Evaluation of Project-Based Learning and Reflective Practices: A Study of Electrical Courses

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Abstract. Project-based learning is seen as appropriate for 21st-century learning. This study aims to analyze the perceptions of lecturers and students on the application of project-based learning and reflective practice in physics learning in electricity courses. The research subjects consisted of 59 students and 6 lecturers in the physics education study program who took electricity courses. The research method uses a survey by distributing questionnaires. The results showed that students expressed their agreement that project-based learning could improve knowledge, understanding, and skills in physics, and could practice physics problem-solving skills and provide experience doing research. Respondents from lecturers showed positive perceptions of project-based learning, although they also stated that there were obstacles in implementing the project-based learning model, which required more time. In the open questionnaire, student respondents revealed some of the obstacles or weaknesses of project-based learning. The process of reflection is still not well conceptualized in learning, it can be seen that there are still perceptions that are not stable in the reflection activities carried out. Student respondents stated that reflection activities were still limited to verbal delivery at the end of the project or learning activities. There needs to be an effort to optimize reflective practice in learning so that it can improve students' learning abilities and motivation. The implication of this research is the need to develop a project-based learning model by integrating it with reflective practice.

Keywords: Project-based learning, physics learning, reflective practice

1 Introduction

Various learning models are recommended by literature to support 21st Century skills, one of which is project-based learning. Project-based learning provides an educational experience where actively involved in the learning process, students become responsible for independent thinking and creativity [1]. This course is designed to hold students accountable for their learning, encouraging them to develop the skills needed for the competitive world of the 21st century, such as technology skills, advanced communication, and problem-solving[2]. Project-based learning provides opportunities for students to investigate appropriate topics and allows them to learn from experience, and

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apply the knowledge, skills, and attitudes acquired to real cases in their lives [3]. Project-based learning emphasizes the integration of knowledge and fosters students' problem-solving capacity [4]. Project-based learning is seen as a learning process that places a strong emphasis on problem-solving and focuses on product creation or performance [5], [6]. This learning also offers opportunities to develop collaboration skills and improve higher-order thinking skills [7], [8].

Progressive teaching methods such as individual and group project work can be used to foster deep understanding, prepare students to apply their knowledge in new situations, encourage self-regulated learning, encourage metacognition and develop cognitive processes that support problem-solving [9]. Projects involve enhancing creative and critical thinking through interpreting clusters of data, predicting outcomes, drawing conclusions, and presenting results [10]. Project-based learning has a positive effect on problem-solving abilities [11], [12]. The potential use of the project-based learning model can be developed in terms of soft skills, such as collaborative problem-solving, communication involving authentic inquiry, and time factor to ensure efficiency and success in problem-solving efforts.

Reflective practice is a key skill in many professions [13]. Reflecting is asking what happened or what might happen, what was done, and how it relates to the goal, researching when a situation went well, or investigating why or how something went well or wrong [14]. Reflection in learning requires students to be curious, open-minded, and responsible for the knowledge they have or explore [15]. Students' reflective thinking contributes to a better understanding of themselves, their learning, and their learning motivation [16]. Reflective practice can improve the learning process [17], [18].

Reflective practice refers to the process or means by which participants understand their experiences and their meaning [19]. In the professional context of the teacher, the process of reflective practice begins with the professional practice of the teacher, then is a reflection on what has happened in the teaching and learning situation. This reflection may be an evaluation of teaching and learning, for example, whether the learning outcomes set for a session have been achieved, and if not, why not, or are driven by a particular issue in the teaching and learning situation that needs to be resolved. At this stage, the teacher will consider how aspects of teaching and learning can be improved, or problems solved [20]. This reflection resulted in revised practice, which made the necessary changes to change and make improvements to the teaching and learning process. This is followed by another stage of reflection where teachers will ask whether the changes they are making to their professional practice are having the desired effect [20]. The process of learning reflection allows the learner to carry out a critical review and gather a further understanding of self or knowledge, thereby propelling him to a higher level of learning [21]. The reflective practice facilitates the development of new knowledge, skills, and dispositions in teacher candidates by fostering critical contemplation of actions in a real-world environment [22].

