

Application of problem based learning model to improve problem solving ability of student of XI science grade in chemistry

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Abstract. The purpose of this study was to determine the effect of the application of problem-based learning models compared to conventional learning models to improve students' problem solving skills in XI IPA SMAN 2 Labuapi. This research is quasi-experimental, which used nonequivalent control group design. The population in this study were all students of XI IPAN SMAN 2 Labuapi in the academic year 2015/2016. The research sample consisted of two classes, namely class XI IPA 1 as an experimental class and class XI IPA 2 as a control class. The sampling technique used saturated sampling techniques. The instrument used to measure the ability to solve problems in the form of a description test. Data analysis techniques used the Anacova test for hypothesis testing and N-Gain to see the improvement of students' problem solving skills. Anacova test results found that there were significant differences between the variables involved in the study, while the average increase in students' problem solving abilities for the experimental class was lower than the control class. Based on these results it can be concluded that the problem solving abilities of students taught with problem-based learning models do not have a higher increase compared to conventional learning.

Keywords: *problem based learning, problem solving ability, buffer solution*

1. Introduction

Indonesia is recorded as a country that quite often wins international science olympiad. This seems to illustrate that Indonesia is full of intelligent people who are ready to contribute ideas in solving problems in the country. In fact, Indonesia is still filled with problems that have not yet a solution in solving them. For example, the problem of corruption, poverty, unemployment, health, and the most critical problem in this country is the problem of education, which until now there has never been an even improvement in all regions in Indonesia. This indicates that Indonesian people have not been trained in complex thinking skills, especially in problem solving. This indication is strengthened by the results of the PISA (Program for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study) which show that students' problem solving abilities are still low and are in 69th position out of 76 countries [1].

The irony is that the education system in Indonesia places more emphasis on basic thinking skills (one of which is memorizing) rather than complex thinking skills. The most popular activity in the learning process is practising exercises with the same type of questions continuously. If there is a competition, the number of science olympiad medals between Indonesia and Finland is our country the winner. But why has Indonesia's education system collapsed and Finland's education system



recognized globally? This is because Finland places high-level thinking skills, one of which is the ability to solve problems as part of the middle school curriculum, namely through the content of the curriculum "thinking skills and methods of thinking" [2].

Problem-solving skills should be trained and developed early. This can be done by tilting contextual problems in learning. Meanwhile, students independently try to solve these problems with the help of the material being taught. Material in science, especially chemistry, is very good to be developed into contextual problems, this is because chemistry is never released in daily life. This is in accordance with the philosophical intent used to develop the curriculum-2013 set forth in the regulation of the minister of education and culture of the Republic of Indonesia number 36 of 2018 namely education to develop students' potential to be a reflective ability for solving problems in society, and to build a better democratic society life .

One learning model whose learning process is based on contextual problems is a problem based learning model. As the name implies, problem-based learning (PBL) is a learning model based on the problems in daily life faced by students related to the learning that is being studied by students [3].

Problem-based learning is the most significant innovation in education [4]. PBL model helps to improve the development of lifelong learning abilities in an open, reflective, critical, and active learning mindset. PBL model facilitates the success of problem solving, communication, group work, and interpersonal skills better than other approaches [5].

PBL is basically a learning that is grounded in the problems that occur in everyday life. Therefore educators are required to be able to present a problem according to an authentic and meaningful situation to students [6]. This aims to make the learning process work well. The problem presented also needs to be made according to experience and easily recognized by students. In addition, the problem must also be related to the subject matter being taught.

Students who are facing problems based on the situation at hand, will come up with strategies to solve those problems based on experiences in their minds [7]. This situation will dictate the mental activity of students in understanding a concept, principle, and ability, in the situation or problem presented at the beginning of learning through the stages of problem solving. Like other learning models, PBM also has stages for its use in the learning process. The steps of the problem-based learning model are presented in table 1 [8].

Table 1. Syntax for problem-based learning.

