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Influence of Problem-Based Learning Models Improving Students' Problem-Solving Skills

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ABSTRACT

One cognitive skill needed to meet the demands of the complex and dynamic development of the twenty-first century is problem-solving. Therefore, this research aimed to investigate how well 126 students understood chemical difficulties about reaction rate material both individually and collaboratively. Only a posttest is applied in this study's quasi-experimental research design. Sixty-two learners in the experimental class received treatment using a Problem-Based Learning (PBL) model, while sixty-four learners in the learning control group received treatment using traditional methods. According to the findings, pupils in the experimental class were more adept at solving problems than those in the control group. The study's findings also show how collaborative problem-solving significantly aids students' attempts to solve chemical challenges.

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INTRODUCTION

The development of the 21st century has raised the challenges and the changes in the foundation of society in a new and strong way [1]. The challenges faced are related to human survival seen from the physical environment, such as increasing the global population, the existing gap between rich and poor, and increasing consumption of resources. The challenges that exist nowadays require people to be capable of innovating and creating solutions to solve any problems relating to the challenges of the development of the 21st century [2],[3]. One of the abilities that ought to be possessed by students to answer the challenges of the 21st century, both in academic aspects and problems in life, is problem-solving skills [4],[5].

Problem-solving skill is a cognitive process [4],[6],[7], which is needed in the world of science such as chemistry both in understanding chemical concepts and working in laboratory because having problem-solving skills, the students will be motivated or increase their motivation to solve chemical problems [8],[9],[10],[11]. Problem-solving skill is the highest level in learning and an unavoidable life skill. Moreover, in the world of education, the students whose this skill will explore the composition of the solutions and learn to solve new problems at hand [7],[12]. The problem-solving skill is an ability to find solutions that involves deep thinking processes, such as understanding, analyzing, synthesizing, evaluating, reflective thinking, being consistent and being able to connect previous knowledge to obtain solutions, which are then followed up with persistent attitudes and actions to solve problems. Looking at the vital importance of problem-solving skills, the world of education must provide appropriate learning incentives and must be integrated into the learning environment [13].

One key component in developing problem-solving skills that teachers must do is to provide feedback and to provide guidance that enables students to apply the desired skills, and introduces heuristic methods and uses of modeling [14]. In addition, cooperation in groups can also help improve problem-solving skills and become a valuable tool for promoting creative problem-solving skills [15]. The study conducted by [15] shows that collaboration between friends in solving problems can help improve cognitive individuals in which it can be seen when groups provide examples of topics, explain concepts, demonstrate methods of solutions, or provide specific arguments. The current research will see collaborative cooperation between students to find answers to solving chemical problems related to the theory of reaction rates.

Chemistry, which is a family in science, is an integral part of human life, especially in secondary schools [16],[17],[18]. In studying chemistry, it is necessary to understand good concepts about science, and teachers need to know the ability to understand the concepts possessed by students [19]. Johnstone [20] suggests three levels of chemical concepts that must be mastered by students: first, the macroscopic concept related to the seen phenomena, second, the microscopic concepts related to particles, and third, the symbolic concepts related to matter, formulas, and chemical equations. Looking at the characteristics and importance of chemistry, chemical programs should offer opportunities to answer real-world problems to develop and improve problem-solving abilities [8].

The chemical learning process that aims to improve problem-solving skills, both individually and in groups, will not run optimally if the planned process does not use appropriate learning. In addition, learning must use a student-centered approach as the subject of learning. The study conducted by [21], shows that the PBL model is one of several learning models designed to involve students in the gaining knowledge, and may improve learning results and can meet the demands of the times [22]. Gunter and Alpat [23] through their study, they said that the PBL model is an impressive learning model in chemical learning and has been applied throughout the world. Jansson [24] said that students were happy and found PBL models to be an efficient methodology for not only learning but also gaining a deep understanding of chemistry. PBL model is a constructivist teaching model that has characteristics in reflecting learning experiences, building understanding, and focusing on students as learning subjects [25],[21].