In physics learning, the project-based learning model is one of the learning models that facilitates students in building creative thinking, independence, and critical thinking. Electrical courses have many interesting things that can be used as project assignments for students, both individually and in collaboration with other people or colleagues. the important thing to do is to explore in depth the perceptions of students and

lecturers who have carried out project-based learning to find out how effective it is in learning physics, especially in electricity lectures. The results of the exploration are expected to find the strengths and weaknesses of project-based learning as a basis for further development research. Project-based learning has been widely applied in learning and many research results reveal its success. However, in its implementation, several obstacles allow the expected learning outcomes to be less than optimal. Reflection in the learning process can support the meaningfulness of the learning process experienced by students. Generally, the implementation is done through various means, both orally and in writing. Exploration of the reflection process in learning is expected to be a finding that will be the basis for developing an effective reflection activity. This study intends to evaluate the application of project-based learning and reflective practice in electricity courses based on the perceptions of lecturers and students.

2 Method

This research method is a survey method, namely distributing questionnaires or questionnaires to lecturers and students in 5 (five) universities in the physics education study program. The questionnaire was sent via a google form. Questionnaire for lecturers containing open-ended questions related to their experience of project-based learning and reflective practice. Questionnaires for students consist of closed and open questionnaires. The open questionnaire aims to dig deeper and synchronize student answers to the closed questionnaire. The research subjects consisted of lecturers and students in the Physics Education Study Program. The student subjects were 59 students consisting of 23 students from IAIN Palangkaraya, 13 students from Palangkaraya University, 5 students from UIN Antasari, 8 students from Lambung Mangkurat University, and 10 students from UIN Walisongo. The respondents were 6 lecturers, namely 2 IAIN Palangkaraya lecturers, 1 Palangkaraya University lecturer, 1 Walisongo UIN lecturer, 1 Antasari UIN lecturer, and 1 Lambung Mangkurat University lecturer. Qualitative data analysis was carried out interactively and continuously until it was completed so that the data was saturated, the activities included data reduction, data display, and conclusion. [23].

3 Result and Discussion

The data from the questionnaire are first collected and then reduced or summarized and sorted to focus on the important things and discard the unnecessary. The results of the questionnaire analysis show that there is a perception that supports the application of project-based learning in learning, especially in electricity courses, besides that there are also some obstacles or obstacles expressed by lecturers and students who have implemented project-based learning. The description of the electricity subject lecturer who filled out the questionnaire is shown in table 1.

Table 1. Description of lecturers who filled out the questionnaire

Gender	Teaching Experience	Subjects taught (last 2 semesters)
Male (L-1)	3 years	Basic Physics, Waves, Computational Physics, Magnetism, Instrumentation
Male (L-2)	11 years	Basic Electronics 1 and 2
Male (L-3)	16 years	Magnetic electricity, basic electronics, thermodynamics, physics laboratory
Male (L-4)	27 years	Basic Physics II, Electromagnetics, Applied Physics
Male (L-5)	30 years	Electricity, magnetism, solid-state physics, statistical physics
Male (L-6)	5 years	Basic Electronics, Quantum Physics, Mathematical Physics

All lecturer respondents agreed that project-based learning can build students' knowledge, understanding, and skills in learning physics, explaining several reasons, namely because students are directly involved in the problems given by the lecturer, students gain experience in the investigation process to the final product, students will be challenged to complete a tool in completing the application of a theory. There is one lecturer who agrees as long as it is an applied subject, and students have been provided with the required prerequisite knowledge and skills. 5 lecturers stated that they had carried out project-based learning in electricity courses. 1 lecturer stated that he had never. All lecturers stated that they experienced time constraints in implementing project-based learning.