No	Phase	Teacher behavior
1	Orient Students to the problem	Teacher goes over the objectives of the lesson, describe important logistical requirements, and motivates student to engage in problem solving-solving activity.
2	Organize students for study	Teacher helps students define and organize study tasks related to the problem.
3	Assist independent and group investigation	Teacher encourage students to gather appropriate information, conduct experiment, and search for explanations and solutions.
4	Develop and presents artifacts and exhibits	Teacher assists students in planning and preparing appropriate artifacts such as reports, videos, and models, and helps them share their work with others.
5	Analyze and evaluate the Problem-solving Proses	Teacher helps students to reflect on their investigations and the processes they used.

Through the application of problem-based learning models, students are expected to be skilled in solving problems. The problem based learning model changes students from passive recipients of information to active, independent learning and problem solvers, this changes the view of the

educational program so far from teaching to learning [9]. This model allows students to learn new knowledge through problems that must be solved, not in processes that burden students. Problem solving ability is a form of higher order thinking skills which certainly requires thinking to be used and related to various rules based on the experience of each student [10].

Students who are skilled in solving problems certainly meet indicators of problem solving ability. The indicators of the problem solving abilities used in this study are as follows: (1) understanding the problem; (2) planning problem solving; (3) implementing problem solving; and (4) evaluating the results of problem solving [11].

The study of Sahyar have proven that students' problem solving abilities that are taught using the Problem Based Learning Model are better than conventional learning [1]. Another study by Nurdeli concluded that an average increase in problem solving of students using the Problem Based Learning learning model is better than solving students' problems using conventional learning [12]. Subsequent research conducted by I Karma concluded that there were differences in students' problem solving abilities that were taught with problem-based learning models with conventional learning models [13]. Based on this explanation, this article discusses the application of problem based learning models to improve the problem solving abilities of students of class XI Science in chemistry subjects

2. Research method

2.1 Research subjects

The research subjects consisted of population and sample. The population in this study were all students of class XI IPA of SMAN 2 Labuapi which were distributed in 2 classes, with a total of 20 students in each class. The sample used in this study is all members of the population, where the sampling technique like this is called the saturation sampling technique. The XI IPA 1 was chosen as the experimental class and the XI IPA 2 as the control class.

2.2 Research design

This research is a quasi-experimental study. The research design used was nonequivalent control group design by giving pre-test and post-test. The study was conducted in two classes, namely one class as a control class and another class as an experimental class. The experimental class received treatment with a problem based learning model, while the control class received treatment with conventional learning. The dependent variable studied was problem solving ability and the independent variable was the problem based learning model for the experimental class and the conventional model for the control class.

Table 2. Research design.

Group	Pre-test	Treatment	Post-test
Experiment	√	Problem Based Learning	√
control	√	Conventional Learning	√

2.3 Instruments used

Types of instruments used in data collection in the form of a description test that requires students to answer through the stages of problem solving that is understanding the problem, planning problem solving, carrying out problem solving, and evaluating the results of problem solving. Before the instrument is used, the instrument is tested for validity and reliability. The validity test uses expert validity which was consulted with the Aiken's V formula and the reliability test used the Cronbach Alpha formula. The following is one of the six questions in the instrument used in collecting data on students' problem solving abilities.

When visiting your relatives who are sick at the treatment site, you will see a bag or bottle filled with intravenous fluids that have been injected into your relatives' bodies through a tube. The aim is to

replenish fluids and electrolytes as well as to treat and nourish the body of your relatives who are usually alkaline. Based on the discourse above, answer the following question.

- If it is known in the intravenous fluid that the weak base concentration is 0.2 M and the conjugate acid concentration is 0.2 M what is the pH of the intravenous agent? $K_B = 1.8 \times 10^{-7}$.
- What is the purpose of adding a buffer solution to the intravenous fluids?

2.4 Data collection techniques

The technique used in this research is observation test. This observation was carried out to obtain information about the research site. While the test is used to collect data before and after the treatment is given.