The idea behind the PBL methodology is to encourage students to find ideas and concepts that lead to answers for problem-solving [26] by using challenging real-world unstructured issues [27], [28], and [29]. To encourage students to learn, the challenge must be tailored to the course content [22], [30] and call for sophisticated solutions [31]. The PBL model's learning process encourages students to work in small groups and fosters the growth and enhancement of their critical thinking, problem-solving, and other general abilities for dealing with novel and difficult situations in the real world [24], [27], and [31]. According to the PBL paradigm, the teacher's job is to facilitate the investigative process, provide learning problems, and provide a learning atmosphere [27]. Defined PBL models as collaborative, autonomous, and problem-based learning [23].

Several previous studies have proven the effectiveness of the PBL model in improving the ability to solve chemical problems. Cheng et al [32] conducted research that shows that the scientific knowledge, reasoning, and problem-solving abilities of students are successfully improved after receiving Problem-Based Learning (PBL). The PBL model is very effective in improving learning motivation, metacognitive abilities, and learning outcomes of students who have weak basic abilities in the field of science [33-36]. The PBL model is very impressive in helping students to solve problems related to learning, and it can assist students in developing academic abilities [37]. Based on the explanation above, the current research also aims to explore the influence of the PBL model in improving the problem-solving abilities of chemistry students in experimental classes and conventional learning in control classes on the material of reaction rates.

RESEARCH METHODOLOGY

Type of Research

The type of research used in this study is quasi-experimental, with the research design being *a post-test only design*. This study used two research classes, namely the experimental class and the control class. The treatment given to the two classes during the study was conducted differently; in the experimental class, a Problem-Based Learning (PBL) model was applied, and in the control class, applied conventional model was applied. The dependent variables in this study are problem-solving and collaborative ability, while the independent variables are PBL models and conventional models.

Population and sample

The population used in this study was all students of class XI MIPA. The sample taken in the study amounted to 126 students (n experiments = 62 students, n controls = 64 students) who were randomly selected and focused on two public secondary schools located in the city of Kupang, namely SMAN 6 Kupang and SMAN 7 Kupang. Both of these schools have the same characteristics in applying the independent learning curriculum, having the accreditation of "A", and having a chemical laboratory but rarely used in the learning process.

Data collection

Data collection is carried out in this research to measure problem-solving skills and collaborative chemistry in students for 4 times, in the form of observation and a *post-test*. Data collection is carried out during the study process, investigation, and post-test to find out the problem-solving and collaborative abilities related to sub-material polarity, factors that influence the reaction rate (concentration, touch surface area, temperature, and catalyst). Observations in the process of learning and investigation are carried out by 4 observers (chemistry teachers) using observation sheets that have been validated by the experts. The learning process is carried out according to each PBL model syntax and the conventional model contained in the learning process plan that has been validated by theorists and empiricists.

Research instrument

The problem-solving skills exam and observation sheets were the tools utilized in this investigation. The four indicators that make up the problem-solving capacity observation sheet were created by synthesizing expert judgments [38], [39]. In the meantime, the reaction rate comprises three essay questions designed to assess the ability to solve chemical problems. The two tools mentioned above were created by researchers and approved by Yogtakarta State University chemists and theorists. An empirical validation has been obtained for the prior problem-solving ability test instrument.

Data analysis

To determine how the implementation of the learning model affected the students' capacity to solve chemical problems, a post-test was administered to the experimental class and the control class, who received various treatments linked to the model. Following the collection of post-test results, an independent sample t-test will be conducted to determine whether the learning model had a different impact on the two classes' problem-solving abilities. However, the obtained data is first put through a preparatory test in the form of a homogeneity and normality test before being tested using the independent sample t-test. The post-test data in both research classes came from a normal and homogenous population, according to the results of the normality and homogeneity tests (Tables 1 and 2). The SPSS version 25 Windows application can be used to perform an independent sample t-test once the prerequisite test has been completed. The post-check statistics in each research lessons came from a normal and homogenous population, according to the effects of the normality and homogeneity test (Tables 1 and 2). The SPSS model 25 windows utility may be used to perform an independent sample t-test a look at as soon as the prerequisite test has been finished.

