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The Effectiveness of the Problem-Based Learning Model to Improve the Students' 21st Century Skills

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Abstract

The 21st century learning must develop the students' 21st century competencies, including aspects of knowledge, students' problem solving skills, and science process skills. These student skills need to be widely developed in science learning to face the challenges of the century. This study aimed to determine the effect of PBL on students' 21st century skills. The study method was quasi-experimental; using a posttest only randomized control group design. Data analysis used a comparison test of two sample groups and the Mann-Whitney U-test. The analysis results of student science process activities were 84% in the very active category, while problem solving skills were 0.001 < 0.05 and 0.000 < 0.05 at *SMA N 8 and SMA N 9 Padang*. Meanwhile, the analysis results of the knowledge aspect data obtained 0.000 <0.05 and 0.000 <0.05 at *SMA N 8 and SMA N 9 Padang* with the conclusion that Ho was rejected, and it means that in the problem solving aspect and the knowledge aspect there was an influence of PBL on student 21st century skills in the aspects of knowledge, skills problem solving, and students' science process skills.

Keywords

physics learning, problem solving, science process skills

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Introduction

In the last century there has been a significant shift from manufacturing services to services that emphasize information and knowledge (Scott, 2015). Knowledge itself grows and expands exponentially. Information and communication technologies have changed the way we learn, the nature of the work we can do, and the meaning of social relationships. Shared decision making, information sharing, collaboration, innovation, and work speed are very crucial aspects currently. Students are expected to no longer focus on succeeding in manual work or routine machine-assisted work or jobs that rely on the cheap labor market.

Today, indicators of success are based more on the ability to communicate, share, and use information to solve complex problems, adapt and innovate in response to new demands and changing circumstances, and expand the power of technology to create new knowledge (Muhaimin et al., 2019; Hadiyanto et al., 2017). New standards are needed so that-students will have the competencies in the 21st century. Schools are challenged to find ways to enable students to succeed in work and life through mastering creative thinking skills, flexible problem solving, collaboration and innovation. Several sources such as Trilling and Fadel (2009), Ledward and Hirata (2011) demonstrate the importance of 21st century skills to achieve the transformation needed. Delors (1998) from the International Commission on Education for the 21st century proposes four visions of learning including, knowledge, understanding, competence to live, and competence to act. In addition to this vision, four principles, as the four pillars of education, are learning to know, learning to do, learning to be and learning to live together. This framework is considered still relevant to education interests today and can be developed according to the needs of the 21st century (Scott, 2015).

Problem-based learning is one alternative to make student easier to train to solve problems in learning Physics. This learning model application can improve students' problem-solving skills in Physics learning. The essence of problem-based learning is to provide students with various authentic and meaningful problem situations, which can serve as a springboard for investigation and improve problem solving skills in students (Tan, 2009; Muhaimin et al., 2020; Syaiful et al., 2020). A problem-based learning model will increase students' knowledge, problem solving skills and science processes. This study aimed to investigate the use of problem-based learning in Physics learning in the aspects of students' knowledge, problem solving skills and science process skills. The effect of the learning model in question is to positively affect the skills above, which is the target of this study. The PBL model used in this study is the PBL model proposed by (Yanto, 2019) namely observation, problem formulation, problem analysis, data collection, hypothesis testing, developing and presentation as well as analyzing and problem solving processes.

Literature Review

In the modern world, increase students' capacity to solve problems and critical thinking is an educational goal in all fields (Elder & Paul 2012; Olszewski-Kubilius& Thomson, 2015). Technological advances have changed the style of teaching and learning activities from passive learning to active learning, from traditional to contemporary innovative teaching, and producing students from passive listeners to active learners especially in science learning. Physics is a branch of science that makes an essential and beneficial contribution to the development of science, especially in applied sciences such as technology, mechanics, medicine and marine science, Therefore Physics is an essential subject in junior high school. According to Williams et al. (2003), physics is complicated for students to understand since it also considers how to find solutions and knowledge to solve problems related to learning.

Based on observations, the assignment of structured tasks in the form of calculations or questions occupies the highest percentage, which is above 70%. Furthermore, the students' motivation is hopes and aspirations of the future and the desire and desire to succeed is above 60%. However, it is not in line with the implementation of practicum, interesting activities in learning, encouragement and needs in learning which only occupy a percentage of less than 50%, even though teachers have implemented learning models or strategies (53%). In terms of the teaching materials used, printed teaching materials still dominate with a percentage above 60%, and the use of non-printed teaching materials is less than 30%. In general, learning outcomes of Physics are not as expected.