2.5 Data analysis techniques

Data taken from the two classes are initial data (pre-test) and final data (post-test) in accordance with the research design used. Preliminary data and final data are then tested with the data analysis requirements test, namely the normality test (to determine the normality of the sample), the homogeneity test (to determine the homogeneity of the sample), the hypothesis test using anacova and N-Gain to see an increase in problem solving abilities. The normalized Gain Score results are divided into three categories [14], [15].

Table 3. N-Gain criteria.

Percentage	Category
N-Gain > 70	high
$30 \leq \text{N-Gain} \leq 70$	Medium
N-Gain < 30	Low

2.6 Hypothesis

The hypothesis in this study is the problem solving ability of students who are taught with a problem based learning model has a higher increase compared to conventional learning.

3. Results and Discussion

The data collected in this study includes data on the results of the instrument trials and the results of the test results of students' problem solving abilities on the buffer solution material.

3.1 Instrument trial result data

The instrument used previously went through the stages of validity and reliability testing. Based on the results of the expert validity calculation, the coefficient value of Aiken's V ranged from 0.83-1, this shows that the question instrument used is in a very valid category. Reliability test obtained r-count value of 0.672 and r table at a significant level (α) 0.05 and N = 40 was 0.312, so $r_{\text{count}} > r_{\text{table}}$ was obtained, this implies that the instrument of problem solving ability is good or can be trusted.

3.2 Data on test results for problem solving capabilities

The data was used in the normality and homogeneity test. Based on these tests the results obtained are normally distributed and homogeneous data. Because the data meets the criteria for parametric tests, then the data is then performed anacova test.

Based on the results of calculations with anacova test obtained $F_{\text{count}} = 6.760$. This value is then consulted with a F_{table} price at a significant level of 5% and a F_{table} value of 4.11 is obtained. This shows that $F_{\text{count}} > F_{\text{table}}$. Furthermore, the calculation of the N-Gain value with the help of SPSS 16.0 software obtained data on the ability of problem solving students according to the following table 4:

Table 4. Percentage score N-Gain results in problem solving ability.

	Experiment Class (%)	Control Class (%)
Minimum	-7	-7
Maximum	39	61
Average	10	24

These results were consulted with the N-gain Criteria table. So based on the average N-Gain Score, it was concluded that the Experiment class experienced an increase in problem-solving ability by 10%. Whereas the control class experienced an increase of 24%. Although both classes have increased, the increase is in the low category.

Based on these calculations, obtained $F_{\text{count}} > F_{\text{table}}$ with an average $N\text{-Gain}_{\text{experiment}} < N\text{-Gain}_{\text{control}}$, this shows that after being controlled by the pre-test covariables, there are significant differences between the variables involved in the study. However, by considering the N-Gain score, it can be concluded that the problem solving ability of students taught with problem-based learning models does not have a higher increase compared to conventional learning.

3.3 Discussion

In this study, the activity began with a pre-test. Before starting the pre-test, one week in advance students are notified that a pre-test was held. Students are also given teaching material and sheets containing examples and ways to answer pre-test questions. At the time of the pre-test students are given a question sheet and a sheet to fill in the answers that are equipped with problem-solving steps (understanding the problem. Planning the problem solving, doing the problem solving, and summarizing the results of the problem solving).

At the next meeting, the experimental class was given a description of the buffer solution material. This is done as a provision in conducting problem-based learning at the next meeting. At this meeting also, students have formed their respective groups.

The next meeting, students learn through the stages of problem-based learning. Students begin with the first problem, eye drops. The objectives to be achieved in this study are (a) to distinguish between buffer solutions and non-buffer solutions. (b) summarize the components and types of buffer solution. (c) determine the properties of the buffer solution. The following is the scenario that was done in the first problem.

3.3.1. Stage 1 orientating students to the problem

At this stage students are presented with a problem related to eye drops. Students are asked the question (a) why when orange juice hits the eye, can it cause eye pain? (b) why when bathing and soap sprinkled on the eyes cause the eyes also sore? (c) And why does the eye drops that we put on the eyes not make our eyes sore? this question becomes a problem and leads students to find solutions to their problems.

