24 (1), 2023, 161-171

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

The Effectiveness of Problem-Based Learning Model to Improve Problem Solving Skills and Concept Understanding in Acid Base Solution

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Abstract: This research investigates the difference between learning acid base solution material using the PBL model and conventional learning regarding the conceptual understanding and problem-solving ability of grade XI students at Setia Bakti Ruteng senior high school. Three science classes from Grade XI at Setia Bakti Ruteng Senior High School comprised the 76 students who made up the study's population. The research sample, comprised of 56 students, was divided into two classes for the experiments: classes 1 and 2. Experiment class 1 was handled utilizing the PBL approach, and experiment class 2 was conducted using 5 M learning. The cluster random sampling method was used to select the sample. An essay examination was used to assess students' idea understanding, and their problem-solving ability was determined by examining their responses to the problem-solving essay test. The study's findings indicate that when conceptual comprehension and problem-solving skills are tested simultaneously in grade XI students at Setia Bakti Ruteng Senior High School, the PBL approach and conventional learning produce significantly different learning outcomes.

Keywords: problem-based learning, concept understanding, problem-solving.

Abstrak: *Penelitian ini bertujuan untuk menyelidiki perbedaan pemahaman konsep dan kemampuan pemecahan masalah siswa pada pembelajaran materi larutan asam basa dengan menggunakan model PBL dan pembelajaran konvensional. Penelitian ini merupakan penelitian eksperimen semu dengan desain penelitian nonequivalent control group design. Populasi penelitian ini adalah 76 siswa yang terbagi dalam tiga kelas XI IPA di SMA Setia Bakti Ruteng. Sampel penelitian berjumlah 56 siswa yang dikelompokkan menjadi kelas eksperimen 1 dan kelas eksperimen 2. Kelas eksperimen 1 diberi perlakuan dengan menggunakan model PBL, sedangkan kelas eksperimen 2 menggunakan pembelajaran 5 M. Sampel dipilih dengan menggunakan teknik cluster random sampling. Pemahaman konsep diukur dengan menggunakan tes esai, dan kemampuan pemecahan masalah diukur dengan menganalisis jawaban siswa pada tes esai pemecahan masalah. Hasil penelitian menunjukkan adanya perbedaan keefektifan prestasi belajar yang signifikan antara penggunaan model PBL dan pembelajaran konvensional terhadap pemahaman konsep dan kemampuan pemecahan masalah siswa kelas XI SMA Setia Bakti Ruteng jika diukur secara simultan.*

Kata kunci: *pembelajaran berbasis masalah, pemahaman konsep, pemecahan masalah* .

▪ INTRODUCTION

National education system in Indonesia exists to organize, plan, and implement education to achieve educational goals according to the 1945 Constitution. The national education system is usually changing according to the development and progress of the times. The government will evaluate and redesign the national education system and seek to improve the quality of education in Indonesia. Changes in the national education system should solve various educational problems. Curriculum changes are one of the government's solutions to improve the quality of education in Indonesia. The curriculum set by the government is the basis for schools, teachers, and students to carry out the

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DOI: http://dx.doi.org/10.23960/jpmipa/v24i1.pp161-171

Received: 01 February 2023

Accepted: 10 March 2023

Published: 21 March 2023

learning process. A well-applied curriculum will help the learning process. The learning process in schools has been regulated in the Regulation of the Minister of National Education Number 41 of 2007 regarding process standards. The learning process must be by the learning plan contained in the syllabus and lesson plans. Teacher readiness in the process of implementing learning is also one of the determinants of student success. Thus, as determinants of student success, teachers must plan to learn well by the curriculum to achieve national education goals.

Kurikulum 2013 aims to educate the nation's life and produce people with character. Cognitive intelligence is not the only determinant of educational success but must be supported by good feelings. The 2013 curriculum also requires teachers to develop and implement learning more creatively. Learning that takes place must develop students' skills, creativity, and cognitive abilities. Skills and creativity are essential because these competencies are needed in the 21st century. In the 21st century, highly competitive human beings are required so that skills and creativity are expected to produce abilities supporting innovations in students' lives.

