can be concluded that there is no significant difference between the control and experimental classes. It is because the value obtained is > 0.05. Whereas for the post-test score in both classes obtained sig. (2-tailed) 0.000, it can be concluded that the post-test value obtained is < 0.05, so there are significant differences between the experimental and control classes. Based on this, it can be stated that there are significant differences between the two classes. The class that received treatment using the PBL model had a higher value than the class that was not given the PBL model treatment.

Learning by using the PBL model also encourages students to solve the problems given. Learning with the PBL model requires reasoning skills because with sound reasoning can launch students in solving problems and drawing conclusions from these problems. It also consistent with the opinion of Sumartini [24] which reveals that the improvement of student’s reasoning abilities who get the problem-based teaching and learning process is better than those who do not get treatment with problem-based models. The results of the percentage indicators of the control class's experiment and reasoning abilities when the pre-test can be seen in Figure 1. The percentage indicators of the control class's reasoning and experimental abilities when the post-test can be seen in Figure 2.
Based on Figure 1 it can be seen that the highest reasoning ability of the control class occurred in item 8 by 63% with indicators: the ability to present a statement verbally, written, drawings and diagrams, while the lowest reasoning ability of the control class occurred on item 2 by 28% with indicators: ability to draw conclusions from statements. The highest reasoning ability in the...
experimental class also occurs in item 8 by 65% with indicators: the ability to present a statement verbally, in writing, pictures and diagrams, and for the lowest reasoning ability the experimental class also occurs in item 2 by 34% with indicators: ability to draw conclusions from statements. Based on this, it can be concluded that the experimental class's reasoning ability is higher than the control. This is following the opinion Ario [25] which says that reasoning ability can be increased by applying PBL learning models and can have a positive influence on student learning achievement [7].

Figure 2 shows that the highest reasoning ability of the control class when the post-test occurs on item 8 is 78% with indicators: the ability to present a statement verbally, in writing, pictures, and diagrams, while the lowest reasoning ability of the control class occurs in item 3 of 58 % with indicators: ability to submit suspicions. The highest reasoning ability in the experimental class occurred on item 7 of 91% with indicators: the ability to present a statement verbally, in writing, pictures and diagrams, and for the lowest reasoning ability the experimental class occurred in item 2 by 70% with indicators: ability to present an oral, written, drawing and diagram statement. Student’s reasoning abilities increase after the learning process is carried out. The increase in reasoning abilities of control and experimental class students based on indicators is shown in figure 3.

Figure 3. Percentage of n-gain control and experiment class in reasoning abilities based on indicators

Figure 3 shows that the N-gain percentage for each indicator of the experimental class's reasoning ability is higher than the control class. The experimental class is in the high category while the control class is in the moderate category. The highest percentage increase in reasoning ability in the control class occurred in question number 8, namely 70 with the ability indicator to present a statement verbally, in writing, pictures, and diagrams. The lowest percentage increase in reasoning ability in the control class occurred in question number 2, namely 43 with the ability indicator to conclude the statement. The highest percentage increase in reasoning ability in the experimental class question number 7 is 81.67 with the indicator of ability to put forward a guess. The lowest percentage increase in reasoning ability experimental class number 2 is 65.56 with the ability indicator to conclude from the statement.

Based on this, it can be concluded that the student’s reasoning abilities increase after the learning process is carried out, and the value of the experimental class is higher than the control class. It proves
that student’s reasoning abilities can increase with the PBL learning model applied. Improving student’s reasoning abilities is also supported by the results of the evaluation and results of the worksheet. The percentage of the results of the evaluation of the control and experimental classes at the first meeting in a row were 60.83 and 65.5 while the second meeting was 61.5 and 65.2 respectively. The percentage of worksheet in control and experimental classes at the first meeting was 68.75 and 73.33, while the second meeting was 73.75 and 76.67 respectively. The description related to the average percentage increase in learning outcomes in the form of pre-test, post-test, and N-gain of students can be seen in Figure 4.

![Figure 4](image)

**Figure 4.** Percentage of increase in learning outcomes in the form of pre-test, post-test, and n-gain

Based on figure 4, the average pre-test scores of students in control and experimental classes were 40.5 and 44.67, respectively. From this value, it can be seen that the average pre-test values for both the control and experimental classes are still low. It shows that student’s knowledge of petroleum material is still lacking. Furthermore, at the end of the learning process, a post-test was carried out to see how much the student’s knowledge increased after the teaching and learning process took place. The results of the tests carried out obtained the average value of the post-test control and experimental classes, respectively, 68 and 80.33. Judging from the post-test average value, both classes have experienced an increase in knowledge. In the control class, students who obtained scores above the minimum completeness criteria numbered 25 people, while in the experimental class students who scored above the minimum completeness criteria were 29 people.

This shows that the learning process using the PBL model can be accepted by students and obtain better learning outcomes than the learning done in the control class. It is consistent with the opinion of Sumitro et al [26] which states that the application of the PBL model can improve learning outcomes and motivation of students. Also, PBL models can also improve critical thinking skills and student’s discipline characteristics to be better [26]. Besides PBL learning models are also able to improve student’s science skills [19]. Application of the PBL model brings the effect of achieving learning outcomes for students [27]. Improving student learning outcomes is calculated using N-gain. From the N-gain calculation, the average results of the control and experimental classes were obtained, namely...
44.26 (medium category) and 63.19 (medium category). It proves that in general there is an increase in learning outcomes after the learning process is carried out using the PBL model.

The great learning outcomes of students in the experimental class is caused by an opportunity for students to develop the skills and knowledge they have. This is consistent the opinion of Hsu [20] which revealed that the learning outcomes of students using the PBL learning model were higher compared to groups that did not use PBL. This is caused by, learning models using PBL can make students have the skills to solve a proposed problem so that student learning outcomes can be increased [21]. The PBL model also makes students play a more active role in the teaching and learning process, while the teacher is no longer a centre of learning, but in this case, the teacher is a facilitator [28].

Students who are allowed to develop their knowledge become more confident in expressing their opinions. There are 5 stages in the learning process using the PBL model, namely: a) the teacher prepares and gives problems to students, b) students form small groups, between one student and the other students, discuss each other using skills knowledge owned by students, students also formulate problems and make hypotheses, c) students look for information as well as data relating to a problem that has been formulated, d) students gather with their respective groups and report data that has been obtained, e) discussion activities are the final activities [29].

To find out the responses of students to the PBL learning model on petroleum material, a questionnaire sheet was used to be filled out by students at the end of learning. Questionnaires for students were only given to the experimental class. Questionnaires that are disseminated are closed, which have a level of response that is strongly agree, agree, disagree, strongly disagree. The response of students to the PBL learning model can be seen in Figure 5.

![Figure 5. Student’s response to PBL learning model](image)

Based on figure 5 the results of student responses to each aspect of the statement are obtained. The results of the response can be seen that using the PBL learning model can provide good learning outcomes to students. So the results of the response given are also positive. It is consistent with the opinion of Tosun and Senocak [30] which states that the PBL learning model is able to give a very significant influence in improving the positive attitude of students so that the response generated is also good.
4. Conclusions
The teaching and learning process using the PBL model can improve student’s reasoning and learning outcomes in petroleum material. The response to petroleum material through PBL models also received positive responses from students.

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