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The Effect of Project Based Learning (PjBL) Model on Science Process Skills and Student Cognitive Learning Outcomes

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Abstract

This study aims to describe and explain the differences in science process skills and cognitive learning outcomes between students who learn using Project Based Learning (PjBL) and conventional learning in science subjects. This type of research is a quasi-experiment with a matching pretest-posttest control group design. The population in this study is all grade VIII students of SMPN 1 Marga, Tabanan Regency, for the 2022/2023 academic year—research sampling based on class matching techniques. The research instruments are observation sheets of science process skills and cognitive learning outcomes tests. The data in this study is in the form of students' science process skill scores and cognitive learning outcomes scores, which are analyzed based on descriptive analysis and the Multivariate Analysis of Covariance (MANCOVA) test. The results showed that: (1) simultaneously there are differences in science process skills and cognitive learning outcomes between students who learn using Project Based Learning (PjBL) and conventional learning in science subjects, (2) there are differences in science process skills between students who learn using Project Based Learning (PjBL) and conventional learning in science subjects, and (3) there are significant differences in cognitive learning outcomes between students who learn using Project Based Learning (PjBL) and conventional learning in science subjects. The students who learned using Project Based Learning (PjBL) showed that science process skills and cognitive learning outcomes in science subjects were superior to those who learned with conventional learning.

Keywords: Cognitive Learning Outcomes, Conventional Learning, Project Based Learning Models, Science Process Skills

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INTRODUCTION

Science and technology in the fourth industrial revolution era are rapidly developing in various sectors of human life. One sector that is influenced is education (Aspi, 2022) Efforts to improve the quality of education can be carried out through the development of the curriculum in Indonesia (Uliatunida, 2019) The developed curriculum prioritizes the preparation of quality human resources (HR) (Murniyati & Winarto, 2018) The education system in Indonesia currently uses the 2013 Curriculum which mandates active participation of students in the learning process (Triwiyanto, 2022) The 2013 Curriculum focuses on the importance of achieving knowledge, attitudes, and skills competencies as well as character (Makaborang, 2019). The success of curriculum implementation is due to students, teacher roles, economic conditions, facilities, infrastructure, and the environment (Suhandi & Robi'ah, 2022). The success of a curriculum is highly determined by the quality of learning carried out by teachers to achieve educational goals (Anton & Usman, 2020).

There are still problems in the field of education in Indonesia that affect the achievement of planned educational goals One of the problems in the field of education is the low quality of teachers in terms of their ability to apply innovative learning models (Kurniawati, 2022). The implementation of inappropriate learning methods will affect the suboptimal learning outcomes and the development of students' skills (Ulhaq et al., 2020).

In the era of the implementation of the 2013 Curriculum, conventional learning implementation centered on teachers with students as listeners tasked with memorizing the given material is still found (Lestari et al., 2021). Conventional learning results in low student involvement, causing them to become bored following the learning process (Harahap et al., 2022). The factors causing this are changes in students' learning styles due to the Covid-19 pandemic, teachers' inability to design learning with science skills processes that lead students to be active, creative, and innovative in solving every problem, and the lack of laboratory facilities to support science learning (Zakiyah et al., 2022).

Conventional learning presented by teachers through lectures, demonstrations, and solving problems has an impact on passive learning by students, limited student activities, and indirectly affects the development of science skills and student learning outcomes cannot be optimally developed (Rahman, 2022). Teacher-centered learning does not provide direct experience for students to actively seek and discover answers to a question, thus not training students' science skills (Djufri & Ardhian, 2019).

The innovative learning model recommended for use in the 2013 Curriculum to improve science skills is the Project Based Learning (PjBL) model PjBL is a learning process that focuses on students to prepare them to face various real-world problems (Bakar et al, 2019). PjBL is a model that prioritizes contextual learning by involving students in complex tasks that reflect real-world situations (Sudarjat et al., 2022). PjBL is a model that exposes students to problems and uses projects as the core of learning (Sulisworo, 2020).