Teachers are another reason for students' difficulties in learning Physics because of their active role in the teaching and learning process (Ekici, 2016). Alptekin and colleagues (2009) revealed that students think that the teacher plays a paramount role in their understanding to learn physics. Aycan and Yumuşak (2003) stated that one of the possible causes of difficulties in understanding Physics for students is the non-experimental and theoretical treatment of the subject. Teachers take on the crucial task of managing the teaching process well (Ekici, 2016). It requires more serious attention from various groups to find alternative solutions to improve the ability and competence of students in learning, especially Physics.

Every effort has been made by the government to overcome various problems that exist in the world of education today. The government has made several standards in the field of education such as process standards, evaluation, assessment, funds, facilities and infrastructure as well as making changes to the education curriculum. At this time, Indonesia has implemented the 2013 curriculum which focuses on a scientific approach. for implementing this approach into the learning process, the 2013 curriculum suggests choosing a model in learning, including; Problem Based Learning (PBL), Project Based Learning (PjBl), Discovery Learning (DL), Inquiry Learning (IL) (Hosnan, 2014).Problem Based Learning (PBL) is learning that has essence in the form of presentation of various problems that authentic and meaningful to students, so it can work to carry out investigations and to be investigated (Afdareza, Yuanita, & Maimunah (2020), Utrifani and Turnip (2014) revealed that PBL is a model learning that involves students solving a problem through stage of the scientific method so that students can learn the knowledge related to the problem and have the skills to solve problem.

Methodology

The study used a quasi-experimental method. Only a randomized posttest could be used to incorporate this study design into the control group design. The design consisted of experimental and control groups (Johnson & Christensen, 2019). The experimental group used a problem-based learning model, while the control group used a conventional learning model. At the end of the activity, both groups were given a posttest to determine the effect of using the problem-based learning model. The stages of quasi-experimental study carried out were the same as the stages of experimental study by not controlling all variables strictly.

The first stage was to conduct a literature survey related to the problem: learning models and aspects of knowledge, problem solving skills and students' science process skills. The stages were continued by identifying and analyzing problems in learning Physics by conducting a preliminary study. The third stage was formulating hypotheses to estimate the effect of problem-based learning models on student competence. The fourth stage was to develop a study plan with the design of the experimental group and control group, pretest and posttest. The fifth stage was conducting experiments by giving treatment with a problem-based learning model to the experimental group, while the control group did not. Sixth is processing raw data from instruments into data in the form of values. Seventh, applying statistical tests according to the characteristics of students' knowledge, problem solving skills, and science process skills.

The population of this study was students of *SMA N 8 Padang* and *SMA N 9 Padang*. The sampling technique in this study was purposive sampling, namely classes with the same characteristics. According to Margono (2004), finding a way to determine the number of samples in accordance with the sample size that will be used as the actual data source, considering the characteristics and distribution of the population to obtain representative sample.

This study was conducted in the experimental group and the control group. There were 30 students in the experimental group, and 30 in the control group. The pre-test was for to both groups of samples before being given Physics learning material. This test aimed to determine the initial ability of the two groups. The average value of the experimental group was 60.50, while the control group was 60.98. The test results of the two sample groups had data that were normally distributed and had the same variance. The comparison test of the average group of independent samples obtained a value of t = 0.07. This test showed that the initial ability of the two sample groups is the same. The data collection instrument consisted of three parts, namely a written test, an observation sheet, and a performance appraisal sheet. Students' knowledge is measured by using a written test related to the concept of changes in heat energy. The written test used 25 objective questions as a posttest in two sample groups. The questions are multiple choices with five choices and tested on classes outside the sample with the same grade level to determine questions that meet the criteria that can measure students' 21st century skills. The reliability and correlation coefficient of the posttest questions were 0.92 and 0.85, respectively. Inquiries were made online using Google Forms. The performance appraisal sheet is an instrument to measure students' problem-solving skills. The written test result data was in the form of a value scale. On the other hand, the data from the performance appraisal sheet with a Likert scale was converted into a score scale to analyze this data using statistics.