Teachers are essential in learning innovation to direct students to national education goals. The invention is used in developing learning tools to improve students' abilities. Teachers are expected to have the ability to use various models, approaches, and learning strategies to innovate so that students do not feel bored during the learning process. Learning innovations by teachers will allow students to develop various abilities, skills, and creativity. Fun learning occurs when the teacher has the innovation and creativity to choose a learning model according to the concept of knowledge that students want to learn. In abstract concepts such as chemistry lessons, the use of appropriate learning models and approaches is a vital reference to achieve the objectives of chemistry learning. One of the proper learning models and approaches is the problem-based learning (PBL) model with a scientific approach. Teachers' use of a scientific approach can develop various abilities students possess (Handayani et al., 2015). This learning approach has the advantage of supporting the implementation of the 2013 Curriculum. In the 2013 Curriculum, the teacher's role is as a facilitator and not the only source of learning; the role of students is to solve scientific problems and not just receive knowledge. Thus, using a scientific approach is very useful in improving students' various abilities.

An appropriate learning model must support the scientific approach to support the success of a learning process in schools. The PBL model is one of the instructional strategies recommended by the 2013 Curriculum. Students' classroom learning can be aided by the PBL concept (Tatar & Oktay, 2011). The PBL model refers to the problem, the teacher is only a guide, and students must actively conduct investigations to solve problems. Thus, the PBL model with a scientific approach is expected to improve student achievement. According to Tan (2003), the characteristics discussed in PBL are; (1) unstructured or unstructured real-world problems. If simulation problems are used, they need to be made as accurate as possible. (2) Problems that cover several points of view. (3) Problems that challenge students to master new knowledge. Tutorials can be given to assist students in mastering the necessary skills so that problems in PBL can be solved.

Learning with PBL causes students to feel challenged to learn and work cooperatively in solving problems (Tosun & Taskesenligil, 2013). Learning using PBL changes the learning process from teacher-centered to student-centered (Park & Ertner, 2007). Students become more active in learning in the classroom (Tarhan & Ayyıldız, 2014; Ramstedt et al., 2016). Moreover, PBL enables students to learn about real-world issues, higher-order thinking abilities, problem-solving abilities, interdisciplinary learning, independent learning, research to research information, collaboration, and communication skills (Tosun & Taskesenligil, 2013; Yoon et al., 2012). In addition, PBL also helps increase student activities to develop various skills, such as communication, argumentation, and investigative skills (Wilder, 2014; Witte & Rogge, 2014). Students sometimes need help to relate scientific ideas to events they encounter daily, so learning in a classroom cannot guarantee that students will understand the subjects being studied (Hye et al., 2012). PBL will prepare students to think critically, analyze, and creatively find information from various sources. The result is not only an increase in cognitive aspects but also in the development of student skills.

Kurikulum 2013 not only refers to increasing cognitive abilities but also develops students' psychomotor and affective abilities. The PBL model, with a scientific approach, is expected to improve students' cognitive, psychomotor, and affective abilities. Thus, national education goals can be achieved if the PBL model with a scientific approach is used as a learning strategy. Understanding the concept will improve students' cognitive aspects (Schunk, 2012: 408; Demircioğlu & Yadigaroğlu, 2014). The development of science and technology, especially in chemistry lessons, indicates that the need to understand concepts in analyzing a problem becomes essential to note. Students find it difficult to understand something abstract, such as chemistry lessons. Students' difficulty lies in conceptual understanding of the chemical material being studied. Students tend to memorize the subject matter compared to understanding the meaning of the studied concepts. The weakness of learning by memorizing is that students only store knowledge for a short time and tend to have difficulty solving analytical problems.