All lecturer respondents agreed that project-based learning can practice physics problem-solving skills. Almost all teaching lecturers in electricity courses have implemented project-based learning. Only L-6 lecturers stated that they had never, but applied inquiry. The type of learning applied to electricity courses is shown in table 2.

Table 2. The Type of learning applied to electricity courses

Learning Type	Lecturer Code
Discovery Learning	L-1, L-2, L-5
Inquiry learning	L-1, L-2, L-3, L-4, L-6
Project-based learning	L-1, L-2, L-3, L-4, L-5
Cooperative learning	L-1, L-2, L-3
Problem-based learning	L-2, L-3, L-4
Problem Solving	L-4

The form of project assignments that have been given by lecturers are summarized as follows:

1. Making instrumentation related to physics topics and student responses that are more enthusiastic in carrying out assignments (L-1).
2. The form of task is in the form of observing static electricity and the student's response is very good because they can directly observe the symptoms of static electricity (L-2)
3. Projects that can be applied to everyday life,
4. Students are given the task of formulating authentic project problems, reviewing alternative solutions, designing project problem solving, making projects, testing projects, presentations/reflections (L-4)
5. It is given in the form of an experiment and done by 4 students in the form of an experimental group. The guide has been prepared (L-5)
6. Provide a student worksheet and in it explores students' abilities to complete a tool

The core idea of project-based learning is real-world problems of student interest, provoking serious thought as students acquire and apply new knowledge in a problem-solving context. [24]. Project-based learning is an educational approach that focuses on creative thinking, problem-solving, and students' interactions with their peers to create and use new knowledge. [7]. The development of project-based learning is carried out to increase the effectiveness of success in its implementation. Research in the area of effective project-based implementation needs to be continued and extended to a wider audience [25]. Facilitating factors in the implementation of project-based learning such as modern digital technology, high-quality group processes, teacher's ability to effectively design lessons, teacher's ability to provide guidance, teacher's ability to provide support, and balance between didactic teaching with harmonized inquiry and assessment methods [26].

Project-based learning can not only increase learning motivation but facilitate problem-solving skills [27]. Project learning can train students to ask questions, think of various ways to solve problems, train students to categorize data, train students to think about things that other people don't think about, and be able to train students in expressing their own opinions on problems [28]. This model can create fun learning so that it generates confidence [29]. Project-based learning provides opportunities for students to appreciate the ability to work together and will further strengthen student relevance, confidence, and satisfaction [30].

All lecturer respondents stated that they experienced problems or difficulties in applying the project-based learning model to the electrical course material, namely time constraints, besides that they were also constrained in designing learning (L-2) and assessing student performance (L-4). Implementation of project-based learning usually takes several weeks, due to the open scenario orientation, students have to search for more information in the literature and choose their strategies, professor guidance is very important as well as non-face-to-face learning [31].

Challenges in implementing project-based learning such as in experiential settings can take days or weeks, cover one standard or many, multiple skills, and multiple disciplines for multiple purposes [32]. Insufficient facilities, time, and insufficient funds as the main inhibiting factors in the project [33]. A further problem is to design a project with an appropriate level of difficulty for students and the authenticity of the project i.e. comparing a real project with a theoretical project [34]. Some of the problems that

arise in project-based learning are that students accept many new concepts and techniques, students are forced to learn, practice, and master the skills needed in a matter of days, and students have fewer opportunities to reflect and absorb the material, and learning experiences [35]. Other limitations are the lack of time for group processing sessions (sessions for members to acknowledge each other's roles, strengths, weaknesses, and contributions to teamwork), and students feeling less confident, afraid, and embarrassed in front of the instructor for guidance [36]

Reflection in the learning process can encourage learning to be more meaningful. Based on the results of the questionnaire filled out by lecturers who teach electricity-related courses, it was revealed that all lecturers had carried out a reflection process, namely asking students to understand their learning experiences and their meaning and rethinking the learning activities that had been carried out. The reflection process in question also provides opportunities for students to express their assessments and feelings related to learning activities, as well as evaluate the strengths and weaknesses of the student learning process. Reflection activities are carried out by Asking students to provide important notes on the material that has been received (L-1), presenting the results of observations (L-2), feedback orally and in writing (L-1), and reflection by giving a questionnaire about the process they are doing, evaluation at the end of the lecture (L-6), a questionnaire about the teaching and learning process that has been carried out (L-2 and L-3), self-evaluation in the learning process (L-2).

