

The effectiveness physics learning media courses based on project-based learning to improve students' concept mastery

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Abstract

This study aims to determine the effectiveness of physics learning media courses based on the PjBL approach in improving students' mastery of concepts. This study was conducted at FKIP UHAMKA. The sample used in the study consisted of students from the Physics Education program who took physics learning media courses. This study employed a pre-experimental design method, specifically a one-group pretest-posttest design. The results showed that the application of the PjBL model in physics learning media courses was effective in helping students master their concepts. This is evident from the respondents' post-test results, where the majority reported an increase, with an average score of 79.25, and an N-Gain score indicating an average gain of 95.83%, placing it in the moderate category. The benefit of this study is to determine the level of respondents' mastery of concepts. In addition, the research results provide implications for physics learning that educators must examine the application of the PjBL model broadly, especially on material topics that require a deeper understanding of concepts.

Keywords: Physics learning media, PjBL learning model, Mastery of concepts

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I. Introduction

Physics learning in college often faces challenges in terms of students' mastery of concepts. Many students struggle to understand physics concepts because the material is often abstract and theoretical in nature. Lecture-based learning (teacher-centred), which is dominant in most classes, is often ineffective in facilitating in-depth mastery of concepts. Conceptual mastery is the ability to relate new information or knowledge to existing knowledge and to explain it using one's own words [1]. In addition, conceptual mastery is defined as students' ability to interpret the meaning of the information received, apply their understanding based on existing details, and convey ideas with explanations rich in creativity and innovation [2].

Conceptual mastery in the scientific domain involves a combination of in-depth understanding and elements of the thinking process, such as information about facts, concepts, and steps [3]. Conceptual mastery is a highly relevant ability in the cognitive aspect. Various elements can improve cognitive thinking power, including student engagement in completing tasks, attitudes during the learning process, information processing rate, neurobehavioral connections in the brain, and parental contributions and emotions that impact cognitive abilities [4].

Mastery of the concept learned is one of the elements that helps achieve retention, and reflects student performance in teaching and learning activities [5]. Improving students' conceptual mastery throughout the

learning process can be achieved through cyclical learning. Conceptual mastery involves not only understanding pre-existing concepts but also the process of creating new categories and is an act of discovery or formation [6]. Conceptual mastery plays a crucial role for students, contributing to their development as educators and providing a foundation for improving educational standards. To foster students' understanding of physics concepts, this process can be encouraged through lectures or classroom instruction [7].

Concept mastery consists of seven indicators, namely: 1) explaining; 2) giving examples; 3) grouping; 4) summarising; 5) drawing conclusions; 6) contrasting; and 7) describing [8]. Students' understanding of concepts will increase if combined with science learning. This is due to the need for students to participate directly and make real observations to improve learning outcomes [9]. Mastery of ideas can be strengthened by utilising learning tools that are able to represent actual conditions [10].

Educational tools that support the teaching process are known as learning media, which can increase students' enthusiasm for learning through objects and the environment around them [11]. Learning media can take various forms and serve as a means of information to achieve learning objectives [12]. Learning media should be presented in an engaging manner to motivate students in their learning process [13]. Leveraging the capabilities of contemporary media in education enables the development of high-quality educators who can effectively solve professional problems [14]. Learning tools can also be used to hone critical thinking skills [15].

The use of learning tools should be implemented in all subjects, including physics. In physics, the application of appropriate, effective, and sophisticated learning tools is expected to significantly impact students' ability to understand and absorb the material [16]. In determining media for the learning process, students need to consider several aspects, including: 1) learning objectives; 2) support for teaching materials; 3) availability of learning tools; 4) teacher competence; and 5) suitability to the level of student understanding. [17]. Selecting appropriate media supports the delivery of information more effectively, strengthens understanding, and increases interaction in the learning process.

