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# Effect of Project Based Learning Model Assisted by Student Worksheet on Critical Thinking Abilities of High School Students

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**Abstract.** This study aims to determine the effect of project-based learning model assisted by student worksheets on students' critical thinking skills in learning physics. The research was conducted in SMA Negeri 31 Jakarta on the second semester of the 2018/2019 academic year. The samples in this study were class X IPA 1 as the experimental class and class X IPA 2 as the control class. This study used quasi-experimental research method with unequal pretest-posttest control group design. The samples were taken using purposive sampling method, the experimental class was taught by using project-based learning model assisted by student worksheets and the control class was taught by using direct learning model. The data were collected by using tests of critical thinking skills obtained from the pretest and posttest. The results showed that students who were taught by using project-based learning model assisted by student worksheets had higher critical thinking skills than students who were taught by using direct learning model. This can be seen from the average score of the two classes, where the experimental class has an average score of critical thinking skills of 74.57 while the control class has an average score of 61.29. The results difference between the two classes was tested by t-test resulting in a value of 4.569, while the value of t-count on the t-table was 1.995. This means that the value of t-count > t-table so that the result of the t-test rejects H<sub>0</sub> and accepts H<sub>1</sub>. Based on the results of the study, it can be concluded that the application of project-based learning model assisted by student worksheets has a positive influence on students' critical thinking skills in learning physics on work and energy subject at SMA Negeri 31 Jakarta. Therefore, the application of the project-based learning model is highly recommended in secondary school learning.

## INTRODUCTION

The implementation of the curriculum in Indonesia since 2013 has been adapted to the challenges of education in the 21st century which requires students to master a number of skills that will support their lives in the future. The development of 21st century education emphasizes four main competencies that students must possess. These four competencies are often known as 4C, namely (1) Communication, (2) Collaboration, (3) Critical Thinking, and (4) Creativity.<sup>[1]</sup> These four competencies can be possessed by students if teachers can develop learning that contains activities that challenge students to think critically in solving problems, working together, and communicating. The 2013 curriculum focuses on students' potential, development, needs, interests, and environments.<sup>[2]</sup> The learning approach in the implementation of the 2013 curriculum is expected to be directed so that the students are able to not only solve the problems but also formulate problems.<sup>[3]</sup> The 2013 curriculum focuses on the scientific approach,

which is an approach that emphasizes five steps in gaining knowledge. First, observation, where students must be able to observe every phenomenon, both natural, social, and cultural phenomena. There are two aspects that are expected from observing real phenomena, namely: (1) through observation, students gain authentic knowledge, (2) through observation, it is expected that students have a critical soul towards every phenomenon that exists. The second step, asking, from the natural, social and cultural phenomena they observe, students form a curious soul by asking why the phenomenon occurred. Third, explore, by expressing (asking) the questions expected by students to develop reason, both in synthesis and analysis from simple to complex. Fourth, reasoning (association), in this phase students are expected to make connections from the results of synthesis and analysis to form conclusions. Fifth, communicate (presentations) what they see or feel. Although officially the curriculum established in 2013 has been implemented, in reality, there are still many implementations of learning in schools that tend to be teacher-centered, whereas the curriculum should emphasize student-centered learning. This condition has hampered the achievement of curriculum goals since 2013. On the other hand, students only learn by memorizing many topics without deep understanding, which is usually applied when dealing with real situations in their lives.<sup>[4]</sup> In such conditions students tend to only memorize physical theories and formulas that students have difficulty in finding facts and physics concepts in daily life.

Based on observations and interviews with physics teachers, it turns out that the physics learning process so far was carried out using classical methods and teachers only used powerpoint as the learning media. Classical learning methods make students pay less attention to the teacher's explanation so that learning is not effective. Through this learning method, students become less active and less directly involved in learning. In the learning process, teachers must provide guidance and opportunities for students to develop independently through discovery and critical thinking. In addition, the results of observations and interviews with student, most students answered that physics is one of the subjects that is considered more difficult compared to the other subjects. When a test was conducted, most students got bad grades. Lack of students' interest in studying physics results in low student physics learning achievement. The lack of students' interest in studying physics causes low student achievement in physics learning. According to PISA (Programme for International Student Assessment), Indonesian learning achievement in the science competency has increased from 382 points in 2012 to 403 points in 2015. Nevertheless, Indonesia is still ranked in the bottom ten. Regarding the cognitive abilities of students in TIMSS (Trends in International Mathematics and Science Study), the results of the 2015 TIMSS in science aspect showed that Indonesia ranked 45th out of 48 countries. This shows that Indonesia is weak in cognitive aspects.