3.3.2. Stage 2 organizing students for study

At this stage students were shown three solutions namely orange juice (as an acid compound), soap water (as a base compound), and eye drops (as a buffer solution). Students are shown how they will later conduct experiments to collect data. The teacher tries to test the orange juice. The first thing to do is to measure the pH of the orange juice. After that the teacher gets the pH of the orange juice. Furthermore, the orange juice is added a little strong acid (two drops of 0.1 M HCl) and then the pH is measured. After that, add a little strong base (two drops of 0.1 M NaOH) and then measure the pH again. And so on the soap water and eye drops that was done by students. There are several goals to this, the first is that students get the pH of three solutions before and after adding a little strong acid or base. Both students were able to compare the pH changes that occur between the three solutions and found that the pH of the eye drops did not have a significant change despite the addition of a few strong acids and bases. All three students will look for components of eye drops which are a buffer solution that is listed on the eye drops medicine package. And the fourth student can find out the nature of the buffer solution, which is maintaining the pH value. Before conducting an experiment, students in each group were given the opportunity to plan and share assignments for work during the experiment. Because the experience with this model is the first experience, so students were given a worksheet that has provided a blank table to fill in the required data complete with questions that lead to the learning objectives. Do not forget also on the worksheet the teacher put the pH of tears to answer the problem "why do eye drops not sore in the eyes?"

3.3.3. Stage 3 assisting independent and group investigation

At this stage students are given the opportunity to collect data and information as material to solve problems. Students are given the opportunity in a mandatory manner with teacher monitoring. In this stage it is endeavored that teachers do not interfere much in the process. Just observe if something dangerous happens. Mistakes made by students at this stage are natural in this learning process.

3.3.4. Stage 4 developing and presenting artifacts and exhibiting

After students collect data and information in stage 3, students together with their respective groups discuss the data obtained and try to harmonize the problems that have been given at the beginning of learning. And made in the form of a report that was presented briefly.

3.3.5. Stage 5 analyzing and evaluating the Problem-solving Process

This is the final stage in problem based learning. After the data from the problem solving results are discussed and presented, students together with the teacher conclude the results of the problem solving process. The teacher also straightens out a number of theories that are still not properly conveyed by students.

Furthermore, students will do problem solving for the second problem. This problem is related to isotonic drinks. The objectives to be achieved in this study are (a) Explain the working principle of buffer solution in maintaining pH. (b) Calculate the pH of the buffer solution The following is the scenario that was carried out in the Second problem.

3.3.6. Stage 1. orientating Students to the problem

At this stage students are presented with a problem related to isotonic drinks. Students are given several questions. "Have you ever had an isotonic drink? What is an example? How does the drink taste? Does it feel to change after a few days of silence? What causes it to not change? Is it related to pH stability? How does the liquid maintain pH stability? Can you calculate the pH of the solution? If you add strong acids or bases of a certain size can you still calculate the pH of the solution?

3.3.7. Stage 2 organizing students for study

In this stage, students were given worksheets. In the worksheet also contains some data needed to calculate the pH of the buffer solution. Then students are shown material that was used in the practicum. In practicum, students will use isotonic drinks, 0.1 M HCl, 0.1 M NaOH, and Bromtimol Blue indicators. Because the Bromtimol Blue indicator is not obtained at the lab then it is replaced with iodine (wound medicine). The teacher gives instructions to students about what to do in the experiment.

3.3.8. Stage 3 assisting independent and group investigation

At this stage students are given the opportunity to collect data and information as material to solve problems. Students prepare two beakers. Each cup was added 25 mL of isotonic solution and 25 mL of Aquades as a comparison. To each solution 2 indicator drops are added. After that, 1 ml of HCl HCl was added to the isotonic solution and then the color change was recorded. Another 1 mL NaOH is added to the color change. Something similar is done on aquades.

3.3.9. Stage 4 developing and presenting artifacts and exhibiting

After students collect data and information in stage 3, students together with their respective groups discuss the data obtained and try to solve the problems that have been given at the beginning of learning. And made in the form of a report that was presented briefly. After the presentation, students are shown a video about the working principle of a buffer solution in maintaining its pH.