The indicators of assessing students' problem -solving skills consist of asking several questions, thinking in various ways, giving many answers, and giving various reasons. Meanwhile, indicators to assess the skills of students' knowledge aspects were seen from competence at the level of understanding concepts to evaluate and compare. Data from the aspects of knowledge, problem solving skills and students' science process skills were analyzed using a comparison test of the mean of two independent sample groups and the Mann-Whitney U test. Before statistical tests, normality and homogeneity tests were carried out. For parametric statistics, a comparison test of the means of the two sample groups was used for data with the same normal distribution and variance. Meanwhile, if the study has data without the same normal distribution or variance, then the Mann-Whitney U test is used for nonparametric statistics.

Findings and Discussion

The effectiveness of the problem-based learning model for learning Physics is seen from three aspects, they are science process skills, knowledge and student problem-solving skills, meanwhile, the results of the analysis obtained are as follows.

The results of the analysis of students' science process activities

The following table shows the results of data analysis on student activities in the problem-based learning process containing authentic assessments in Physics learning which can be described in Table 1.

Table 1. *Student activities in learning physics using the problem-based learning model*

Observed Aspects	Average	Criteria
Science Process Activities		
Make observations (observations) according to the student worksheets	3.75	Very active
Formulate the problem according to the prepared student worksheets	3.68	Very active
Make predictions according to the demands of the student worksheets	3.75	Very active
Formulate the hypothesis according to the problem posed	3.87	Very active
Collecting information/data through practicum activities/library study/ resource persons	3.81	Very active
Organizing data in the form of tables, diagrams	3.62	Very active
Processing data/information and drawing conclusions from the data/information obtained	4	Very active
Drawing conclusions from the data/information obtained	3.75	Very active
Communicating the acquired knowledge and skills	3.62	Very active
Group activities	3.68	Very active
Share the tasks that the group has to do	3.68	Very active
Participate in group activities	3.93	Very active
Listen when friends share opinions	3.75	Very active
Ask friends in the group	3.87	Very active
Activities in a scientific attitude	3.81	Very active
Thorough	3.81	Very active
Honest	3.68	Very active
Diligent	3.68	Very active
Average	3.77	Very good
Percentage of agreements	84%	Agreement

Based on the data in Table 1 that the students' activities in learning physics using the problem-based learning model are in the very active category both for problem solving activities, group activities and activities in scientific attitudes. The percentage of agreements between the two observers is 84% or is in the very good agreement category. Under the established criteria, the learning model is effective if the student's activities meet the criteria above 3.1 (quite active - very active), it mean that the problem-based learning model for learning physics is effective in terms of student activity.

The results of the data analysis of problem-solving skills

The effectiveness test of the problem-based learning model for learning Physics is the learning outcomes in the form of problem solving. Problem solving skills are tested after students take part in learning using a problem-based learning model.

Tabel 2. *Average of student problem solving skills learning outcomes*

Schools	Classes	N	Average Pre test	Average Post test	Average Gain (Δ)
SMA N 8	Experimental	30		86	0,70
Padang	Control	40		65	0,60
SMA N 9	Experimental	30		90	0,73
Padang	Control	30		58	0,61

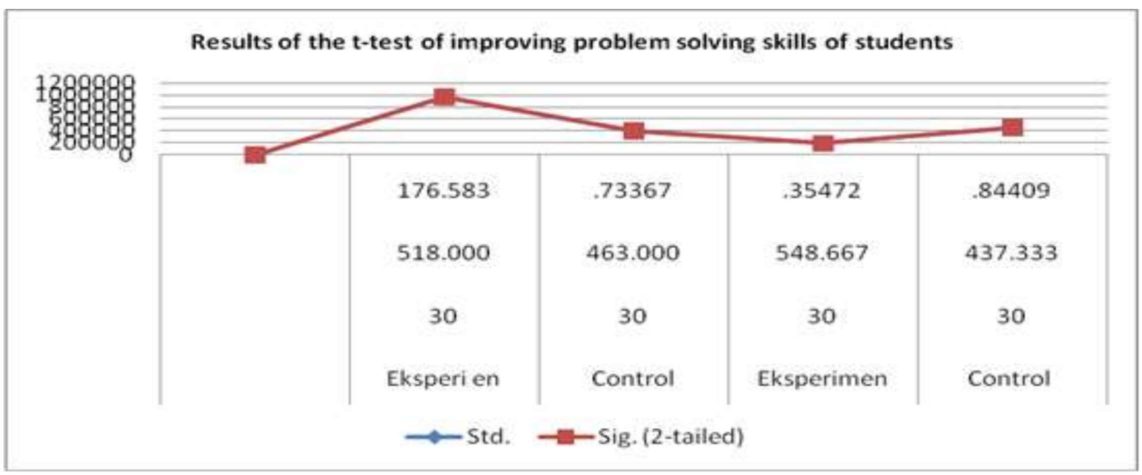
Table 2 shows, the improvement in the learning outcomes of students' problem solving skills with the problem-based learning model is higher than the learning model commonly used by teachers. Furthermore, the analysis prerequisite test was carried out for the analysis for normality using the Mann-Whitney and Shapiro-Wilk tests. The data criteria are normally distributed if the significance >0, 05. The data processing with Kolmogorov-Smirnova showed significance in the experimental class 0.227> 0.05 and for the control class 0.324> 0.05, as well as the analysis using Shapiro-Wilk; it means that the data for both classes were normally distributed. The results of the homogeneity of variance test showed the criterion for homogeneous variance is when sig > 0,05 the data processing results showed that at SMA N 9 Padang, the significance value obtained was 0.070 > 0.05, while at SMA N 8 Padang, the significance value was 0.033 > 0.05. It means the variance of the data on increasing aspects of student problem-solving skills was homogeneously distributed. So, it is homogeneous. Based on the results of the normality test and the homogeneity of variance test results, the hypothesis test uses the t-test using SPSS 19. The t test results for problem-solving skills are in Table 3.