Based on the problems above, there needs to be new innovations in learning models. One of them is the project-based learning model. The project-based learning model is an effort to train and improve students' critical thinking skills. Project-based learning is a learning model that uses projects or activities as media. Students conduct exploration, assessment, interpretation, synthesis, and information to produce various forms of learning outcomes. Project-based learning is designed to be used on complex problems that require students to investigate to understand them. Project based learning encourages learners to engage in activity-investigation, problem-solving, decision-making, and artifact-designing.<sup>[5]</sup> According to Acacia Warren, project-based learning is a learning model that focuses learning responsibilities of students.<sup>[6]</sup> Milan Kubiato and Ivana Vaculova's research mention four main characteristics of project-based learning, namely: 1) responsibility for thinking and learning; 2) awareness of social responsibility; 3) think and act from a scientific perspective but in practical applications; 4) both group processes and products relate to professional practice.<sup>[7]</sup> Project assignments will train students' critical thinking skills during the project implementation process.

According to Pithers and Soden, critical thinking is thinking that involves the ability to answer questions through independent search and questioning of knowledge, a sense that knowledge can be challenged, and can present evidence to support arguments.<sup>[8]</sup> In addition, Facione stated that critical thinking is self-regulation in assessing something that results in interpretation, analysis, evaluation, and inference, as well as exposure using evidence, concepts, methodologies, criteria, or contextual considerations that form the basis of decisions.<sup>[9]</sup> Murat Karakoc argues that when students think critically, they are encouraged to think for themselves, question hypotheses, analyze and synthesize events, to go further by developing new hypotheses and testing them against facts. [10] Robert and William in their research put forward eight general components for critical thinking. The eight components are: 1) making conclusions through fact-based logical reasoning; 2) gathering information through questions; 3) being open to new evidence that refutes previously believed ideas and beliefs; 4) understanding the problem; 5) using analogies; 6) seeing the problem from more than one side; 7) assessing and interpreting information with an impartial view; and 8) having domain knowledge.<sup>[11]</sup>

To facilitate students in the project implementation process can be supported by student worksheets. According to The Ministry of National Education, student worksheets are sheets containing assignments that must be carried out by

students usually in the form of instructions, steps for completing assignments with reference to the basic competencies to be achieved.<sup>[12]</sup> I Made Astra in his research stated that according to his interviews with students, using student worksheets made students feel curious and enthusiastic in learning because they had direct experience, students also stated that they were motivated to conduct experiments and could clearly understand concepts.<sup>[13]</sup> With student worksheets, projects assigned to students will be more directed and systematic. In addition to facilitating students in project implementation, the presence of student worksheets will also make it easier for teachers to monitor the project implementation process carried out by students.

Based on the description above, this research focuses on the effect of project-based learning model assisted by student worksheets on students' critical thinking skills.

## RESEARCH METHODS

The research method used was quasi-experimental type, with Non Equivalent Pretest-Posttest Control Group Design. This research method aims to look for the effect of certain treatments. The research was conducted at SMA Negeri 31 Jakarta. The population in this study were all students of class X IPA of SMA Negeri 31 Jakarta in the second semester of the 2018/2019 academic year. The sample selection technique used purposive sampling technique, then class X IPA 1 was selected as the experimental class and class X IPA 2 was selected as the control class. The experimental class was taught by using project-based learning model assisted by student worksheets and the control class was taught by using direct learning model.