In the research results of Andini & Fitria (2021), the implementation of PjBL showed that in the stage of determining essential questions, students asked very simple problems in the sense that their solutions could be done in a very short time, and conversely, students asked problems that were too complicated to be solved through a project. The implementation of PjBL carried out by Indrawati et al. (2022) did not provide significant results in the project design stage; according to him, this was because students were not yet able to independently determine a project to solve the problems that arose. The research results of Pratiwi et al. (2020) have not shown optimal results in applying PjBL in developing science process skills because students still have difficulty in project planning, so the products produced have not been able to solve the problems faced fully. Other research conducted by Wibowo (2022) did not obtain optimal results in the stage of communicating project results in the form of reports; students did not structure the preparation of reports, so the data on the results of product creation and use were not well described. This is a weakness in the implementation of PjBL, especially in the development of science process skills of students as reflected in the results of the stages of PjBL application.

The process skills in learning science are basic abilities to acquire knowledge about scientific products (Suja, 2020). According to Sakdiah et al. (2018), the optimal learning achievement of students is facilitated by the cultivation of process skills during the learning process. The low level of science process skills in science learning is due to students not properly using experimental tools and materials to complete tasks and being less careful even though the teacher has explained the procedure (Darmawansyah, 2012). Low science process skills are indicated by most students being able to provide data in the form of tables but still lacking the ability to communicate project results (Wahyuningsih & Fatonah, 2021).

Scientific knowledge is an important aspect of science education and developing science process skills. Learning outcomes are formed through reciprocal relationships between the learning process and teaching actions (Dimyanti et al., 2009). Student learning outcomes are related to knowledge (cognitive), attitudes (affective), and skills (psychomotor) that result from active interaction with the environment (Sutianah, 2022). Several variables contribute to low learning outcomes One problem is the use of learning models that are not in line with the characteristics of the subject matter and the characteristics of individual students. This was proven by Apsari et al. (2020) through their research, which showed that students perceive science lessons as difficult because they are still memorization-based and teachers still use conventional teaching methods. Thus, the quality of student learning becomes low. Sitompul et al. (2020) conducted a study that showed low learning outcomes because students only played a passive listening role, which caused boredom in the following lessons. Other studies also stated that student learning outcomes were included in the low criteria in terms of every learning outcome domain (Kusumadewi et al., 2022; Mahardika et al., 2022; Parwasih & Warouw, 2020). Therefore, teachers should apply the appropriate learning model according to the characteristics of students in the class to improve learning outcomes (Sholekah, 2020). In addition, the cause of low student learning outcomes is due to the teacher's approach to learning always being oriented towards solving problems, conventional learning models, and teachers competing to complete material just to meet the curriculum target (Sutrisna & Sasmita, 2022). The teacher has a role in optimizing learning outcomes in all learning domains by creating an active and quality learning atmosphere using appropriate learning models or methods (Narut et al., 2019).

Based on the comparison between the theoretical foundation and empirical study of the PjBL model, the author conducted an experimental study to assess the effect of the PjBL model by involving variables of science process skills and junior high school science learning outcomes.

METHODS

This research is a type of quasi-experimental research. The research design used is a non-equivalent pretest-posttest control group design. Furthermore, both research classes give a pretest and posttest after treatment. The experimental class is taught using Project-Based Learning (PjBL), and the control class is taught using conventional learning.

The population of this study consists of all eighth-grade students of SMP Negeri 1 Marga, Tabanan, totaling 128 people spread across four classes. The sample selection process or sampling strategy used for the experimental and control classes uses cluster random sampling techniques. The population consists of four classes; two random classes are selected as the experimental class, and the other two classes become the control class. The experimental class applies the PjBL model, while the control class applies conventional learning.

RESULTS & DISCUSSION

General Description of Research Results

Cognitive learning outcomes of experimental and control class students measure the variable of cognitive learning outcomes in science lessons. Data from observations of students' science process skills are presented in Table 1.

Table 1. Results of Observation of Science Process Skills

Results	Observation of Science Process Skills	
	Experimental Class	Control Class
Average	82,59	74,36
Standard Deviation	3,727	3,736

The results of descriptive data analysis indicate that the science process skills of students taught with the experimental proof method in the experimental class are higher than the science process skills in the control class taught with conventional learning methods Cognitive learning outcomes data before (pretest) and after (posttest) are presented in Table 2.

