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The Influences of Project-based Learning (Pjbl) Model on the Scientific Creativity of Physics Education Undergraduate Students at Madura Islamic University

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Scientific creativity is a skill needed in the 21st century. 21st-century skills are known as 4C skills, one of which is being creative to produce innovative work to answer the challenges of the Industrial Revolution era 5.0. The Project-based learning model is a learning model that can guide students to increase students' scientific creativity through a series of questions that direct and explore students' scientific knowledge and creativity. This researches used a quasi-experimental research designs with 36 students divided into control classes and experimental classes. This research aims to see how much influence the PjBL learning model has in increasing the sciece creativity of students on physics subjects in term of the implementation of the model and the influence of the PjBL model. The instruments used to obtain data were essay test questions for pretest and posttest, and observation sheets to observe the implementation of learning in class. All test questions have been validated by experts and tried out to test the reliability of the questions, degree of difficulty, and differentiating power of the questions using the ANATES Essay Questions application. Concept mastery data (posttest) was analyzed by hypothesis testing (t-test) using the SPSS application. The research results show that (1) using the Project-based learning model significantly influences students' mastery of physics concepts. A significance value of 0.031 (Sig < 0.05) was obtained at the 95% confidence level. (2) The implementation of the project-based learning model accompanied by probing prompting techniques is included in the excellent category. This has implications for students' attitudes which tend to be positive in responding to learning using the PjBL model.

Keywords: Scientific Creativity; Project based Learning

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INTRODUCTION

Universities have a very important role in preparing prospective physics teachers to adapt to technological advances in the era of the Industries Revolution 5.0.In that era, human life was inseparable from technology. Prospective physics teachers need to be equipped with the skills needed in the 21st century (Broks, 2020; Sikhakhane, 2020). These four skills are in accordance with the 21st-century learning framework needed by students as prospective physics teachers, namely creativity and innovation, critical thinking and problem-solving, communication, and collaboration (4C). The 21st-century learning framework must meet the development of skills and knowledge to achieve success when reaching the professional zone. The 21st century learning framework includes: 1) core subjects for the 21st century theme, 2) learning and innovation skills, 3) information skills, related to media and technology, and 4) life and career skills (Ilma, 2021; Rahayu et al., 2022; Wibowo, 2023).

Scientific creativity is crucial in shaping the nation's future as a provision for future success (Prahani et al., 2021). *Scientific creativity* is a specific domain that is important for the progress of a nation. Individuals with scientific creativity are more capable of developing original, practical, and unique scientific ideas (Siew & Chin, 2018). Creative scientific ideas are built from extensive theoretical, technical, and experimental construction processes (Hu & Adey, 2002). Scientific ideas produced by students must be supported by correct mastery of concepts. Concepts in physics learning are related to each other, and the relationship of concepts in physics to each other will form a cognitive structure (Lee & Park, 2021). Scientific creativity is emphasized on indicators of skills in understanding science phenomena scientifically, developing scientific knowledge creatively (advances science knowledge), skills in solving creative science problems (Science problems), improving the quality of a product (technical product), being able to design creative products (creative science product design capability) (Hu & Adey, 2002).

The rapid development of technology cannot be separated from the development of science, especially physics, one example of which is the discovery of airplanes, rockets, steam engines, and so on. Great discoveries regarding technology cannot be separated from the creativity of the inventor. Discoveries related to physics provide great benefits in the lives of the wider community. Innovative discoveries are the result of scientific creativity in the form of ideas or technological products to provide convenience to humans (Intelligence & Bank, 2014). Therefore, scientific creativity is considered very important to be taught, especially to prospective physics teachers who will later provide examples of how to become a creative person and produce an innovative product. Increasing scientific creativity in the physics learning process can be done through activities; 1) projects, investigations involving scientific creativity as a scientific process, 2) understanding, involving students in understanding knowledge creatively, 3) presentations, involving students building knowledge obtained from the results of in-depth study of physics material and sharing the results of creative ideas (products) with other people, 4) facilitate students in finding new ways in planning activities, designing products, designing products, and improving product quality technically (Ayas & Sak, 2018; Suyidno et al., 2017).