Students' prior knowledge is also needed to manage existing knowledge to facilitate problem-solving (Kelly & Finlayson, 2007; Kaya, 2013). Mauke et al. (2013) stated that understanding or comprehension is the level of ability that expects students to understand the meaning of concepts, situations, and facts. The ability to understand requires the proper process and guidance by the teacher, so professionalism is needed to create fun learning for students (Mei et al., 2007). This process requires innovative learning by applying appropriate models, approaches, strategies, and learning methods. Various sources such as professional teachers, books, the internet, and print/online media are used as sources of information that assist student learning activities in understanding concepts (Atasoy, Akkus & Kadayifci, 2009; Cigdemoglu, Arslan & Cam, 2017). Chemistry teachers are essential in overcoming analytical problems (Handayani, Karyasa & Suardana, 2015). Learning innovation with the PBL model using a scientific approach is an excellent choice to improve students' understanding of concepts. Thus, students no longer learn to memorize but learn to understand according to the paradigm shift contained in the 2013 Curriculum.

Problem-solving refers to efforts to achieve goals, and Polya (1954) describes problem-solving, namely understanding problems, planning solutions, implementing plans, and looking back. This problem-solving step, according to Polya, is called a heuristic. Problem-solving becomes difficult for students (Lorenzo, 2005; Armagan et al., 2009). The problem-solving process requires a good understanding of concepts. Students who understand the concept will tend to be able to solve problems (Chun & Chang, 2010; Salta & Tzougraki Fang, 2011, 2010). Frequent learning by solving problems will help students slowly to be better able to think and actively solve problems (Festus & Ekpete, 2012). Students need a reason and a high way of thinking to solve problems. Thus, the teacher's learning model must be appropriate and can direct students toward problem-solving abilities. Assistance from trained teachers is needed so that students are directed in associating their knowledge to improve their problem-solving abilities (Pedersen & Liu, 2002; Dogru, 2008; Ozgur, Temel & Yilmaz, 2012). The research findings by Rafiuddin, Dali, and Anton (2018) demonstrate how problem-based learning grounded in a scientific methodology affects students' comprehension of chemical concepts related to solubility and solubility results. Also, the findings of a study by Sastradewi, Sadia, and Karyasa (2015) demonstrate how problem-based learning models may be applied to chemistry learning materials to enhance students' conceptual comprehension. Therefore, the problem-based learning approach efficiently enhances students' knowledge of chemical concepts during classroom learning.

Problem-based learning helps enhance students' learning outcomes in chemistry in terms of critical thinking and problem-solving abilities, according to Aidoo, Boateng, Kissi, and Ofori (2016). Adityas & Saadi's (2016) research findings also show that the PBL approach, which is focused on metacognition exercises, impacts class XI students at SMA Negeri 2 Banjarmasin's capacity to answer solubility and product of solubility problems. Consequently, problem-based learning helps students become more adept at solving chemical problems. As mentioned earlier, the findings of the studies demonstrate how problem-based learning impacts conceptual knowledge and problem-solving abilities. Nevertheless, those studies looked at the impact of a problem-based learning approach on one variable. So, evaluating how well problem-based learning develops conceptual knowledge and the ability to solve chemical puzzles simultaneously is crucial. The goal is to determine how problem-based learning concurrently improves idea comprehension and chemical problem-solving abilities.

Based on the results of observations on chemistry learning at Setia Bakti Ruteng High School, it is known that learning is less contextual, so the abstraction of the subject matter causes students to find it difficult to understand concepts. Difficulties in understanding concepts make it easier for students to solve problems scientifically. Chemistry teachers still dominate the chemistry learning process in the classroom. To improve the chemistry learning process according to the demands of the 2013 Curriculum, Setia Bakti Ruteng High School needed an innovation in chemistry learning. Chemistry learning innovations at Setia Bakti Ruteng High School can also be carried out with the PBL model using a scientific approach that can lead students to learn fun through contextual learning and by the reality that students find in everyday life. Acid-base solution material is an example of a chemical concept that students can learn and observe in everyday life. Students are not directly introduced to something abstract but are prepared with concepts they usually find daily. Thus, the existence of learning innovations with the PBL model using a scientific approach can be used as a solution to improve students' understanding of concepts and problem-solving abilities.

Based on the background description above, the researcher is interested in researching the differences in the effectiveness of teaching acid-base solution materials using the PBL and conventional models to understand high school students' concepts and problem-solving abilities.