Table 2. Early and Late Cognitive Learning Outcomes

Results	*PjBL Model*		Conventional Model	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Average	53,28	84,32	53,65	75,52
Standard Deviation	8,698	7,961	8,903	8,083

The descriptive data analysis shows that the cognitive learning outcomes of the experimental group posttest participants who were given the PjBL model showed superior cognitive learning outcomes compared to the control class given the conventional learning model. Participants were taught with the PjBL model with a pretest score of 53,28 and a posttest score of 84,32. Participants taught with conventional learning obtained a pretest score of 53,65 and a posttest score of 75,52.

Description of Science Process Skills Data Based on Learning Models

The observation results of science process skills are presented in the form of frequency distribution and percentage, the value of science process skills of students in the PjBL model is presented in Table 3.

Table 3. Frequency Distribution and Percentage Value in the PjBL Model

Score Interval	Category	Experimental Class	
		fo	Percentage (%)
81 – 100	Very Good	43	67,19
61 – 80	Good	21	32,81
41 – 60	Good Enough	0	0,00
21 – 40	Not Good	0	0,00
0 - 20	Very Not Good	0	0,00
Sum		**64**	**100**

Table 3 shows that the science process skills of students taught with the PjBL model have the highest frequency and percentage in the very good category with 43 students and a percentage of 67,19%. Students with science process skills in the good category are 21 people with a percentage of 32,81%, and there are no students with a frequency and percentage of good enough, less good, and very bad. The results of observations of science process skills in the form of frequency distribution and percentage of KPS values in conventional learning are presented in Table 4.

Table 4. Frequency and Percentage Distribution Value in Conventional Learning

Score Interval	Category	Control Class	
		fo	Percentage (%)
81 – 100	Very Good	2	3,12
61 – 80	Good	62	96,88
41 – 60	Good Enough	0	0,00
21 – 40	Not Good	0	0,00
0 - 20	Very Not Good	0	0,00
Sum		**64**	**100**

Table 4 shows that the science process skills of students taught with conventional learning have the highest frequency and percentage in the very good category with 2 students and a percentage of 3,12%. Students with science process skills in the good category are 62 people with a percentage of 96,88%, and there are no students with a frequency and percentage of fairly good, low, and very poor. Next, a comparison graph of the science process skills of students taught with the PjBL model and conventional learning is presented, which can be seen in Figure 1.

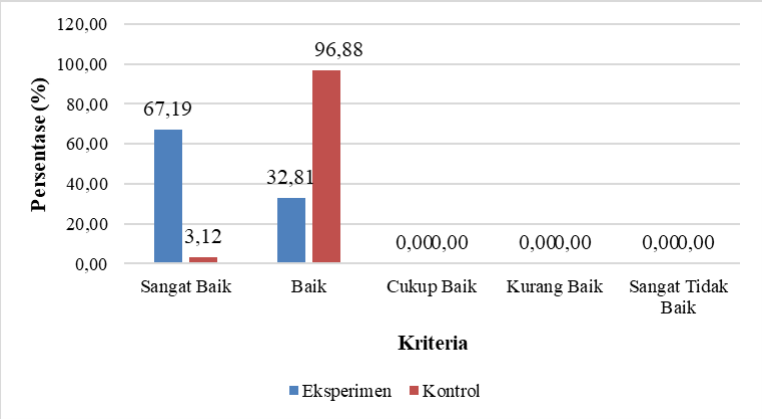

Figure 1. Comparison of PPP students who are taught with the PjBL model and Conventional Learning

Based on Figure 1, experimental class students prove to have superior science process skills compared to the control class. This is due to the higher number of students in the experimental class who proved their science process skills with very good criteria compared to the control group.

Description of Cognitive Learning Outcomes Data Based on Learning Methods

Table 5 presents the distribution of cognitive learning outcomes and student learning outcomes in the PjBL model and conventional learning.

Table 5. Frequency Distribution and Pretest Presentation of Cognitive Learning Outcomes in PjBL Models and Conventional Learning

Score Interval	Category	PjBL Model		Conventional Model	
		fo	Percentage (%)	fo	Percentage (%)
85 – 100	Very Good	0	0,00	0	0,00
70 – 84	Good	3	4,69	3	4,69
55 – 69	Good Enough	23	35,94	24	37,50
40 – 54	Not Good	35	54,69	34	53,13
0 - 39	Very Not Good	3	4,69	3	4,69
Sum		**64**	**100**	**64**	**64**

Frequency distribution graphs and pretest presentations on PjBL models and conventional learning are presented in Figure 2.