Learning carried out in schools must equip students with abilities covering three domains: attitudes, knowledge, and skills. In the realm of expertise, the 2013 Curriculum recommends the formation of graduates who have factual, conceptual, procedural, and metacognitive knowledge at a technical, specific, detailed, and complex level in science, technology, arts, and culture with insight into humanity, nationality, statehood, and civilization related to phenomena and events in specific work fields. Therefore, conceptual knowledge must be developed in learning at school (Aswegen et al., 2019).

Scientific creativity in physics subjects In particular, it is not enough for students to just read references such as books or just listen to explanations from teachers, students must be able to observe and discover how a phenomenon can occur through appropriate, clear procedures and steps. and interesting in presenting learning. Apart from that, to find out students' scientific creativity in studying physics, students must build their knowledge in their minds (relevant experience), and search for and find for themselves the meaning of everything they will study. According to Jatmiko's statement (Prahani, 2023; Siswanto & Susantini, 2012), students should be trained to find learning information independently and actively create cognitive structures in interaction with their environment. It will have an impact on scientific creativity, and students' memories of what they learn will last longer (Wicaksono, 2020).

Along with the development of learning models, several models prioritize student activity and generate learning motivation. In this case, students are required to be more active because this is an opportunity for students to find their thoughts and ideas in the learning process in class. Meanwhile, the role of the teacher is as a motivator, facilitator, inspirer, and mediator, and also acts as a director for the smooth continuity of the learning process. One of them is the Project-based learning model, namely discovery-based learning (Rusmini et al., 2020; Sena, 2020). When using PjBL, the direct experience experienced by students will attract students' attention and enable the formation of abstract concepts, easier absorption of material, and increased motivation. increased, as well as more realistic and meaningful learning (Wijayati et al., 2020) Project-based learning is also effective in helping students construct their understanding and knowledge (Fatonah et al., 2023). The syntax of the Project-based learning model is (1) Start with essential questions, (2) Design a Project Plan, (3) prepare an activity schedule, (4) overseeing the progress of the project, (5) assessing results, and (6) evaluating experience (Fikri et al., 2019).

Based on the results of observations and interviews conducted by researchers with several lecturers from the Pamekasan Physics Education Bachelor's study program, it was found that the learning taking place had implemented several learning models according to the 2013 curriculum, but the students' scientific creativity had not been maximized. This happens because students who are slow in the thinking process will tend to be confused in understanding and solving every problem given by the teacher related to the material being taught, while smarter students will tend to monopolize the learning process in class.

To balance the learning atmosphere in teaching and learning activities, aside from choosing the suitable learning model, student creativity has an essential role in the learning process. Therefore, several previous researchers presented the results of their research in terms of solving problems. However, in this research students are not only able to solve problems but must have creative ideas of a scientific nature to produce work that is original and has contribution value to science. This is a differentiator from previous research (*Novelty Research*). Scientific creativity is already popular in science learning, but there is still no in-depth research regarding learning models that will influence its components. In this research, researchers used Scientific Phenomena to identify the syntax of the PjBL learning model that has not trained students' scientific creativity. The aim of this research is the influence of the PjBL model on students' scientific creativity. Therefore, researchers are interested in researching the influence of learning models that can increase students' scientific creativity.

METHOD

This type of this research is quasi-experimental with a nonequivalent control group design. Sampling was taken by purposive sampling, which obtained class A as the experimental group and B as the control class in Table 1.

[Table 1 about here.]