▪ METHOD

Participants

Three science classes from Grade XI at Setia Bakti Ruteng Senior High School comprised the 76 students who made up the study's population. The research sample, comprised of 56 students, was divided into two classes for the experiments: classes 1 and 2. Experiment class 1 was handled utilizing the PBL approach, and experiment class 2 was conducted using 5 M learning. The sample was selected using a cluster random sampling technique, namely the sampling in the form of a simple group with group randomization (Dantes, 2012: 44).

Research Design and Procedures

Quasi-experimental research is this kind of study. In this experimental study, the group received treatment first, and the results of that treatment were subsequently examined. This study employs a nonequivalent control group design (Creswell, 2015: 607, Campbell & Stanley, 1963: 47). The research design used two groups: experimental group 1 and experimental group 2. Experimental group 1 was given treatment using the PBL model, and experimental group 2 used conventional learning commonly used by teachers. The research design is presented in Table 1.

Table 1. Research design

No	Class	Pre-test	Treatment	Post-test
1	Experiment 1	O_1	X_1	O_2
2	Experiment 2	O_1	X_2	O_2

Description: O1: Pretest, O2: Posttest, X1: PBL, X2: conventional learning

Instruments;

This study has two variables that are essential references to be analyzed. The independent variables used are learning with PBL models and conventional learning commonly used by teachers. The dependent variable used is conceptual understanding and chemical problem-solving. The topic material that is the focus of this research is the acid-base solution material. The data used in this research is the value of students' conceptual understanding and solving chemistry problems. The data collection technique used is a test in the form of a description.

This study employed both test and observational equipment. The test's descriptions are intended to assess students' conceptual knowledge and problem-solving abilities. Four description questions make up the test used to gauge students' idea comprehension. Two description questions comprise the problem-solving abilities section. In this study, observation is done through student work, mainly to examine students' problem-solving abilities. An observation sheet was a reference for this study's observations as they evaluated students' problem-solving abilities.

Data Analysis

This study uses descriptive analysis to determine the data descriptively and hypothesis testing using multivariate analysis (MANOVA). The inferential technique tests the research hypothesis so that conclusions can be drawn. The hypothesis in this study is as follows.

H_0: There is no significant difference in effectiveness between learning with PBL models and conventional learning regarding conceptual understanding and problem-solving abilities at a significance level of 0.05 for students of class XI SMA Setia Bakti Ruteng.

H_a: There is a significant difference in effectiveness between learning with the PBL model and conventional learning regarding conceptual understanding and problem-solving ability at a significance level of 0.05 for class XI students of SMA Setia Bakti Ruteng.

Before testing the hypothesis above, a prerequisite test is carried out first. The prerequisite tests are the data normality test, the data homogeneity test, and the correlation test between the dependent variables—the data normality test of conceptual understanding and problem-solving skills using Kolmogorov-Smirnov and Shapiro-Wilk. Homogeneity test using Levene's Test and Box's M. Collinear testing of the dependent variable using the product-moment correlation test. The tool used to analyze the data is SPSS 22.

▪ RESULT AND DISSCUSSION

The results of the conceptual understanding test and problem-solving ability are described in Tables 2 and 3.

Table 2. Pre-test and post-test result data conceptual understanding

No.	Description	Pretest		Posttest	
		Experiment 2	Experiment 1	Experiment 2	Experiment 1
1.	Average	41.14	43.42	71.87	77.63
2.	Minimum Value	29.16	20.83	50	54.16
3.	Maximum Value	70.83	62.50	91.66	95.83
4.	Standard Deviation	12.25	12.98	11.93	11.30

Table 3. Pre-test and post-test result data problem-solving skill

No.	Description	Pretest		Posttest	
		Experiment 2	Experiment 1	Experiment 2	Experiment 1
1.	Average	17	18.26	26.96	37.16
2.	Minimum Value	0	0	10	16
3.	Maximum Value	29	30	40	50
4.	Standard Deviation	8.76	8.23	773	8.86

The Kolmogorov-Smirnov test for normality reveals that the normality of the conceptual understanding data for experimental classes 1 and 2 is 0.200, more significant than the significance threshold of 0.05, indicating that the data are normally distributed. The results on problem-solving abilities for experimental classes 1 and 2 are normally distributed because their normality values are 0.053 and 0.200, respectively, more significant than the 0.05 significance level. A homogeneity test uses the Levene statistic. Data on conceptual comprehension were subjected to a homogeneity test, and the results showed that the data were homogeneous because the result was 0.350, more significant than the significance level of 0.05. The data on problem-solving abilities show homogenity because the homogeneity test result is 0.097, more significant than the significance level of 0.05.

