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Application of Problem-Based Learning and Scientific Approach to Self-Efficacy and Problem-Solving Ability in Reaction Rate Material

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Abstract: The purpose of this study was to determine differences in self-efficacy and problem-solving abilities of students in problem-based learning and scientific approach learning. This study uses a quasi-experimental research design with a pretest-posttest group research design. The sample used in this study consisted of two classes, namely class XI Mathematics and Natural Sciences 4 as the experimental class and class XI Mathematics and Natural Sciences 2 as the control class. A total of 70 class XI students were randomly selected as the research sample using random sampling technique. The instrument used was a test in the form of a description of the ability to solve problems and a non-test, namely a self-efficacy questionnaire. The analysis technique in this study used the Manova test and the Paired Sample T-Test. The results of this study indicate that there are significant differences in the self-efficacy and problem-solving abilities of students who take problem-based learning with students who take scientific approach learning. The contribution given by the problem-based learning model to self-efficacy and the ability to solve problems simultaneously is 71.5%, students' self-efficacy is 61.8%, and problem-solving skills is 43.3%.

Keywords: Scientific approach; Self-efficacy; Problem solving ability; Problem based learning; Reaction rate

Introduction

The development of science and technology in the 21st century cannot be avoided. The development of science and technology has a positive impact in alleviating human work (Hidayat et al., 2017). Conversely, if you are not able to adapt to the development of science and technology, then this development of science and technology will be a disaster. Someone needs skills to be able to adapt to developments in science and technology in order to be able to compete globally. One of the abilities needed to be mastered and possessed by an individual is the ability to solve problems (Siahaan et al., 2017).

One of the most important abilities that must be possessed by students is the ability to solve problems (Greiff et al., 2013). Through the ability to solve problems, students get new experiences about themselves, thus enabling them to find solutions and processes to get solutions to the problems they face (Lismayani et al., 2017). The ability to solve problems developed by students can have a positive effect on other skills, such as scientific process skills (Yulianti et al., 2012); critical thinking skills (Zunanda et al., 2015); scientific literacy (Thummathong et al., 2016); and entrepreneurial skills/entrepreneurship (Kim et al., 2018). Therefore, the development of problem solving skills in students needs to be of particular concern to teachers in the learning process. Problem-solving activities that are integrated into the learning process are proven to contribute to new knowledge for students, so that problem-solving skills are an aspect that must be considered and developed further by teachers, especially in the field of chemistry (Mukhopadhyay, 2013).

The purpose of chemistry subjects is to want students to be able to deal with various problems by using the knowledge they have. Problem solving is done

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to help individual students in dealing with changes and adjustments in life (Heppner et al., 2004). The teaching strategy applied will improve students' problem-solving abilities. This will make the ability of students to solve problems appropriately because they gain concrete experience from previous problems. Topics in chemistry show that the ability to understand concepts and analyze a problem is very important. Chemistry subjects play an important role in human life and are widely applied in everyday life. However, it turns out that this chemistry subject is one of the subjects that still causes difficulties for students (Sirhan, 2007). Johnstone (2000) explained in chemistry subject the most important thing to know is understanding the concept of chemistry is abstract and requires abstract reasoning. Abstract concepts in chemistry, the ineffectiveness of the learning approach applied by the teacher, and the lack of support from the teacher are the causes for students experiencing difficulties when studying chemistry (Woldeamanuel et al., 2019).

The matter of reaction rates is an example of a chemical concept that can be studied and observed for its application in everyday life. In studying the concept of reaction rate, students are introduced and confronted with concepts that they usually encounter every day. The application of chemistry concepts in learning should not only be done by memorizing theory, but also connecting theory with its application. Thus, understanding the concept based solely on memory is a wrong understanding (Uzuntiryaki et al., 2009). Based on the results of observations made by researchers, it shows that students are less active in asking questions and responding when asked questions by the teacher. This implies that the quality of chemistry learning is still low and only some students complete the minimum completeness criteria.