Table 3. *The T-test of improving problem solving skills of students at SMA N 8 and SMA N 9 Padang*

Schools	Classes	N	Mean	Std.Error Mean	Std. Deviation	Sig. (2-tailed)
SMA N 9 Padang	Experimental	30	51.8000	1.76583	9.67186	0,001
	Control	30	46.3000	.73367	4.01849	
SMA N 8 Padang	Experimental	30	54.8667	.35472	1.94286	0,000
	Control	30	43.7333	.84409	4.62328	

Criterion Ho is rejected if the significance of (2-tailed) <0,05. The results of the analysis in show sig (2-tailed) <0.05 which means Ho is rejected. It means that the improvement of students' problem-solving skills in each school taught by the problem-based learning model for Physics learning is better than that are not taught. It proves that using a problem-based learning model is effective in improving students' problem-solving skills. Data processing for problem solving skills is Appendix 1.10. Furthermore, Figure 1 shows the gratification of the effectiveness test of the problem-based learning model, for learning Physics towards improving students' problem-solving skills in each sample school.

Figure 1. *Results of the T-test of improving students' problem-solving skills*



The results of the data analysis of the knowledge aspect

The further effectiveness test of the problem-based learning model for learning physics is learning outcomes in the knowledge aspect. The knowledge aspect is tested after students take part in learning using a problem-based learning model. Improving learning outcomes in the knowledge aspect is in Table 4.

Table 4. *Average learning outcomes of knowledge aspects*

Schools	Classes	N	Average Pre-test	Average Post-test	Average Gain (Δ)
SMA N 9	Experiment	30	53	90	0,78
Padang	Control	30	30	75	0,63
SMA N 8	Experiment	30	52	85	0,74
Padang	Control	30	27	75	0,60

Based on Table 4, the increase in learning outcomes in aspects of student knowledge with problem-based learning models for learning is commonly used by teachers. Furthermore, the analysis prerequisite test was to perform a normality test using the t-test. The data criteria are normally distributed if the significance >0,05. The data processing result using Kolmogorov-Smirnova showed significance in the experimental class 0.163> 0.05 and for the control class 0.200> 0.05 as well as using Shapiro-Wilk. It means that the data for both classes were normally distributed. The homogeneity of variance test is shown. The criterion for homogeneous variance is when sig >0,05 . The data processing result at SMA N 8 Padang showed a significance of 0.294 > 0.05 mean-while, at SMA N 9 Padang showed a significance of 0.170 > 0.05. It means that the variance of the data on increasing aspects of student knowledge was homogeneous.