The implementation of learning tools requires a supportive approach so that students can experience firsthand what they are experiencing, so that learning becomes more effective [18]. One of the educational methods that can be applied is the Project-Based Learning (PjBL). PjBL is a method based on constructivism and focuses on students. The PjBL model provides opportunities for students to actively develop their knowledge and solve problems through activities that produce products [19].

PjBL is an educational approach that focuses on mastering skills essential for life in the modern era by providing students with opportunities to solve challenges and meet community demands through simple and efficient projects [20]. PjBL has been widely used to promote progress in science literacy skills at various levels of education, from elementary school through secondary education and higher education [21]. The PjBL model can encourage students to be actively involved in solving problems in science courses so that they can achieve the expected learning process and results [22]. The application of the PjBL model in physics learning media courses enables students to conduct investigations on a topic. This is because students actively deepen their understanding through methods that focus on research related to important, real, and relevant issues and questions [23].

In learning, the PjBL provides benefits for students' curiosity, participation, problem-solving skills, analytical thinking, and communication skills [24]. PjBL has the following steps: 1) answering direct questions; 2) designing project results; 3) preparing reports; 4) supervising students and project progress; 5) assessing results; and 6) evaluating project results [25]. Based on these steps, students can learn in a more in-depth and comprehensive way [26]. In the PjBL model, when students are involved in personal learning experiences, teachers provide support or guidance to students as they carry out the projects they are working on [27].

Thus, the use of digital media in project-based learning is very important. Digital media provides resources that help students understand lessons better. Technology in project-based learning makes it easier for students to find information and improve their digital skills [28]. Based on this background, the formulation of the problem in this study is how effective the use of PjBL-based physics learning media is in improving students' mastery of concepts and what factors influence the effectiveness of the use of PjBL-based physics learning media in improving students' mastery of concepts.

Therefore, this study integrates the PjBL model in the Physics Learning Media course, which emphasises mastery of physics concepts and the ability to develop learning media. Then, a comprehensive evaluation of the effectiveness of PjBL implementation covers three aspects, including cognitive to measure student concept mastery, affective to measure student motivation and attitudes, and psychomotor to measure student ability in

producing media products. In addition, the analysis of student learning experiences in the application of PjBL in the course is oriented towards the production of learning media.

The contribution of this research is to provide learning innovation in higher education, particularly in improving the quality of prospective physics teachers through the PjBL approach. The PjBL model allows students to develop learning media directly, so they understand the application of physics concepts in real-world contexts and active learning. In addition to mastering concepts, this research also encourages important skills such as collaboration, problem-solving, creativity, and communication. The use of experimental methods, including pre-tests and post-tests, demonstrates a systematic effort to measure effectiveness objectively.

II. Methods

This research employs a quantitative approach with a pre-experimental design. The pre-experimental design method is an approach that cannot be considered a real experiment because there are still additional factors that influence the formation of dependent variables [29]. This study uses a one-group pretest-posttest design because there is only one experimental group that is given treatment in the physics learning media lecture process based on PjBL. The one-group pretest-posttest research design is shown in Table 1.

Table 1. One group pretest-posttest research design

Group	Pre-test	Treatment	Post-test
Experiment	O1	X	O2

The variable X represents students who were taught the physics learning media course using a Project-Based Learning (PjBL) approach. The symbol O1 refers to the group of students who were given a pre-test before the implementation of the learning intervention, while O2 represents the group of students who were given a post-test after the learning activities. This design allows for measuring changes in students' understanding or skills as a result of the PjBL-based instruction.