RESULTS AND DISCUSSION

Research was carried out using a confidence interval of 95%, so that the level of significance (alpha) or the level of error used in each study analysis amounted to 0.05. Before the independent sample t-test was carried out to measure the difference in the influence of the learning model in the two research classes, a prerequisite test was carried out in the form of a normality test and a homogeneity test. Post-test data that has been collected after a pre-requisite test, is said to be normal and homogeneous when the significance value of the analysis results is greater than 0.05.

The normality test in this study was evaluated using Kolmogorov-Smirnov. Based on the results in Table 1, it can be concluded that the post test results of the ability to solve the chemical problems of the two research classes (experimental class, Sig = 0.055; control class, Sig = 0.200) came from the normal population, because they have Sig. greater than 0.05 in the Kolmogorov-Smirnov table.

Table 1. Normality Test in Problem-solving Ability

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
KMM Experiment Class	0.111	62	0.055	0.960	62	0.041
KMM Control Class	0.087	62	0.200	0.951	62	0.015

Table 2. Homogeneity Test in Problem-solving Ability

Levene Statistic	df1	df2	Sig.
2.051	1	124	0.154

After the normality test is carried out, a homogeneous test is performed to measure the post-test data that has been collected. The homogeneity test that had been done before was evaluated using the Levene Statistics test. Based on the results in Table 2, it can be concluded that the post-test data on students' chemistry problem-solving ability came from homogeneous data, because the significance value produced was greater than 0.05 (Sig = 0.154).

Based on the results of the two prerequisite tests above, an independent sample t test can be done to measure the difference in the effect of the learning model in the two research classes in improving the ability to solve chemical problems, because both prerequisite tests have been fulfilled.

Table 3. Mean dan Standard Deviation Problem-solving Ability

	Class	N	Mean	Std. Deviation	Std. Error Mean
KMM Result	Experiment	62	45.89	24.504	3.112
	Control	64	36.64	20.530	2.566

Table 4. Independent Sample t Test

		t-test for Equality of Means		
		t	df	Sig.(2-tailed)
KKM Result	Equal variances assumed	2.299	124	0.023
	Equal variances not assumed	2.292	118.923	0.024

The purpose of the independent sample t-test used in this study's analysis is to compare how PBL and traditional models affect students' ability to solve problems. The Sig (2-tailed) value can be used to interpret the results of the independent sample t-test. If the Sig (2-tailed) value is less than 0.05, it can be said that the two research classes' post-test results on chemical problem-solving skills have different influences on improving problem-solving skills.

Because the Sig (2-tailed) was less than 0.05 (Sig. (2-tailed) = 0.024), it can be inferred from Table 4 that the post-test data on chemical problem-solving abilities in the two research classes given different treatments showed differences in the effect of applying the learning model in improving chemical problem-solving between the application of PBL models and conventional models.

The results of the chemical problem-solving ability test material reaction rate in the control class treated with the conventional model showed a lower average value of problem-solving ability, namely the post test value as in Table 3 ($M = 36.64$, $SD = 20.530$) compared experimental class ($M = 45.89$, $SD = 24.504$). The independent sample t-test results (Table 4) showed there were different effects of applying the learning model in improving the ability to solve chemical problems ($t = 2.292$, $p = 0.024$). Meanwhile, to see the size effect of the learning model in improving problem-solving skills, Cohen's score ($d = 0.41$) was calculated, and the results showed that the PBL model applied in the experimental class affected the overall ability to solve students' chemical problems.

DISCUSSION

Using two research classes that received different treatments, the use of PBL models for experimental classes and conventional models for control classes the study examined how PBL models enhanced students' trouble-fixing abilities and collaborative chemistry of the reaction rate material. The six-meeting learning approach was tailored to each PBL model syntax, and traditional models were included in the researcher's learning design.

The chemical material discussed in conducting this research is the reaction rate. The reaction rate is the rate of change in concentration per unit of time. Subtopic of reaction rate material discussed in learning is related to molarity, the concept of reaction rate, equation, and reaction order, graph of reaction order, factors that influence the reaction rate (concentration, surface area, temperature, catalyst), and application of reaction rate material in human life. Supporting the delivery of material for the rate of reaction, the study process is carried out in the process of investigation to prove the relationship between theory and facts relating to molarity, substrate, and factors that influence the rate of reaction during 3 meetings. During the learning process, four observers made observations related to the students' ability to solve chemical problems using observation sheets on chemical problem-solving abilities.

