The Effect of Student Worksheet-Assisted Project-Based Learning on Learning Outcomes and Critical Thinking in Moderation of Student Learning Motivation in Electrolytic Cell

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Abstract

This study aims to discover the differences between learning outcomes and critical thinking skills between students who follow project-based Learning and conventional Learning. Second, to know the impact of project-based learning on student worksheets on learning outcomes and critical thinking in moderation of student learning motivation. The method used in the initiation is a quasi-experiment with a pretest-posttest control group design. The results show that (1) there are differences in learning outcomes between students who follow project-based learning and students who follow conventional learning; (2) there is a difference in critical thinking capabilities among students who go with project-based learning and conventional students; (3) motivation to moderate project-based learning to help students worksheets to improve student's learning outcomes; (4) motivation not to moderately project-driven Learning to help students' worksheets on critical think ability.

Keywords: *critical thinking, learning outcomes, worksheets, motivation, project-based learning*

I. Introduction

Electrolysis cell material is part of chemistry lessons in class XII science. The working principle of the electrolysis cell is to utilise an electric current source to produce chemical reactions, and it is often used in everyday life, such as in the metal plating process, as a corrosion prevention method. One of the implementations of learning in the classroom is that students are oriented towards the problems of everyday equipment, such as metal, that rusts easily. Hence, efforts to overcome it need to be prevented by electroplating. This can stimulate students' ways of thinking to find out, analyse, and find out more

about the causes of metal objects around them that experience corrosion phenomena as well as prevention efforts. This pattern of thinking is called the critical thinking process.

Critical thinking is processing thoughts in more detail and making things concrete [22]. Critical thinking is described as a pattern of thinking about any subject, problem, or topic by optimising thinking skillfully by coordinating the inherent thought structures and applying intellectual standards [16]

There are several conditions based on the results of this study which show that body conditions, fear, brain development, incentives, habits, and environment are dominated by the factor of habit [20]. So, in the teaching and learning process, the teacher's habit of implementing a learning strategy has an important role in intellectual development and encouraging students to develop critical thinking processes.

Broad emotional intelligence, the ability to analyse concepts, and the ability to combine multiple sources of knowledge [23] are needed to apply learning strategies with critical thinking skills. Have difficulties in learning chemistry because there are challenges in understanding terms that arise when most students only memorise terms and do not understand the meanings of terms that are commonly used; they also face difficulties in understanding chemical concepts because, according to them, The concepts discussed are foreign and difficult to understand [13]. Almost all ideas are complex in nature and cannot be directly explored with the naked eye.

Understanding microscopic material requires a high mindset to solve unobserved problems, such as the phenomenon of chemical reactions produced by electrical energy in the electrolysis process. This explanation illustrates that students' critical thinking skills and higher reasoning power are needed when studying electrolytic cell material. The importance of critical thinking skills during the learning process can affect whether students understand the material correctly and sincerely. Positive learning outcomes are manifested by a good relationship between capabilities in critical thinking and student learning independence [5].

The learning outcomes obtained by students measure academic achievement and student achievement after going through the learning process [2]. Achievement of learning outcomes can be assessed by using testing to increase student progress in various aspects. The success rate of student learning is influenced by the teacher's ability to apply learning strategies to manage the teaching and learning process by managing subjects and students, equipment, and time effectively and efficiently to achieve predetermined learning objectives [12].

Researchers collected data through interviews to learn about the implementation of chemistry learning at Widya Darma Senior High School, Surabaya. The interviews showed that almost all students did not like learning chemistry because, according to them, the material was difficult and

difficult to understand. Students said that they never linked chemistry to everyday life during the learning process. The researcher confirmed the information conveyed by the students to the chemistry teacher, and the teacher confirmed this statement. The activities showed one-way learning, and students were not active in expressing opinions. As a result, this harms the development of independent learning skills and critical thinking skills.

This finding indicates that optimal effort has not been achieved to improve students' critical thinking skills for chemistry learning. This is something that many parties, especially teachers, must consider. Found that the most influential factor in critical thinking is habit, and the habits of teachers in applying learning approaches often used have an impact on students' mindsets [20]. Many lessons can be used to overcome this. Project-based learning is defined as one of the highly recommended learning methods.

Project-based learning is another option for creating a fun, quality learning atmosphere that involves students in the learning process [1]. This method can potentially improve academic achievement and students' ability to think critically. Project-based teaching methods can provide significant benefits for the development of process skills. In this approach, real problems or situations become the foundation for students to acquire, integrate, and apply new knowledge based on the experiences they gain. In addition, students are also invited to apply this knowledge in a real-world context [15].

Describe the characteristics of project-based Learning (PjBL) as developing students' thinking skills, helping them become creative and competent, and encouraging them to work together [8]. In its application to electrolysis cell material, students will be faced with a problem of everyday equipment such as metal rusting. Students identify what causes corrosion and can design an idea to prevent it using the concept of electrolysis during the investigation. In the learning process, students must work together to identify a problem, collect supporting data, design an experimental idea, and apply their creativity to a project.