Measuring the success of education is not enough if it is only measured from the cognitive aspects of students, but also from the affective aspects felt by students, such as student self-efficacy. Self-efficacy is the belief of students in their own abilities to complete and complete the tasks/jobs given. According to Bandura (1986) self-efficacy is a component of self-awareness that influences activities in everyday life. Bandura also emphasized that the process of psychological change is influenced by self-efficacy. Self-efficacy is very important because self-efficacy reflects students' ability to solve chemical problems and apply them in everyday life (Uzuntiryaki et al., 2009). In fact, students' low self-efficacy is caused by anxiety and poor concentration on exams, which causes their learning outcomes to decline (Permana et al., 2017). This means students continue to underestimate their knowledge and become less confident in their abilities. In addition, research results Ramnarain et al. (2018) also shows a low self-efficacy rating in daily application, students have little experience in applying concepts in chemistry in everyday life. Learning is needed that can encourage students to apply their knowledge in real situations designed to increase students' self-efficacy.

The 2013 curriculum, which was launched after distance learning during the pandemic through the use of technology in face-to-face classes as a result of the Covid 19 pandemic, is a formidable challenge for teachers. Various problems arise as a result of distance learning. These problems include, for example, students do not want to learn unless given assignments, students think that distance learning is not part of school activities, students find it difficult to understand what they are learning, some students think that collecting assignments is the main thing, and learning is not the main thing, many students cannot concentrate, especially in learning, some students are too picky about assignments, only complete easy tasks, and some students are not able to filter information from learning materials so that the information found is less relevant to the task requested. The ability of students who were assessed as being in good condition by the teacher during distance learning was not as imagined. The expectation that students are more independent and creative when studying at home is the opposite. Based on the results of the study it was found that during online learning as much as 41% of students could not understand all chemistry concepts properly, 46% of students could not remember chemistry concepts longer, and 43% of students felt tense during learning.

This research is important to do and is one form of improving the above. Classroom learning is improved by using interesting learning methods to create an atmosphere for learning to be fun so as to overcome boredom and revive student learning motivation. Therefore, as educators, we must be able to learn and apply various techniques, models, or technologies in the learning process (Smetana et al., 2012). To change the learning paradigm which is still teacher-centered, this research carries out learning innovations, namely through the application of learning methods that are transferred from teacher-centered to student-centered. One of the student-centered learning methods is the PBL method, which is a learning model that involves students in solving real/direct problems. In PBL, students learn to solve problems that reflect their experiences (Engle, 1981). In this activity, students must also apply existing knowledge and skills, or find knowledge that is necessary and relevant to the problem (Leary et al., 2013). PBL is also a learner-centered approach in which students determine what they need to learn. Students derive the main problems from the problems they face themselves, then explain their knowledge gaps, catch up and acquire missing knowledge (Barrows, 2022; Hmelo-Silver et al., 2006).

PBL is considered very suitable for providing facilities for students to become active learners because this model directs learning into real problems and makes students more responsible for their learning. It has a dual focus: helping learners strategize and build knowledge (Hmelo et al., 1997). This causes students to learn to think critically when analyzing and solving a problem. Students who are able to think critically are students who are able to identify, evaluate, and develop arguments and problem-solving skills. When a person feels socially safe, he will not feel anxious and will feel more comfortable and be able to develop his behavior in social situations. It is said that people with high self-esteem can control their destiny, not people with low self-esteem, but other people can control it.

Method

This research was conducted using a quasi-experimental method with a pretest-posttest control group design. This research was conducted to determine the differences in self-efficacy and problem-solving abilities of students in the reaction rate material by applying a problem-based learning model (PBL). This study used two classes, namely one class as the control group and the other class as the experimental group with different learning treatments between the two. The experimental class will be carried out using the PBL model and the control class will use a scientific approach. The experimental class and control class will also be carried out pretest-posttest at the beginning and end of learning as well as self-efficacy questionnaires. The flow chart in this study is presented in Figure 1. The design of this study can be observed in Table 1.