The correlation test showed a correlation between conceptual understanding and problem-solving abilities of students of class XI IPA SMA Setia Bakti Ruteng on acid-base solution material. The correlation test results showed a significance value of 0.002, which is smaller than a significance level of 0.05. The correlation test concluded that there was a correlation between conceptual understanding and problem-solving skills. Statistical analysis used in testing the hypothesis is a multivariate analysis using the SPSS 22 program. The choice used multivariate analysis because, in this hypothesis, we wanted to see the differences in the effectiveness of the learning model used from experimental class 1 and experimental class 2 to increase students' conceptual understanding and problem-solving skills simultaneously. This multivariate analysis used four statistical tests at once, Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root tests.

The results of hypothesis testing obtained a significance value of 0.007 which is smaller than the 0.05 significance level for the Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root tests. A significance value smaller than the significance level provides information that the alternative hypothesis (Ha) is accepted and the initial hypothesis (H0) is rejected. Hence, at a significance level of 0.05, it can be concluded that learning through PBL models is significantly more effective than conventional learning regarding conceptual knowledge and problem-solving skills for students in class XI SMA Setia Bakti Ruteng. The results of the hypothesis test above indicate a significant difference in effectiveness between learning with the PBL model and conventional learning in terms of conceptual understanding and problem-solving skills of class XI students of SMA Setia Bakti Ruteng. Tables 1 and 2 show increased students' conceptual understanding and problem-solving skills. Thus, the PBL model further enhances conceptual understanding and problem-solving abilities compared to conventional learning.

Concept understanding and problem-solving abilities can both be improved through problem-based learning. The findings of a study by Rafiuddin, Dali, and Anton (2018), which illustrates how problem-based learning enhances students' grasp of chemistry concepts, support the findings of this study. Moreover, Aidoo, Boateng, Kissi, and Ofori (2016) discussed how problem-based learning successfully enhances students' learning outcomes in critical thinking and problem-solving abilities in chemistry. Hence, problem-based learning is successful in enhancing conceptual knowledge and chemical problem-solving abilities at the same time.

This study shows that using a suitable learning paradigm, such as problem-based learning, improves students' conceptual understanding of the information related to acid-base solutions and their problem-solving ability. One of the instructional approaches suggested by the 2013 Curriculum is problem-based learning. The PBL idea can help students learn in the classroom (Tatar & Oktay, 2011). The teacher merely serves as a guide in problem-based learning, and students must carry out inquiries to solve difficulties actively. As a result, the PBL model is anticipated to raise student achievement. Thanks to problem-based learning, students feel challenged to learn and collaborate when tackling challenges (Tosun & Taskesenligil, 2013). Problem-based learning shifts the focus from teacher-centered to student-centered (Park & Ertner, 2007). In the classroom, students become more engaged (Tarhan & Ayyldz, 2014; Ramstedt et al., 2016). As a result, problem-based learning will equip students with the ability to think critically, analyze information, and find information in novel ways. As a result, pupil skill development occurs along with an improvement in cognitive characteristics. Learning using problem-based learning impacts student activities that are more active in learning. The activeness of these students impacts increasing students' conceptual understanding and chemical problem-solving abilities, as seen in Tables 2 and 3. A good understanding of student concepts will significantly assist students in improving their problem-solving skills.

▪ CONCLUSION

This study demonstrates variations between the effectiveness of using the PBL approach and traditional learning in terms of concept knowledge and students' capacity for solving chemical problems based on the findings of hypothesis testing. The use of the PBL model helps students in improving learning activities in the classroom. Increased student learning activities have an impact on increasing students' understanding of concepts. Furthermore, increasing students' understanding of chemical concepts has an impact on students' chemistry problem-solving abilities.

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