Data collection techniques were carried out in two stages, namely pre-test and post-test. Pre-test was given to see students' initial abilities, this stage was carried out before the treatments in both samples. From the pre-test results, it was expected that the two sample classes have equivalent initial skills. Post-test was given to see the results after treatments to both samples and to test hypotheses using the t-test statistical formula with the criteria  $H_0$  accepted if  $t\text{-count} < t\text{-table}$  and  $H_0$  is rejected if  $t\text{-count} > t\text{-table}$ . Before conducting the t-test, the data must be tested with normality and homogeneity tests first. Normality test serves to determine whether the sample was normally distributed or not by using the Lilliefors test. Homogeneity test was performed to determine whether the two samples come from populations that have the same variants. In this case homogeneity test was done using the Fisher's test.

## RESULT AND DISCUSSION

Based on the results of the study, students' critical thinking skill scores in the experimental class and the control class were obtained. These scores were obtained through the research instruments in the form of pretest questions given to students before the treatments and posttest questions given to students after the treatments.

Based on data collection and processing, each class showed normal distribution of data. This was proven after seeing the comparison of L-count results with L-tables in the experimental class and the control class, namely L-count  $< L\text{-table}$  with a value of  $0.086 < 0.149$  for the experimental class and  $0.074 < 0.149$  for the control class. Furthermore, homogeneity tests were carried out in the two classes and the results did not differ significantly in the two classes. This was evident after seeing the comparison of the results of F-count with F-table, namely F-count  $< F\text{-table}$  with a value of  $0.474 < 1.772$ .

Based on the prerequisite test data analysis (normality and homogeneity test) on the results of students' critical thinking skills test, both classes were normally distributed and homogeneous. Therefore the research hypothesis was tested with parametric statistics using the t-test. The T-test was conducted to determine the differences in students' critical thinking skills between the experimental class and the control class.

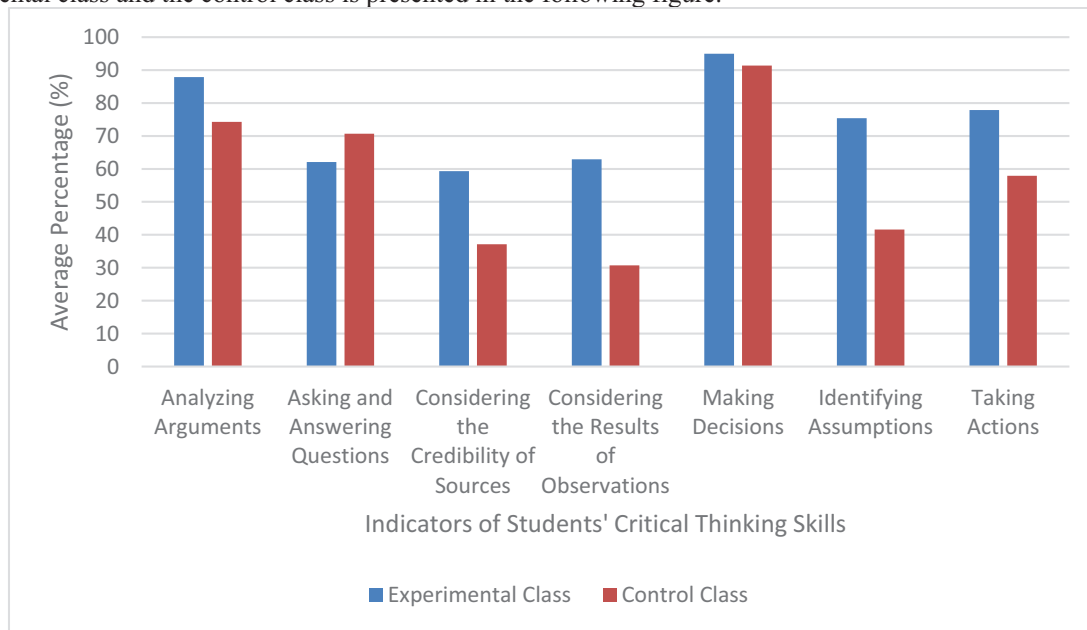
The result of t-test calculation was 4.569. At the 5% significance level, the value of t in the table is 1,995. These results indicate that the  $t\text{-count} > t\text{-table}$  is  $4.569 > 1.995$ . This means that  $H_0$  is rejected and  $H_1$  is accepted. Which means that there is a positive effect from the application of project-based learning model assisted by student worksheets on students' critical thinking skills.