The results of the questionnaire on student perceptions of project-based learning in electricity courses are shown in table 3. The percentage of student responses indicates a positive perception of project-based learning. This can be seen from the level of student agreement that project-based learning can improve their knowledge of understanding and skills towards physics, namely strongly agree 50.8% and agree 45.8%. Students also stated their agreement that project-based learning could train them to solve physics problems in their daily lives, namely strongly agree 55.9% and agree 40.7%. They also stated that through project-based learning they gained experience in designing a product and conducting research, as well as providing real experience in the form of knowledge, understanding, and skills about electrical materials.

This is reinforced by the statement of students on the results of an open questionnaire about their experience related to the knowledge, understanding, and or skills obtained in project-based learning, namely, they gain experience in product-making skills, such as microcontrollers, skills in using electronic devices, viscosity testing of a product, Arduino application skills, understands the concept of electromagnetic induction, skills in electrical assembly, skills in using welding tools, drills, and grinders in making waterwheel projects, skills in making simple water pumps, skills in using solder, alternative energy concepts, windmills and water purifiers, skills in making aero-modeling, students understand more about the concept of Bernoulli's Law and its application to aircraft, making environmentally friendly energy, namely bio-battery.

Table 3. Student perceptions of project-based learning in electricity courses

	Statement	Response percentage				
		Strongly agree	Agree	Disa-gree	Strongly Disa-gree	Oth-ers
1.	Based on my experience, the project-based learning model can improve my knowledge, understanding, and skills in physics.	50,8 %	45,8%	1,7 %	1,7 %	
2	Based on my experience, the project-based learning model can practice my skills to solve physics problems in everyday life.	55,9%	40,7%	1,7 %	1,7 %	
3	Learning physics related to electrical courses has given me the experience to design products and conduct research (formulating problems, testing hypotheses, collecting and analyzing data, and making conclusions).	30,5%	59,3%	5,1%	1,7 %	2,4%
4	Designing and making projects in lectures on electrical course materials will give me real experience in the form of knowledge, understanding, and skills	28,8%	66,1%	1,7 %	1,7 %	1,7 %

The summary of student questionnaires regarding the strengths and weaknesses of the project assignments that have been given to them is shown in table 4.

Table 4. Strengths and weaknesses of the assigned project tasks

Strengths	Weaknesses
• Make students more active and succeed in solving complex problems • Adding practical insight, tool-making skills, designing ideas, and realizing them	Lecturer support is limited to ideas, takes a lot of time, lacks publications, lacks assistance, and goals that are not monitored Difficulty applying theory to real life It costs a lot

Strengths	Weaknesses
• Better understand the problem points or characteristics to be researched, gain experience in making products, gain knowledge using new tools, • Understand the best quality of product comparison • Knowing firsthand the application of Physics, • Communication, knowledge, and knowledge between students is wider, • Understand more easily the concept material and gain new experiences • Make learning physics fun • Gaining experience such as making electrical installations independently and making it easier to understand electrical equipment at home, • Gain experience making products such as tesla coil, • understanding of the concepts gained is more immersive, very fun, and gives new experiences and the projects created can be useful for people in need • Lessons are easy to understand with the project, • Gain hands-on experience in creating projects and using tools in projects • Implement an understanding of the material being studied, • Foster collaboration between students, • Gain experience in making products and be able to know the benefits of surrounding materials, • Gain experience in designing tools • The materials used are easy to obtain • Better understand the material.	There are group members who are lazy and lack initiative, Requires patience and sufficient knowledge, takes energy Difficult to design project Weaknesses in using tools during the project Constrained access to equipment Too focused on the project so that we forget about the material or theory that we also need to master. A lot of time wasted thinking about concepts Lack of understanding in project creation Takes a long time to understand how it is made and how it works Difficulty in understanding concepts Difficulty in finding tools and materials The steps for making the project are not well understood The project does not look neat because it uses improvised materials Difficult to design products Limited time, tools, and materials