The PjBL approach emphasises the need to create a learning environment that encourages students to be responsive to their own learning and to face real problems in implementing learning. This will motivate students to think more deeply about the material they are studying and increase their academic achievement. Applying a problem-based learning method using worksheets is an effective strategy that increases student motivation in the learning process [3]. The purpose of the LKS media is to ensure students have media following the material being taught and that the learning process will occur systematically. Learning using appropriate student worksheets will motivate each student [17]. Thus, all students will be actively involved in learning and produce better learning achievements. The application of project-based learning systems positively impacts critical thinking skills in

electrochemistry lessons. Implementing a project-based learning system positively impacts essential thinking skills in electrochemistry lessons [24].

Based on the presentation of the problem and other supporting sources, researchers researched the effect of project-based learning assisted by student worksheets on learning outcomes and critical thinking in moderation of student learning motivation. The research objective was to determine the effect of project-based learning assisted by student worksheets on learning outcomes and critical thinking in moderating student learning motivation in electrolytic cell subjects.

II. Method

Researchers used a non-equivalent control group design in this study. This study compared a project-based learning strategy treatment to the experimental group and provided a control group with conventional strategies. The pre-test was distributed to both groups, and they were given treatment. The post-test was distributed afterwards. The sample used comprised class XII high school students at Widya Darma Surabaya.

The instruments in this study included lesson plans, worksheets, fifteen multiple-choice items on cognitive learning outcomes tests, ten essay questions on critical thinking skills, and seventeen student learning motivation questionnaire questions. Data analysis prerequisite tests include normality tests and homogeneity tests. The independent sample t-test was conducted to determine whether the project-based learning strategy influenced critical thinking skills and student learning outcomes. The regression test was conducted to determine whether learning motivation moderates project-based learning, as assisted by student worksheets, on student learning outcomes and critical thinking.

III. Results and Discussion

Both groups used pre- and post-test data to measure the increase in cognitive learning outcomes and critical thinking skills in electrolytic cell subjects. The mean of the students' pre-test scores in the two groups was not significantly different, indicating that the students' abilities in both groups were uniform.

Table 1. Average Pre-test Score

Group	Learning Outcomes	Critical Thinking
Experiment	20,20	12,50
Control	23,00	14,75

The post-test was conducted to measure the development of critical thinking and students' academic achievement after the groups finished the learning process. The average post-test scores in the two groups increased, but the scores in the experimental group appeared superior.

Table 2. Average Post-test Score

Group	Learning Outcomes	Critical Thinking
Experiment	82.00	69.00
Control	71.00	55.00

The prerequisite checks involved normality and homogeneity tests, which showed that the data from the two groups had a regular and homogeneous distribution, which was determined based on the sig value. ≥ 0.05

Table 3. Normality Test of Learning Outcomes

Group	Shapiro-Wilk		
	Statistic	df	Sig.
Experiment	.950	30	.170
Control	.948	30	.147

Based on normally distributed data and homogeneous population variances. Then, parametric statistical analysis is used to test the hypothesis. To determine whether Ho or Ha is accepted or rejected based on the testing criteria, we need to compare the value of *Sig. (2-tailed)* with a significance level of 0.05. If the *sig. (2-tailed)* Ho can be accepted if the value is more significant than 0.05. However, if the *sig. (2-tailed)* If the value is less than the significance level of 0.05, then the hypothesis is accepted.

The first hypothesis test uses an independent sample t-test to determine whether there are differences in learning outcomes between students who follow project-based learning strategies and students who follow conventional strategies.

Table 4. Critical Thinking Normality Test

Group	Shapiro-Wilk		
	Statistic	df	Sig.
Experiment	.941	30	.099
Control	.948	30	.148

The independent t-test in both groups shows that the *sig. (2-tailed)* value is 0.000 greater than 0.05, with a t count of 4.611 greater than the t table (1.672). The data indicates variation in learning

achievement between students using Project-Based Learning and traditional learning methods (control). This difference is because students in the experimental class are allowed to build their own knowledge through solving problems in a given project. The PjBL learning method can potentially improve student learning outcomes because it focuses on memorising concepts and teaches students how to apply these concepts in various problem situations. In this case, it is easier for students to complete the challenges and understand the concepts being taught [10].

Table 5. Homogeneity Test

	Levene Statistic	**df1**	**df2**	**Sig.**
Experiment	.014	1	58	.907
Control	.051	1	58	.822

Students work on projects based on a given theme in electrolysis cell material. Students investigate by looking for sources of information to answer questions. The problem the students are solving is the prevention of corrosion on metal accessories using the electroplating method. The phenomena that emerged during the experiment were related to the competency of the electrolytic cell material, including determining the appropriate pair of electrodes and electrolytes, determining the redox reaction of each electrode, determining the mass of metal deposited, determining the time needed, and analysing the factors that affect the electrolytic cell. Students learn about electrolytic cells based on their understanding during the investigation process. On this occasion, the teacher's role is only as a liaison, guiding students by providing instructions through discussions and questions in the Student worksheet.