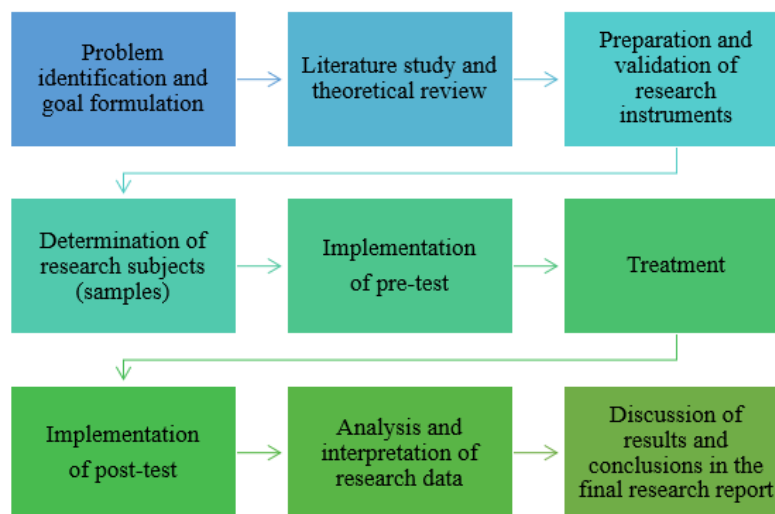


Figure 1. Research flow diagram

The population of this study was students of the Physics Education Study Program in the 2024/2025 Academic Year. The sample in the study, namely students of the Physics Education Study Program, was selected learning a simple random sampling technique because the sampling came from members of the population, which was carried out periodically without looking at the population layer [30].

This study used an essay test to measure students' conceptual mastery. The essay test consisted of 10 questions that matched the skill indicators. The essay test assessed students' understanding of media use in the context of physics learning. The test was administered twice: before and after the lesson. The instrument developed for this study was the result of the researcher's analysis based on several previous findings.

The data analysis techniques used were descriptive statistical analysis and effectiveness testing using the N-Gain test. The formula for calculating the N-Gain test is as follows:

$$N\text{-Gain} = \frac{\text{Post-test score} - \text{Pre-test score}}{\text{Ideal score} - \text{Pre-test score}} \times 100\% \quad (1)$$

Then, the N-Gain test results are interpreted with the following criteria:

Table 2. N-Gain value criteria table

Treatment	Post-test
≥ 0.07	High
0.30 – 0.70	Medium
0.00 – 0.29	Low

This study is expected to produce findings that show that the use of PjBL-based learning media can improve students' mastery of physics concepts. In addition, this study is also expected to identify factors that influence the effectiveness of PjBL, such as student involvement, media quality, and support from lecturers.

Furthermore, the learning stages in the PjBL-based physics learning media course are as follows: 1) answering direct questions, namely, the lecturer explains the function of media in the physics learning process and shows several examples of creative media. Students observe the problems faced when understanding physics concepts so that they obtain the formulation of project problems and the objectives of developing physics learning media; b) designing project results, namely students compile project designs in accordance with physics concepts that are developed in a structured and collaborative manner; c) preparing a report, namely students prepare a complete project proposal and according to the lecturer's instructions; d) guiding students and project progress, namely the lecturer and students agree on consultation times, progress evaluations, and progress presentation targets. Then, the lecturer monitors the media creation process, provides input related to physics concepts, instructional design, and media creation techniques; e) assessing results, namely students present project results, and the lecturer assesses the suitability of the project with the initial concept and tests the usefulness of the product when used. Projects developed by students must go through an expert validation stage; and f) evaluating project results, namely the lecturer provides a final evaluation based on the results of student presentations regarding the projects developed through an assessment rubric. Additionally, other students can offer constructive feedback on the projects developed.

Targeted achievement indicators: 1) increased mastery of student concepts after taking the PjBL-based physics learning media course; and 2) utilisation of the results of the physics learning media project developed by students. This research was conducted by one lecturer as the Chief Proposer and research members consisting of one lecturer and two students.

III. Results and discussion

Based on the students' pre-test scores, the results of the descriptive statistical calculations were obtained, which are shown in Table 3.

Table 3. Frequency distribution table of students' pre-test scores

Treatment	Pre-test
N	24
Mean	57.83
Median	60.00
Mode	60
Standard Deviation	4.488
Minimum	50
Maximum	63

Table 3 shows that the respondents' pre-test scores have an average value of 57.83 with a median value of 60.00. Then, the data has a mode value of 60 and a standard deviation value of 4.488. The highest score in the data is 63, and the minimum score is 50. The results of the descriptive statistical calculations that have been carried out are interpreted in the form of a histogram, as in Figure 2.