Strengths	Weaknesses
• Can recycle garbage. • Practice skills in making tools and concepts to become more understandable. • Stimulate creativity.	

Based on an open questionnaire about student obstacles in implementing project-based learning, namely lack of time effectiveness, lack of mentoring or monitoring from supervisors or lecturers, lack of group effectiveness in working on projects, funding problems or project costs, difficulty making project designs, difficulties in understanding and skills in using tools during the project, forgetting to understand the material or theory due to focusing too much on making project products, limited tools, and materials, lack understanding in project making, group members who do not participate.

Students and lecturers stated that the form of project assignments that were easy to do was as shown in table 5. The highest frequency for students is project assignments whose tools and materials are easily found in the student's environment. The lecturer stated that the project assignment that gave students independence in determining the goals, steps, and product forms was an easy project task, totaling 4 people, namely L-2, L-3, L-4, and L-6.

Table 5. Frequency of easy project assignments based on student statements

Statement	Frequency of choice student	Frequency of choice Lecturer
Project tasks whose objectives have been clearly defined	18	L-2,L-3,L-5
Project tasks whose completion steps are available	17	L-1,L-2,L-3,L-5
Project assignments for which tools and materials are readily available in the laboratory	19	L-2,L-3,L-5
Project assignments whose tools and materials are easy to find in the student's environment	31	L-2, L-3
Project assignments related to real-life contexts or related to students' daily lives	30	L-1,L-2,L-3,L-4
Project assignments that give students independence in determining goals, steps, and the form of the resulting product	23	L-2,L-3,L-4,L-6

Based on the closed questionnaire, showed that the student respondents said that the reflective practice in the electricity course had been implemented. This can be seen

from the percentage level of their agreement on each statement related to reflective practice as shown in table 6.

Table 6. Implementation of reflective practice in electrical courses

	Statement	Response percentage				
		Strongly agree	Agree	Disa-gree	Strongly disagree	Other
1.	Learning physics in electricity course material has allowed me to understand the learning experience and its meaning, and to rethink the learning activities that have been carried out	27,1%	64,4%	3,4%	1,7%	3,4%
2.	Learning physics in the electrical course material has provided an opportunity for me to express my assessment and feelings related to the learning activities that have been carried out.	11,9%	74,6%	8,5%	1,7%	3,4%
3.	Learning physics in electrical course material has allowed me to evaluate the strengths and weaknesses associated with learning activities.	15,3%	76,3%	5,1%	1,7%	1,7%
4.	Learning physics in electrical lecture materials has allowed me to search and read literature to increase knowledge and understanding to understand the learning that occurs, finally make conclusions and reach the stage of action plans to formulate new lessons.	28,8%	66,1%	1,7%	1,7%	1,7%

However, when traced using an open questionnaire, students' statements were contradictory where most stated they had never, and only a small part stated that reflection activities were still limited to verbal delivery at the end of the project or learning activities. Reflection activities are expressed through open questionnaires such as conveying the progress that has been achieved and the obstacles faced, presentations so that they get input from the audience, more often suggestions and good learning solutions are given, giving appreciation for the best projects, after completing the products of each student team. Conduct an evaluation related to the learning process and product development process, and was told to make a report, the project task had been completed and was assigned to make a report from the report maker, it was necessary to analyze data and what obstacles occurred and find a solution.