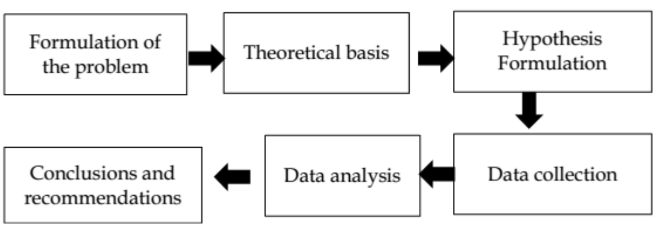

Figure 1. Research flowchart

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	X_1, X_2	Y_1	X_1, X_2
Control	X_1, X_2	Y_2	X_1, X_2

Information:
Y_1 : Problem-based learning on reaction rate material
Y_2 : Learning with a scientific approach to the material reaction rate
X_1 : Test the ability to solve the reaction rate problem
X_2 : Self-efficacy questionnaire

This research was conducted at State Senior High School 1 Wedi Klaten in odd semesters of the 2022/2023 academic year. This research took place from August to September 2022. The sample for this research was 70 students in class XI at State Senior High School 1 Wedi Klaten.

The techniques used in this study to collect data are tests and non-tests. The test is in the form of description questions to measure the ability to solve problems. The indicators used to measure the ability to solve problems in this study are formulating problems, formulating hypotheses, testing hypotheses, and drawing conclusions. Problem solving ability on the matter of reaction rates in this study consisted of collision theory, determining factors of reaction rates, reaction orders and reaction rate equations. While the non-test instrument in this study was a questionnaire to measure students' self-efficacy before and after being taught the reaction rate material. The self-efficacy questionnaire in this study used 4 scales, starting from very unsure to very sure. The self-efficacy questionnaire that was tested consisted of several aspects, namely belief in self-ability, self-regulation, effort and perseverance in facing difficulties, and performance in achieving goals.

The data analysis technique in this study was carried out using inferential statistics (multivariate analysis of variance/Manova using a significance level of 0.05).

Result and Discussion

The following are the test results that must be examined in this study:

Description of Research Results

Self-efficacy and problem-solving abilities of students in the matter of reaction rate with problem-based learning have differences with students with scientific approach learning. The description of the mean posttest scores of self-efficacy and problem-solving abilities in the control and experimental classes can be seen in Table 2.

Table 2. Average Value of Self-Efficacy and Ability to Solve Students' Problems

Class	Self-Efficacy		Problem Solving Ability	
	Pre-test	Post-test	Pre-test	Post-test
Control	42.34	63.83	50.60	63.80
Experiment	52.00	74.31	40.63	75.51

Manova Test Results (Hotelling's Trace)

The results of the multivariate test (Hotelling's Trace) at a significance level of 95% obtained a result of 0.000 < 0.05, indicating that Ho was rejected. Therefore, it can be concluded that there are significant differences in self-efficacy and problem-solving skills between students who take problem-based learning and students who take learning using a scientific approach.

Table 3. Hotelling's Trace Test Results

Effect	Value	F	Sig.	Partial Eta Squared
Hottelling's Trace	2.513	84.201b	0.000	0.715

The follow-up test from the Manova test is the Test of Between-Subject Effect. This test was used to determine whether there were differences in self-efficacy and problem-solving skills between the experimental and control classes. The magnitude of this influence can be determined through the results of the Test of Between-Subject Effect. The results of the Test of Between-Subject Effect analysis of self-efficacy and problem-solving skills can be seen in Table 4.

Table 4. Test Results of Between-Subjects

Dependent variable	F	Sig.	Eta Squared	Decision
Self-Efficacy	110.201	0.000	0.618	Ho was rejected
Problem Solving Ability	52.223	0.000	0.434	Ho was rejected

The follow-up test from the Manova test is the Test of Between-Subject Effect. This test was used to determine whether there were differences in self-efficacy and problem-solving skills between the experimental and control classes. The magnitude of this influence can be determined through the results of the Test of Between-Subject Effect. Based on the test results obtained a significance for self-efficacy of 0.000 < 0.05 then Ho is rejected. Therefore, at a significance level of 5%, there is a significant difference between self-efficacy in learning chemistry material for the reaction behavior of the experimental class and the control class. This is supported by the eta squared value which indicates that the contribution value of the self-efficacy variable is 61.8%. The test results of the Test of Between-Subject Effect for the ability to solve problems obtained a significance value of 0.000 < 0.05, so Ho was rejected. Therefore, it can be concluded that at a significance level of 5% there is a difference in the ability to solve problems in chemistry learning material for reaction rates in the experimental class and the control class. This is also supported by the eta squared value which shows the contribution value of the problem-solving ability variable of 43.4%.