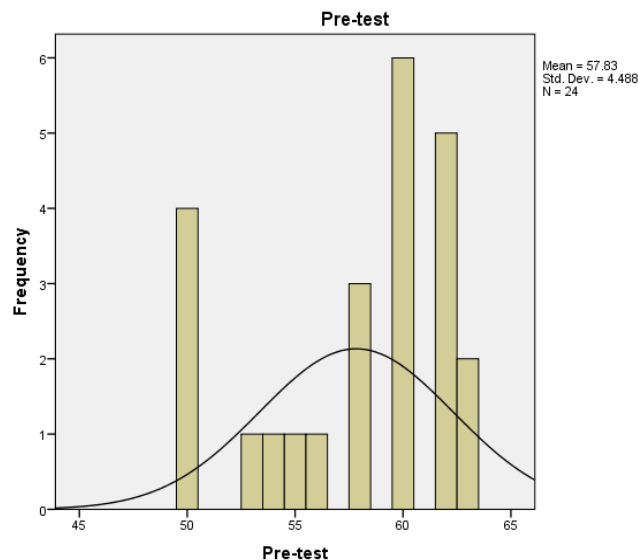


Figure 2. Histogram of student pre-test scores

From the Figure 2, it can be seen that 24 students who had not received treatment using the PjBL model in the physics learning media course had an average score of 57.83 with a standard deviation of 4.488.

Next, students take a physics learning media course based on the PjBL model for one semester. At the end of the meeting, each student makes one product with a different theme. The resulting product is presented to the lecturer and friends and uploaded to the public via each student's YouTube Channel. This aims to introduce physics learning media to the general public and can be implemented well as a learning support tool.

An example of the results of student products is shown in Figure 3.