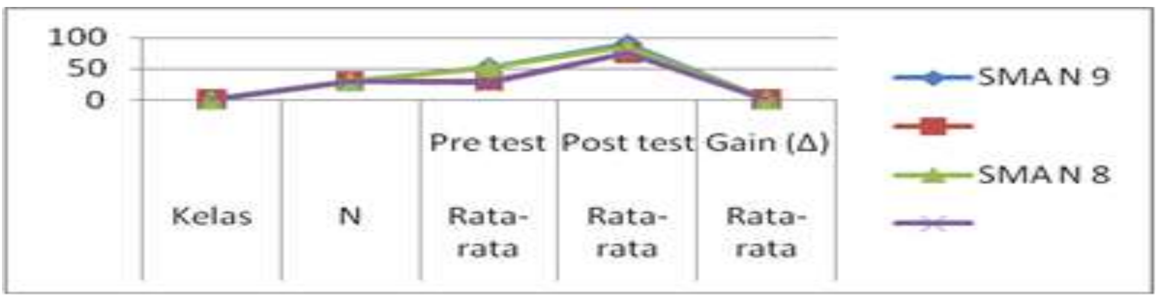
Based on the normality and the homogeneity of variance test, then the hypothesis test result the hypothesis uses t-test. The hypothesis tested is Ho = knowledge competence of students who are taught with problem-based learning model for Physics learning is significantly different from the knowledge competence of students taught without the problem-based learning model. The statistical hypothesis is: Ho = 1 - 2 with the help of SPSS 19. The results of the t test for the knowledge aspect are shown in Table 5.

Table 5. *Results of the T-test of knowledge aspect improvement*

Schools	Classes	N	Mean	Std.Error Mean	Std. Deviation	Sig. (2-tailed)
SMA N 9	Experiment	30	89.8667	1.67999	9.20170	0,000
Padang	Control	30	75.6000	1.79245	9.81765	
SMA N 8	Experiment	30	85.0667	1.48474	8.13224	0,000
Padang	control	30	75.6000	1.79245	9.81765	

Criterion Ho is rejected if the significance (Asymp. Sig) < 0,05 . The results of the analysis obtained Asymp. Sig .000 < 0.05 for both schools means Ho is rejected. It means that the increase in the knowledge competence of students who are taught the problem-based learning model for learning Physics is better than the increase in the knowledge competence of students taught without the problem-based learning model. Figure 2 shows a graph of the effectiveness of the problem-based learning model for learning Physics in increasing students' knowledge competence in each sample school.

Figure 2. *Increasing students' knowledge competence*



The criteria set to declare the problem-based learning model for physics learning to be effective are (1) student activity is in the moderate to very active category, (2) increased learning outcomes in aspects of knowledge is higher than students in the control class, and (3) increased results learn problem solving skills is higher than the students in the control class. Based on this, the problem-based learning model for learning Physics is effective when it is set in learning where the increase in learning outcomes for both knowledge competence and problem solving skills is higher than the control class, and student activities are in the very active category.

To see whether there is an interaction between the application of the problem-based learning model and student learning outcomes in aspects of knowledge in schools at different levels, then after testing the hypothesis, a two-way ANOVA test is carried out. The analysis results shown interaction between the problem-based learning model and student activities ($F=61.759$; $p<0.01$). It means there is a line of intersection between these two lines, the data shows an interaction between the applications of the problem-based learning model with learning outcomes in aspects of student knowledge at different school levels. It means the problem-based learning model can be applied middle and low levels. The analysis results of student science process activities were 84% in the very active category while problem-solving skills were 0.001 < 0.05 and 0.000 < 0.05 at SMA N 8 Padang and SMA N 9 Padang.

Meanwhile the analysis results of the knowledge aspect data were 0.000 <0.05 and 0.000 <0.05 at SMA N 8 and SMA N 9 Padang. It means Ho is rejected and in the problem-solving and the knowledge aspect there is an influence of PBL on student 21st century skills of students in the knowledge aspects problem-solving skills, and students' science process skills. Problem based learning is learning that has essence in the form of various problem presentations that are authentic and meaningful to students so that it can work to carry out investigations and to be investigated (Arends, 2008). Utrifani and Turnip (2014) revealed that PBL is a model learning that involves students' to solving a problem through stage of the scientific method so that students can learn the knowledge related to the problem and have the skills to solve problem.

Conclusion

The study results concluded that the use of problem-based learning models had a significant effect on three aspects of skills, namely knowledge, problem solving skills, and students' science process skills. This effect showed that the problem-based learning model was effective in developing students' knowledge skills, problem solving skills, and science process skills. The development of problem-solving skills, aspects of students' knowledge and science process skills could occur because in the implementation and application of this problem-based learning model students were motivated and actively involved in linking science learning materials with real-world contexts based on a theme, conducting scientific investigations, writing investigative reports, and solve the problem. As an implication of the results of this study, science teachers must motivate, direct, and guide students to construct problem solving skills, knowledge and students' science process skills through the application of problem-based learning models in learning processes and activities.

Disclosure statement

No potential conflict of interest was reported by the authors.

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