Paired Sample T-Test Results

Value of sig. (2-tailed) obtained based on the test results in the table < 0.05, so that 0.000 < 0.05 states that there is a significant difference between the self-efficacy of students before and after the application of problem-based learning models and scientific approaches.

Table 5. Description of the Control Class Paired Sample T-Test Self-Efficacy Test

Class	Paired Sample T-Test		
	t	df	Sig. (2-tailed)
Pretest-Posttest Control Class	-16.676	34	0.000

Table 6. Description of the Experimental Class Paired Sample T-Test Self-Efficacy Test

Class	Paired Sample T-Test		
	t	df	Sig. (2-tailed)
Pretest-Posttest Experimental Class	-23.671	34	0.000

The existence of different treatments in the two classes led to different results for students' self-efficacy. The emergence of differences in student self-efficacy between the two classes indicates that the self-efficacy of students in the experimental class is better than the control class. The application of problem-based learning has a positive impact on students' self-efficacy. In this study, it showed good self-efficacy of students after being taught with problem-based learning. These results are in accordance with research conducted by (Siew et al. (2017) states that the application of problem-based learning has a more positive impact on self-efficacy compared to other learning because problem-based learning makes students practice thinking skills and problem solving a lot. Students become more confident about their own abilities as problem solvers after learning with the implementation of problem-based learning because students are required to be able to investigate relevant knowledge on their own from various sources such as chemistry textbooks, research literature and on the internet (Yoon et al., 2014).

Table 7. Description of the Paired Sample T-Test Problem Solving Ability of the Control Class

Class	Paired Sample T-Test		
	t	df	Sig. (2-tailed)
Pretest-Posttest Control Class	-17.515	34	0.000

Table 8. Description of the Paired Sample T-Test Problem Solving Ability of the Experimental Class

Class	Paired Sample T-Test		
	t	df	Sig. (2-tailed)
Pretest-Posttest Experimental Class	-24.827	34	0.000

The ability to solve problems in the experimental class and the control class showed that there was a significant difference between the pretest and posttest scores, namely 0.000 < 0.05. The average value obtained between the experimental class and the control class has a difference, namely the experimental class has a higher problem solving ability value than the control class. The existence of differences in the ability to solve problems of students in the two classes is due to differences in treatment in the two classes. The difference between the two classes shows that the experimental class with problem-based learning has a higher problem-solving ability value compared to the control class with learning to apply a scientific approach.

Problem-based learning applies teaching and learning conditions that require students to learn more actively in order to discover their own knowledge by giving problems as contextual examples that can improve students' problem-solving skills. The benefits of problem-based learning are conveyed in the results of research conducted by Orji et al. (2018) which shows that there is a difference between the experimental class which is taught by problem-based learning and the control class which is taught by conventional methods. The experimental class with problem-based learning has a higher problem-solving ability than the control class. The effect of problem-based learning on students' problem-solving abilities has a significant difference shown in research conducted by Aidoo et al. (2016) this is because problem-based learning can explore the ability to solve problems well, so that students' problem-solving skills are also good. Research results by Tarhan et al. (2007) explains that students' problem-solving abilities are better in the experimental class that applies problem-based learning than the control class.

The success of problem-based learning on student learning achievement is due to problem-based learning helping students to think, solve problems, train students' thinking skills so that they can improve by building real situations such as resembling conditions related to the material being studied. Some students admit that their knowledge is getting better if they are given problems or concepts related to the material provided. Problem-based learning encourages better interaction between friends in the learning process as well as a good sense of control in each lesson with the implementation of problem-based learning.

Conclusion

Based on the results of the research that has been done, it can be concluded that there are significant differences in the self-efficacy and problem-solving abilities of students who apply problem-based learning with students who apply scientific approach learning.

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