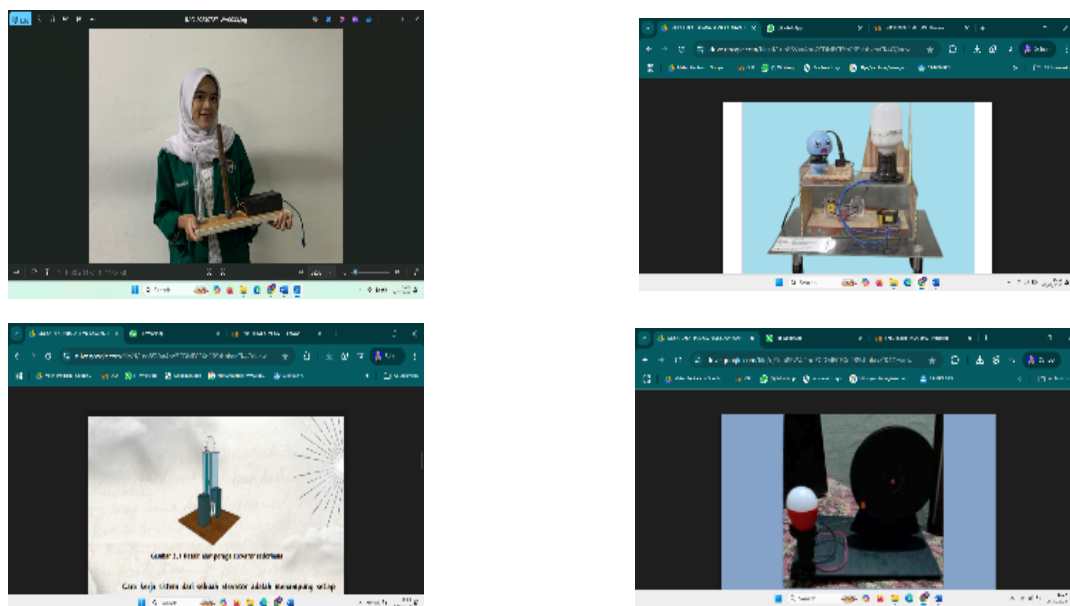


Figure 3. Student product results

After that, students were given a test to see the post-test score on the mastery of the concept of the learning media created. Based on the students' post-test scores, the results of the descriptive statistical calculations are presented in Table 4. Table 4 shows that the respondents' post-test scores have an average value of 79.25 with a median value of 80.00. Then, the data has a mode value of 80 and a standard deviation value of 4.646. The highest score in the data is 85, and the minimum score is 70. The results of the descriptive statistical calculations that have been carried out are interpreted in the form of a histogram, as in Figure 4.

Table 4. Frequency distribution table of students' post-test scores

Treatment	Post-test
N	24
Mean	79.25
Median	80.00
Mode	80
Standard Deviation	4.646
Minimum	70
Maximum	85

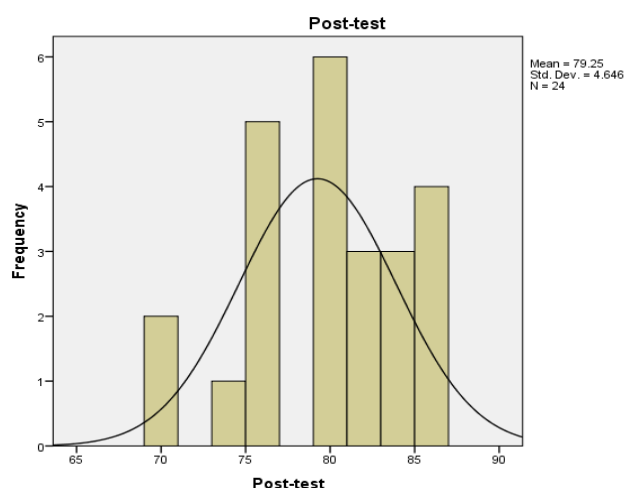


Figure 4. Histogram of student pre-test scores

From the Figure 4, it can be seen that 24 students who were given treatment using the PjBL model in the physics learning media course had an average score of 79.25 with a standard deviation value of 4.646.

Then, all pre-test and post-test scores obtained by respondents were tested using the normalised Gain equation (N-Gain) to determine the extent of the increase in concept mastery that occurred. The results of this score calculation are shown in Table 5.

Table 5. Results of respondents' N-Gain calculation

Category	Frequency	Percentage
High	1	4.17%
Medium	23	95.83%
Average Score	0.5	

According to Table 5, one respondent, or 4.7%, reported an increase in mastery of physics concepts in the high category. Meanwhile, 23 other respondents, or 95.83%, had an increase in mastery of physics concepts that fell into the moderate category. The average increase in concept mastery experienced by respondents was 0.5, indicating a moderate level.

Based on Figure 5, it is observed that the N-Gain score in the high category has a score of 0.7. Then, the N-Gain value that has the most frequency is in the medium category with a score range of 0.3 to 0.6. Figure 6 shows that the N-Gain value with the medium category has a higher average percentage (95.83%) than the other two categories, where the low category has an average percentage of 0% and the high category has an average percentage of 4.17%. So the overall average percentage is 33.33%. Therefore, the results of the study indicate that there is an increase in students' mastery of physics concepts in physics learning media courses based on the PjBL.