This data collection with technique used in this research are tests based on scientific creativity, observation using learning implementation observation sheets, and documentation in the form of a list of student names, student pretest-posttest scores, and photos of learning activities. The research procedure starts with a preliminary study, compiling an instrument. Determine the validity and reliability of the instrument, carry out the pretest, carry out learning, and carry out the posttest. Data analysis uses the t-test with the help of the SPSS 2021 application and percentage of learning implementation. The objectives of this research are (1) To determine whether or not there is an influence of the PjBL learning model on the scientifice creativity of students in the Physics Education Study Program at the Islamic University of Madura, (2) To determine the implementations of the Project-based learning model. This research was conducted on students of the physics education study program or students of the biology education study program taking basic physics courses at the Islamic University of Madura. The scientific creativity test is first carried out by a validation test by experts in the field and then analyzed and matched with the assessment criteria in Table 2.

[Table 2 about here.]

The scientific creativity test is carried out before learning using the PjBL model, and after learning using the PjBL model, the scientific creativity test refers to indicators of fluency, flexibility and originality. This test instrument consists of five description questions related to basic physics material. Next, the pretest and posttest results were tested differently using the t-test to determine the significance of the differences in the results of the posttest and pretest.

Normallity test

To find out the normality of the sample, I used the Liliefors test with the equation.

$L_0 = F_{zi} - S_{zi}$

Information:

F_{zi} = opportunity Zi

Szi = Proportion Zi

The sample is said to be normally distributed if $L0$ is smaller than the L Table with a significance level of 0.05 and N=80 ((Inayah et al., 2020).

RESULT AND DISCUSSION

The pretest and posttest data management result for each class obtained an average value of concept mastery, as in Table 3-4.

[Table 3 about here.]

Preliminary research conducted by researchers using scientific creativity components from (Hu & Adey, 2002) is shown in Table 1.1 above. The highest fluency scores come from flexibility and originality, while the flexibility and originality scores are still relatively low. One example of a fluency score for product improvement 3.3 is that each student only wrote 3.3 out of 4.0 ways to improve the product. The score for designing and developing products creatively was 1.3 out of 4.0, which means students gave incomplete answers because they were still far from the maximum score of 4.0. Other preliminary research conducted by (Wicaksono, 2020) stated that students' scientific creativity still needs to improve, especially in the indicators of flexibility and originality. The same thing was done by (Suyidno et al., 2017). Most students need help with using physics knowledge to solve real-life problems, improve product quality, and design products creatively. The low scientific creativity of students in basic physics courses is one of the researchers' concerns about finding out what needs to be improved. Therefore, researchers are trying to change the learning model towards scientific phenomena and produce creative products.

After being given treatment in the experimental and control classes, a posttest was carried out to see the effect of the

PjBL learning model in increasing students' scientific creativity. Before carrying out the t-test, a Normality test is first carried out, as in Table 2. After obtaining the data, prerequisite data analysis tests are carried out, namely the normality and homogeneity tests. If it meets the requirements, then proceed to the t-test.

[Table 4 about here.]

Based on the results of the normality test in Table 2, the significant value was greater than 0.05 (sig>0.005). So, the pretest and posttest data for the experimental and control classes were usually distributed. Furthermore, the homogeneity test was carried out, as shown in Table 5.

[Table 5 about here.]

Based on the variance homogeneity test results in Table 4, the sig value is > 0.05; it can be concluded that the control class and experimental class students come from the same variance population or that the two classes are homogeneous. Based on the prerequisite tests, it was found that the data on students' mastery of physics concepts was normally distributed and homogeneous, so a paired sample t-test ware carrieded out. The results of the t-test are in Table 6.

[Table 6 about here.]

Table 6 shows that the significance value (Sig) of 0.031 on the scientific creativity data of physics students is less than 0.05. This shows a significant influence of the PjBL learning model on students' scientific creativity. The thickness above shows the difference in the pretest and posttest results to measure students' scientific creativity. The activity-based physics learning model has a positive impact on increasing students' knowledge, so that student learning outcomes experience a good improvement. The results of the research are in accordance with research conducted by previous researchers which stated that physics learning should focus on students, so that students have the opportunity to explore their knowledge (Fatonah et al., 2023; Prajoko et al., 2023; Suyidno et al., 2017). A summary of the results of the implementation of learning can be seen in Table 7.