Students tend to recognize and value reflection as a learning tool called reflection for learning [13]. Reflection is suggested as a means to integrate learning into cognitive structures and relate it to prior knowledge [21]. When learners engage with reflective practice they can do so at different levels from superficial reporting to deeper and critical levels [37]. Action-oriented authentic reflection is an active process of self-discovery [38]. Only people who reflect can judge whether learning has occurred that is important to them [39]. Choosing reflective assignments taking into account the level of professional knowledge and previous experience can make it possible to develop students' high-level skills across space and time [40].

Despite the findings stating positive perceptions from students and lecturers about project-based learning, the open questionnaire section revealed several obstacles or weaknesses of project-based learning which are important things to study for further solutions such as lack of monitors from lecturers, and lack of group effectiveness in working on projects. the project, lack of understanding of the material or theory due to focusing too much on making project products, and the presence of fewer participating group members. The process of reflection is still not well conceptualized in learning, although the results show that reflection has been implemented. The reflection activity shows that there are still perceptions that are not stable, for example, there are still respondents who interpret making a project report as a reflection activity or an activity to give appreciation. Of course, it will be more meaningful if students are asked to express their thoughts and feelings about the project that has been done as a reflection. This is an interesting finding for further research to find a good and integrated reflection model in a learning model.

4 Conclusion

The results showed that there were positive perceptions from lecturers and students toward project-based learning in learning. Several reasons were stated by lecturers for supporting project-based learning, namely, students gain experience in the investigation process to the final product, and students will be challenged to complete a tool in completing the application of a theory. A high level of agreement in students' responses to project-based learning can improve their understanding of knowledge and skills in physics. Through project-based learning, they gain experience in designing a product and conducting research, as well as providing real experience in the form of knowledge, understanding, and skills about electrical materials. However, there are obstacles experienced by students in implementing project-based learning, namely lack of time effectiveness, lack of mentoring or monitoring from supervisors or lecturers, lack of group effectiveness in working on projects, project cost problems, difficulty in making project designs, difficulties in understanding and skills in the use of tools during the project, lack of focus on understanding the material or theory, limitations of tools and materials, lack of understanding in project creation, lack of participating group members. Respondents from lecturers also stated that they experienced problems in applying the project-based learning model to the electrical course material, namely time constraints,

besides that they were also constrained in designing learning (L-2) and assessing student performance (L-4). The next research challenge is how to overcome these obstacles in implementing project-based learning.

Reflection is an important process in learning. Based on the closed questionnaire, shows that the student respondents stated that the reflective practice in the electricity course had been carried out. This is contrary to the answers to the open questionnaire where most of the student respondents stated that they had never done reflection activities, and only a small part stated that reflection activities were still limited to verbal delivery at the end of the project or learning activities. Furthermore, it is necessary to optimize the reflective practice in learning so that it can improve students' learning abilities and motivation. The practice of reflection applied to students in the learning process can be done in various ways by asking reflective questions such as what have they learned, what are the learning outcomes they have obtained, how they feel about what they have learned, has their learning process has been going well, if not what can be done to make it better. Reflection practice can also be done by making a reflective journal. Journals as a means of practicing reflection are records of experiences, thoughts, and feelings about certain aspects of life [41].

Evaluation of the implementation of project-based learning and practice of reflection has implications for the next research step, namely trying to develop a project-based learning model by integrating it with reflective practice. It aims to increase the effectiveness of the project-based learning model and make learning meaningful for students. The advantages of project-based learning that have been revealed have the impact that this model can be an option for lecturers in learning physics or electricity courses. The revealed model weaknesses can be used as the basis for research as challenges and opportunities for further development. The learning reflection process revealed in this study is still not conceptualized and has not been integrated into the learning process. In-depth exploration of students' thoughts and feelings about the learning process they have done can train critical thinking, thus encouraging higher-order thinking.

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