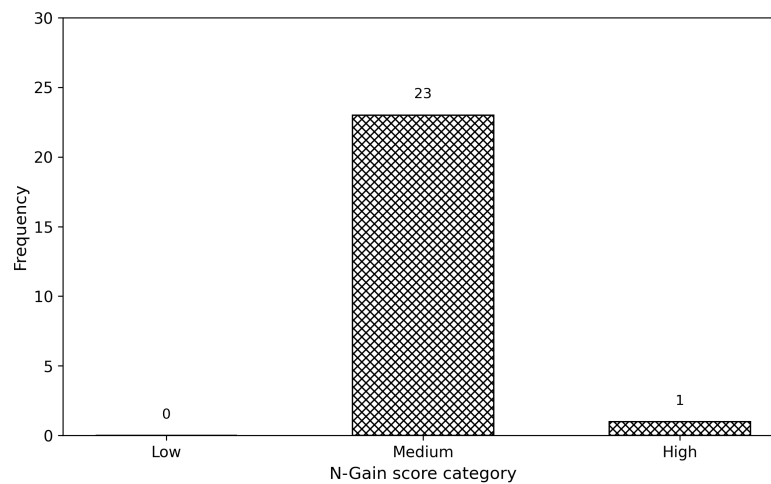


Figure 5. Frequency diagram of respondents' N-Gain scores

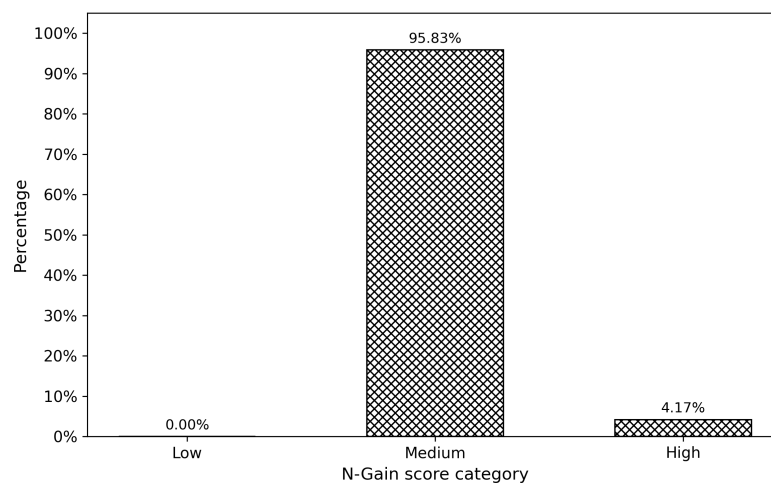


Figure 6. N-Gain score percentage diagram

Based on these results, the application of the PjBL model in the physics learning media course was quite effective in improving students' mastery of concepts. This can be seen from the results of the post-test, which showed that most respondents experienced an increase, with an average score of 79.25. In contrast, the average score of respondents before receiving treatment was 57.83 (pre-test). Based on the N-Gain scores obtained, one respondent had an average increase in the high category, and 23 other respondents had an average increase in the moderate category. Furthermore, from all respondents, the highest N-Gain score was 0,7 and the lowest N-Gain score was 0.33. Thus, lectures on physics learning media courses based on PjBL can provide students with effectiveness in mastering their concepts. This aligns with research conducted by Sonia [18] that found that implementing a Project-Based Learning model effectively improves students' understanding of physics concepts. This occurs because students actively participate in real-life projects, honing their critical thinking and collaboration skills while connecting physics concepts to everyday applications.

IV. Conclusions

Based on the research results, the application of the PjBL model in the Physics Learning Media course has proven effective in improving students' mastery of concepts. Through the PJBL approach, students are more actively involved in the learning process, starting from planning, project implementation, and presentation of learning media work results. This involvement encourages a deeper understanding of physics concepts because students are faced with real applications of the material being studied. In addition, project-based learning also improves students' critical thinking skills, creativity, and collaboration. Thus, PJBL can be used as an

alternative relevant learning approach to strengthen the mastery of concepts and professional competence of prospective physics teachers in the future.

It is hoped that the research conducted can be integrated into learning with the help of interactive media through the utilisation of local resources. Furthermore, the learning model used can be combined with other approaches according to the ongoing learning conditions. However, this study has limitations, specifically that the results may only apply to a particular population or sample. If this research is conducted in the short term, it may not necessarily reflect the long-term impact of PJBL on student concept mastery. Implementing PJBL requires intensive planning and guidance. Not all lecturers and students are prepared to face this paradigm shift, which can be a significant obstacle to its implementation.

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