In this study there were seven indicators of students' critical thinking skills, namely analyzing arguments, asking and answering questions, considering the credibility of sources, considering the results of observations, making decisions, identifying assumptions, and taking action. The results of the analysis of the average percentage of students' critical thinking skills on each indicator from the experimental class and the control class are presented in the following table.

**TABLE 1.** The average percentage of each indicator of students' critical thinking skills in the experimental class and the control class.

Indicators of Students' Critical Thinking Skills	Experimental Class	Control Class
Analyzing Arguments	87.9	74.3
Asking and Answering Questions	62.1	70.7
Considering the Credibility of Sources	59.3	37.1
Considering the Results of Observations	62.9	30.7
Making Decisions	95	91.4
Identifying Assumptions	75.4	41.6
Taking Actions	77.9	57.9

Based on the data in table 1, the average percentage of students' critical thinking skills in each indicator in the experimental class and the control class is presented in the following figure.



**FIGURE 1.** The average percentage of each indicator of students' critical thinking skills in the experimental class and the control class.

Based on the data, it can be seen that on the seven indicators of students' critical thinking skills, the results between the experimental class and the control class are different. The most significant difference is the considering the observations indicator. This illustrates that students' critical thinking skills can be improved by applying appropriate learning models, one of which is by applying project-based learning methods assisted by student worksheets.

The results of the analysis of the students' critical thinking skills categories in the experimental class and the control class are presented in the following table.

**TABLE 2.** The students' critical thinking skills categories in the experimental class and the control class.

Class	Percentage	Category
Experimental Class	74.57	Moderate
Control Class	61.29	Low

From the table above, it can be seen that the percentage of students' critical thinking skills in the experimental class is higher than the control class. The critical thinking skills of the experimental class students were categorized as moderate, while the critical thinking skills of the control class students were categorized as low.

The implementation of project-based learning models was carried out through structured steps, namely determining fundamental questions, designing project plans, managing schedules, monitoring students and project progress, testing results, and evaluating experiences. Through these steps, students' critical thinking skills such as analyzing arguments, asking and answering questions, considering the credibility of sources, considering observations, making decisions, identifying assumptions, and determining actions can be trained. Thus, the critical thinking skills of students in the experimental class who were taught by using the project-based learning model assisted by student worksheets had higher scores than the control class students who were taught by using the direct instruction model. This is supported by Sasson's research which stated that project-based learning is more successful than traditional approaches for developing higher order thinking skills.<sup>[14]</sup> Other research that is in line is Wurdinger's research which stated that project-based learning promoted an increase in students' life skills, specific problem solving, creativity, responsibility, communication, and self-direction.<sup>[15]</sup>

In this study, student worksheets have an important role in optimizing the application of project-based learning model. With student worksheets, project implementation becomes more structured and easier to understand for students in implementing projects. In addition, student worksheets also greatly assist teachers in monitoring students and project progress.

Based on the results of the study, the experimental class learning outcomes were higher than the control class. This is proportional to the score of students' critical thinking skills in the experimental class and the control class. These results indicate that cognitive abilities play an important role in critical thinking. This is supported by Sukran Ozkahraman and Belgin Yildirim who stated that critical thinking and learning are interrelated, individuals must think to gain knowledge, to increase the depth and breadth of individual knowledge, individuals must be more aware of cognitive processes.<sup>[16]</sup>

## CONCLUSION

Based on the results of the study it can be concluded that the application of the project-based learning model assisted by student worksheets affects the critical thinking skills of high school students on work and energy subjects. The influence was seen in the posttest results in both classes, where the critical thinking skills of the experimental class students were higher than the control class. Project-based learning is suitable for classes with large numbers of students. Project-based learning is also in accordance with the 2013 curriculum implemented in Indonesia, which demands students' higher-order thinking skills. For research in classes with a large number of students, it is also necessary to try to find out the effect of project-based learning assisted by other media such as virtual laboratories, visual media or other audio visual media.

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