Table 6. Independent t-Test Learning Outcomes

	Levene's Test for Equality of Variances				
	F	Sig.	T	df	*Sig.(2-tailed)*
Equal variances assumed	.000	.992	4.611	58	.000

Learning that focuses on a particular issue or topic and involves students in finding solutions will encourage learning because students feel challenged to find information relevant to everyday life. The project given must be realistic and provide direct and real information to convince students of the realities of everyday life that often occur. Therefore, applying the project-based learning strategy in this study influences student learning outcomes in electrolytic cell material [19]. An influence on

student learning outcomes occurs due to the implementing the Project-Based Learning (PjBL) strategy [8].

In the second hypothesis test, an independent sample t-test was used to examine whether differences arise in critical thinking skills between students who follow project-based learning strategies and students who follow conventional strategies.

Table 7. Independent Test t Test Critical Thinking

	Levene's Test for Equality of Variances				
	F	Sig.	T	df	*Sig.(2-tailed)*
Equal variances assumed	10.024	.002	3.149	58	.003

Referring to the results of the independent t-test in both groups, it can be seen that the sig. (2-tailed) value is 0.003, greater than 0.05, with a t-count value of 3.149, greater than t-table (1.672). The data shows that students with the PjBL learning system (experimental) have different critical thinking skills from students who take conventional learning (control). This difference in ability is based on the fact that students are directly involved in the learning process, hoping they will better understand and remember the subject matter and develop skills relevant to real life. In this learning method, students will be involved in investigative activities, including analysis, experimentation, and making hypotheses and conclusions. They will also be involved in design activities, where they must plan the actions and steps needed to achieve their project goals [17]

To improve critical thinking skills during the learning process, students are accustomed to critically analysing information sources when answering each question in the Student Worksheet. The students carry out analytical activities by seeking information on preventing corrosion through electroplating projects with the help of the internet or other sources of information. There is an analysis process during the investigation, and students can construct their knowledge independently by completing the projects they are working on.

Project-based learning methods (PjBL) can optimise critical thinking skills by inviting students to seek information from different sources, deepen discussions, and encourage them to actively ask questions and explore problems from various perspectives [susanawati]. In addition, PjBL also teaches students to ask relevant questions, collect information, solve problems, and be responsible for the results presented.

Therefore, applying project-based learning strategies affects students' critical thinking skills in electrolytic cell material. PjBL has a very significant influence on students' critical thinking skills [maubana].

This study uses learning motivation as a moderator variable. The analysis used is a simple regression test carried out with a significance value or level of significance (sig.). If the results are significant with a sig. greater than 0.05, the use of project-based learning with the help of student worksheets has a moderate effect on student learning outcomes and critical thinking skills.

Table 8. Regression Test of Learning Outcomes in Moderation of Motivation

Sum of Squares	df	Mean Square	F	Sig.
392.788	1	392.788	5.731	.024[b]

The results of the regression analysis test show that the significance value (sig) for the relationship between motivation and learning outcomes is 0.024, which is smaller than the significance threshold value of 0.05. In contrast, the sig value on motivation for critical thinking skills is 0.210> 0.05. In moderation of learning motivation, the research shows that project-based learning using student worksheets positively influences student learning outcomes. However, learning motivation did not moderate students' critical thinking skills when using project-based learning student worksheets on electrolysis cell material.

Table 9. Critical Thinking Regression Test in Moderation of Motivation

Sum of Squares	df	Mean Square	F	Sig.
223.940	1	223.940	1.647	.210[b]

The reason is that students need to train and get used to thinking critically through relevant activities to improve critical thinking skills. The application of critical thinking skills, which takes less than one month, shows that students' motivation only encourages enthusiasm for learning but has not been able to sharpen reasoning fully. [6] Critical thinking skills can be applied to development results that are still imperfect and caused by a lack of time in their implementation. A study conducted in England took up to eight years to implement the CASE (Cognitive Acceleration through Science Education Projects) project in order to improve critical thinking skills [14].

On another occasion, having high learning motivation can encourage students to learn the material. Learning motivation plays an important role in stimulating enthusiasm and excitement for learning and giving students a lot of desire to complete the learning process [9]. Student learning outcomes in learning mathematics are influenced by motivation [21]. Between students' learning motivation in learning chemistry and their achievement, has a positive and significant correlation [4].

IV. Conclusion

Based on the results of the research, it can be concluded that there are differences in learning outcomes between students who use project-based learning strategies and those who use conventional learning methods. These findings are supported by a significance value (2-tailed) of 0.000, which is below 0.05, a t-count value of 4.611, which is smaller than the t-table value (1.672), and the experimental class mean value of 82, while the ordinary class value is 71. There is a difference in critical thinking skills between students who use a strategic approach to project-based learning and students who follow conventional learning methods. There is a significant difference in the value of Sig. (2-tailed) 0.003 less than 0.05 and a t-count value of 3.149 smaller from the t table (1.672), and the mean value of the control class is 55 while the mean value of the experimental class is 69. Motivation moderates project-based learning-assisted student worksheets on improving student learning outcomes. Still, motivation does not moderate the ability to think critically, based on the regression test, which shows the value sig on motivation on learning outcomes is 0.024 < 0.05, while the sig value on motivation on critical thinking skills is 0.210 > 0.05.

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