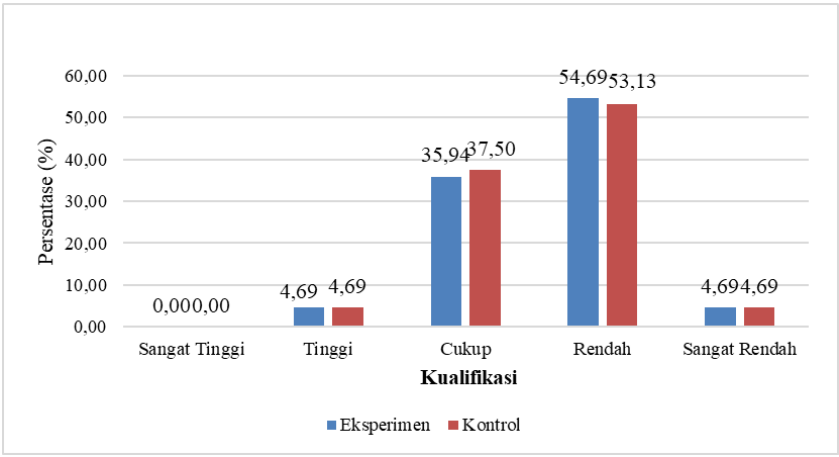

Figure 2. Frequency Distribution and Pretest Presentation of PjBL model and conventional learning

Table 5 and Figure 2 show the pretest results of cognitive learning of students who were taught using the PjBL model, namely students with a very low category of 3 people (469%), low category of 35 people (5469%), sufficient category of 23 people (3594%), high category of 3 students (469%), and there were no students with very high categorized values. Meanwhile, the pretest results of cognitive learning of students who were taught using conventional learning with a very low category of 3 people (469%), low category of 34 people (5313%), sufficient category of 24 people (3750%), high category of 3 students (469%), and there were no students with very high categorized values. This shows that the average difference between the two class groups is not too high, which also proves that the initial knowledge of students in both classes is equivalent before the given. This shows that the average difference between the two class groups is not too high, which proves that the student's prior knowledge in both classes is equivalent to the treatment in the form of learning models. The frequency distribution and presentation of students' cognitive learning outcomes in the PjBL model and conventional learning are presented in Table 6.

Table 6. Distribusi Frekuensi dan Presentasi *Posttest* Hasil Belajar Kognitif pada Model *PjBL* dan Pembelajaran Konvensional

Score Interval	Category	PjBL Model		Conventional Model	
		fo	Percentage (%)	fo	Percentage (%)
85 – 100	Very Good	30	46,88	9	14,06
70 – 84	Good	34	53,13	42	65,63
55 – 69	Good Enough	0	0,00	13	20,31
40 – 54	Not Good	0	0,00	0	0,00
0 - 39	Very Not Good	0	0,00	0	0,00
Sum		**65**	**64**	**100**	**64**

Frequency distribution graphs and posttest presentations on PjBL models and conventional learning are presented in Figure 3.

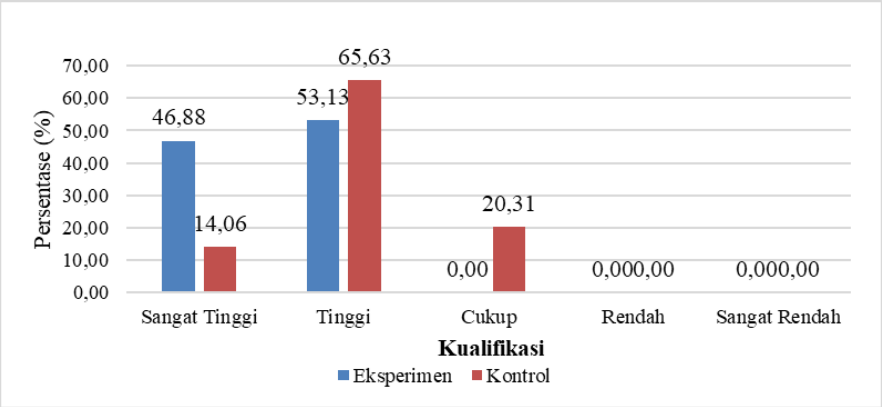

Figure 3. Distribusi Frekuensi dan Presentasi *Posttest* model *PjBL* dan pembelajaran konvensional