The investigation process that takes place within the experimental class that makes use of the PBL model, guides guided to make their investigation plans to prove the material they studied [27]. In making an investigation, students are guided by a draft report that will guide them in finding theories, investigation procedures, discussion, and conclusions related to the investigation process that will be carried out. In the final results of the learning process, students together with group friends report the results of their investigations that have been made.

Figure 1. Investigation, Discussion, and Presentation Process

The results obtained showed that learners who learned using a PBL model had trouble-fixing and collaborative abilities that were better than the control class that applied conventional models. This difference in this ability illustrates that active involvement of students in the teaching and learning activities is required. This is because, in the teaching and learning activities students who are in the experimental class are stimulated to think about using problems related to their lives, so in finding solutions to chemical problems related to the material reaction rates, students are encouraged to look for various solutions because the problems that exist have been observed and even experienced directly by students. For example, the problem given by the teacher is why the rusting process in iron takes a long time, while the peeled apple is faster to get brown. Both of these things have been observed directly by students, so it will arouse student motivation to find answers to why these two things can happen. Research conducted by Chua et al [29], shows that learning how to immerse students in problems related to their lives can nurture students knowledge abilities and develop new cognitive systems for brand spanking new knowledge.

The process of finding answers made by students can be done individually or in groups. In the research process, when we observed, the students seemed more eager and quicker to find solutions when discussing with their group friends, because PBL models of students are required to collaborate with their buddies to provide solutions to problem-solving in learning [27]. Agreeing with this, the observation conducted by Yasin et al [40], shows that the mastering technique that applies the PBL version can enhance student achievement and know-how, and has an impact on problem-solving talents [23]. The implementation of the PBL version can also enhance inquiry skills, problem-solving talent, and metacognitive abilities, and produce a holistic view related to investigating chemistry [33],[41], [42] and [43].

Different things can be observed in the control class, which is in the teaching and learning using conventional models. It can be observed that students still have difficulty in determining the reduction rate and the addition rate associated with changes in concentration per unit of time. During the face-to-face process and discussion of the reaction rate sub-topic question before being tested, most students said that they had understood this sub-topic well. However, when a post-test was conducted to degree the capability to solve the rate of chemical reaction problems, the results obtained showed that students were now longer capable of applying the concept of the rate of reaction in the chemical formula. Research conducted by Chen et al [16] shows that most students still difficult to conceptualize chemical formulas, partly because of the abstract character in chemical formulas and having weak structure knowledge [10]. Responding to this problem, Robinson [44] says that the way students learn tends to involve memorizing more without going through the thinking process. Teaching and learning like this will obstruct the development of understanding concepts and high-level thinking abilities in students' chemistry. A weak understanding of chemical concepts and mathematical skills causes many students to be unable to explain the relationship between various concepts.

The weak ability to solve students' chemical problems in research is due to the lack of active students in the collaborative process to conduct investigations, so that students who follow the investigation process based on procedures can maintain their understanding related to the material they have learned. Problem-solving collaborative problems is very important to do because by collaborating, students can exchange ideas in finding the best solution to overcome chemical problems [10],[14]

CONCLUSION

Based on the research that has been completed, it produces a conclusion that the application of the learning model PBL may be very supportive for teachers in improving the talents that scholars have. The consequences of the have a look at the display that once the instructor applies a Problem-Based Learning (PBL) model it could assist college students in enhancing their potential to solve chemical problems. This is because the problems given in the learning process are closely related to the lives of students, thus encouraging students to learn to explore the problem to produce a variety of solutions to problem-solving. Further, the outcomes of the study additionally show that making use of the PBL model enables students independently able to collaborate independently with their friends in looking for solutions and finding solutions to solve problems. Therefore, the trainer who acts as the supervisor in the gaining knowledge process must maximize every learning model, including the PBL model, to stimulate and maximize each student's abilities and dare to innovate to provide a learning process that can support students in activating themselves in each teaching and learning activity.

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