3.3.10. Stage 5 analyzing and evaluating the Problem-solving Processing

This is the final stage in problem-based learning in this second problem. After the data from the problem solving results are discussed and presented, and students see how the working principle of buffer solution from the video. Students deduce theories about buffer principle correctly. And students see the teacher provides a way to calculate pH correctly.

The learning process in the control class is done through giving lectures and exercises. When given a question exercise, they immediately implied working with the stages of problem solving in order to know the flow in answering questions. In the final stage of the activity, students do a post-test to see the ability to solve the problem. Same as pre-test, during post-test also students are given a question sheet and a sheet to fill in answers which are equipped with steps to solve problems (understand the problem. Plan problem solving, do problem solving, and summarize the results of problem solving).

Thus the range of learning that students do in this learning process. If you pay attention, the stages in this model are very long and complicated so it takes a long time to implement it too. Nevertheless, if learning like this continues to be done it will train students in applying problem solving abilities. [12]-[14]. Researchers have implemented all the syntax in the problem based learning model. This is consistent with the observation sheet of the observance of the model by the observer.

Therefore the main cause should lie in the instruments used by researchers in measuring problem solving abilities. The assessment instrument used is only in the form of an essay test where students are expected to answer according to the four stages of problem solving. This is also an indication of why the control class's problem solving skills are higher than the experimental class. In the experimental class they are given problems to be solved through a problem based learning process. This means they go through a stage that is quite complicated in solving problems. However, this solution process is very meaningful to find solutions. While in the control class they learn through lectures and practice exercises, meaning that they are accustomed to the same questions and ways of answering that they always do in the learning process.

In working on problem solving questions students must be coherent in solving them starting from understanding the problem; plan problem solving; carry out problem solving; and finally evaluate the results of problem solving. But sometimes many students ignore this rule. In other words, students are not interested in the technique but rather prioritize the completion of the final result [15]. In addition, researchers also conducted an analysis of each indicator of students' problem solving abilities based on the results of the post-test. This can be seen from the following table.

Table 5. Average student problem solving ability for each indicator.

	Understanding the problem	Planning Problem Solving	Implementing Problem solving	Evaluating the result of problem solving
Experiment Class	13,59	7,3	5,85	5
Control class	13,9	9,3	7,7	6,05

Based on table 5, the average student grade on each indicator is very low. After the researchers conducted the analysis, it turned out that many of the students could not solve all the questions. This is due to the limited knowledge that researchers have. Researchers only do internal validity (content validity) of the instruments used, but do not do external validity so that the instruments provided are felt quite a lot by students.

One of the four indicators that the researcher analyzes is the problem-solving planning indicator. In the problem planning indicator students are expected to be able to write step by step in answering questions. students in the control class can write it easily but not for the experimental class. This is due to the habits of both classes when the learning process takes place.

The control class is accustomed to completing questions used for tests, because the types of questions used during the test and in the learning process have the same type, so the way to answer them is the same. Unlike the experimental class, the learning process in this class takes place with a problem-based learning model that is coupled with practical methods. Therefore, students are accustomed to planning problem solving to do practical work. As a result when given questions that are not for practicum, students become a little confused. Some students even fill in the problem-solving planning section with plans for practicum. As a result, many students run out of time in

completing this indicator. Therefore the average problem solving ability of the experimental class is lower than the control class.

Problem solving is the process of finding answers by individuals who apply knowledge and skills [16,5]. So it is not fair if the assessment is only done through a written test by writing down the appropriate steps in completing the problem. Because indicators of problem solving ability are in the form of steps, it is necessary to observe the students' abilities during the learning process.

4. Conclusions

The problem solving abilities of students who are taught with a problem based learning model do not have a higher increase compared to conventional learning. Essay tests conducted to measure problem solving skills are not enough to assess students' problem solving abilities. Because this ability is a collaboration between knowledge and skills, it is necessary to make direct observations to assess students' abilities in the learning process.

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