Table 6 and Figure 3 show the posttest results of cognitive learning of students who were taught using the PjBL model, namely students with a high category of 34 people (4888%), and there were no students with scores categorized as sufficient, low, and very low. Meanwhile, the posttest results of cognitive learning of students who were taught using conventional learning with a sufficient category were 13 people (2031%), a high category of 42 people (4688%), and no students with scores categorized as low or very low. This shows that students in the experimental class show higher cognitive learning outcomes than the control class. This is seen from the significantly higher scores the experimental group students achieved in the posttest cognitive learning assessment. Learners taught with the PjBL model demonstrated higher qualifications in science cognitive learning outcomes, exceeding control group learners taught with conventional learning.

The Hypothesis Testing Results

The data analysis technique used for hypothesis testing in this study is Multivariate Analysis of Covariance (MANCOVA). Before conducting statistical testing with MANCOVA, assumptions or prerequisites consisting of (1) normality test of data distribution, (2) variance homogeneity test, (3) homogeneity test of variance matrices, (4) correlation test between dependent variables, (5) linearity test, and (6) homogeneity test of

regression line slope are performed first. The results of the hypothesis testing show that there are differences in cognitive learning outcomes between students taught using the PjBL model and conventional learning in the Respiratory System in Human Science subject. In addition, the r square value of 0665 or 665% indicates the magnitude of the simultaneous influence of the PjBL model variable on the science process skills and cognitive learning outcomes of students.

Discussion

There are several theoretical and empirical foundations that the PjBL model provides better results in science process skills and cognitive learning outcomes. Capraro et al. (2018) revealed that by implementing this PjBL model, in addition to creating an increase in responsibility and cooperation among students, it also increases student activity by producing many ideas/concepts/ways to solve problems so that they are accustomed to building creativity and improving science process skills. Project-based teaching models can encourage students to gain deeper knowledge through active exploration of real-world challenges.

Project-based learning models are based on various components of science, technology, engineering, arts, and mathematics that can cultivate students' soft skills. Learning with this method strengthens the theory and concepts discovered by students. Consistent with the findings (Rohman et al., 2022), integrating the PjBL model educates students to gain more profound knowledge by actively engaging and exploring challenges and problems faced by creating and finding solutions to these problems. The acquisition of these findings is also in line with the study of Hasan et al. (2022), Nurjanah et al. (2021), and Safaruddin et al. (2020), who stated that there is a better influence of the PjBL model on the science process skills. The use of the PjBL model affects students' science process skills because it can make students actively involved in learning activities to stimulate their science process skills. This indicates an increase in science process skills with the model.

Based on the findings obtained from data analysis, students who follow the PjBL model show superior cognitive learning outcomes than students who follow conventional learning. Anis et al. (2020) stated that PjBL can improve students' cooperation and cognitive learning outcomes. This is because the PjBL model teaches students to find problems and solve problems themselves.

Through this PjBL model, by giving students freedom in finding and solving problems, they can stimulate students' high-level thinking skills. Thus, students will find it easier to remember the material, which has an impact on high cognitive learning outcomes. This is also in line with previous studies, where the use of the PjBL model provides results that tend to be good for cognitive learning outcomes (Amsikan, 2022; Lette et al., 2019; Yuniasih et al., 2022).

CONCLUSION

Based on some of the discussions that have been described, several things can be concluded as follows: 1) There are simultaneous differences in science process skills and cognitive learning outcomes between students who learn using the Project Based Learning (PjBL) model and conventional learning in science subjects. Learning models work simultaneously and provide a significant influence from the application of the PjBL model that contributes to the science process skills and cognitive learning outcomes of learners; 2) There is a significant difference in science process skills between students who learn using the Project Based Learning (PjBL) model and conventional learning in science

subjects. The science process skills of students in the experimental class were higher than those in the control class, and 3) There were significant differences in cognitive learning outcomes between students who learned using the Project Based Learning (PjBL) model and conventional learning in science subjects. The cognitive learning outcomes of students who were taught using the PjBL model proved to be better than those of students who were taught using conventional learning.

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