[Table 7 about here.]

Based on the table above, the implementation of learning in the control class was obtained on average 86.5%. In contrast, for the experimental class, the average was 91.5%, with a good category in each class. The percentage difference is because in the control class, the students were less enthusiastic and learning was only focused on the students, this gave students less creative space. Student creativity will be maximized if students are given responsibility in their learning process (Ayas & Sak, 2018; Suyidno et al., 2017). Other researchers also expressed the same thing, stating that creativity must be supported by a good learning process, a good learning process if students can solve their own problems without any coercion from outside parties (Siew & Chin, 2018). To support a good learning process, one of the models used by teachers is more dominant in student activities (Wibowo, 2021).

CONCLUSION

Based on the discussion and analysis of the research data described, it can be concluded that: (1) There is a significant influence of the PjBL learning model accompanied by probing prompting techniques on students' mastery of physics concepts. (2) Implementing the PjBL model learning is included in the excellent category.

RECOMMENDATION

Suggestions that can be put forward in this study include (1) In applying the PjBL model accompanied by the probing prompting technique, the number in the group should be manageable because students will tend to do other activities outside the group. (2) Teachers can apply the Project-based Learning model accompanied by probing prompting techniques on other subject matter.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

LIST OF TABLES

TABLE 1 / Research Design Nonequivalent Control Group Design

Sample	***Pretest***	**Treatment**	***Posttest***
Exsperiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

(Sugiyono, 2013)

Information:
O_1 = *Pretest in the experimental class.*
O_2 = *Posttest in the experimental class.*
O_3 = *Pretest in the control class.*
O_4 = *Posttest in the control class.*
X_1= Treatment with a Project-based learning model based on scientific creativity
X_2= Treatment with the Project-based learning model.

TABLE 2 / Test Instrument Validation Criteria

Score Range	Assessment criteria
3, 51 – 4,00	Very Good
2,60 – 3,50	Good
1,70 – 2, 59	Not Good
0,00 – 1, 69	Very Not Good

Adapted from Ratumanan & Laurent in (Inayah. Et.al, 2020)

TABLE 3 / Scientific Creativity Pretest Scores in UIM Madura Physics Education Study Program

NO	Components of scientific creativity	Average score of students' scientific creativity			Amount
		Fluency	***Flexibility***	***Originality***	
1	*Advances sciencetific knowledge*	3,2	2,2	0,5	5,9
2	*Sciencetific problem*	3,5	2,5	0,7	6,7
3	*Technical product*	3,3	1,6	0,3	5,2
4	*Understanding science phenomena*	3,2	0,8	0,5	4,5
5	*Science problem solving*		0,7		0,7
6	*Imagination design a bility*		1,3		1,3
	Total	**13,2**	**9,1**	**2,0**	

TABLE 4 / Summary of Normality Test Results

Group	Sig	Conclusion
Pretest Exsperiment	0,132	Normal
Posttest Exsperiment	0,200	
*Pretest C*ontrol	0,138	
*Posttest C*ontrol	0,200	

TABLE 5 / Summary of Homogeneity Test Results

Tes	Sig	Keterangan
Pretest	0,922	Homogen
Posttest	0,629	Homogen

TABLE 6 / Summary of the T-test

Hasil	t	Sig
Pengaruh Kreativitas ilmiah	2,208	0,031

TABLE 7 / Summary of Learning Implementation

Observed Aspects	**Percentage**	
	Exsperiment	**Control**
Introduction	100%	100%
Core activities	82,50%	82,50%
Closing	100%	87,50%
Time management	75%	75%
Observation of class conditions	100%	87,50%
Average	**91,5%**	**86,5%**
Category	**Good**	**Good**