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Project Based Learning Model to Increase Scientific Process Skills and Knowledge Learning Outcomes of Students on Colloid System

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Abstract

The lack of students' scientific process skills on colloidal system material causes less active behavior in the learning process which results in the quality of low knowledge learning outcomes. This study aims to improve students' scientific process skills and knowledge learning outcomes on colloidal system material. This study employed experimental research and quasi-experimental methods. The research subjects in the experimental and control classes were 33 people in total. The data collection techniques used were test and non-test techniques. Test instruments included scientific process skills test instruments and knowledge learning outcomes, while non-test instruments were observation sheets and response questionnaires. The factors studied were (1) scientific process skills, (2) knowledge learning outcomes and (3) responses. Data analysis techniques used descriptive and inferential analysis techniques. The results showed that there was an increase in scientific process skills and knowledge learning outcomes after applying the Project Based Learning model (PjB). The results of the increase in scientific process skills with indicators measured, namely: observing, predicting, classifying, interpreting, and communicating were 43.95, 50.90, 55.76, 59.10. The percentage of knowledge results amounted to 85.15% and the results of the questionnaire response amounted to 90.91% with a positive category. It can be inferred that the PjBL model can improve students' scientific process skills and knowledge learning outcomes on colloidal system material.

Keywords: Colloidal Systems; Experiment; Knowledge Learning Outcomes; Project Based Learning; Science Process Skills

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INTRODUCTION

It is common knowledge that learning significantly influences the quality of education. Individuals are expected to remain current with the ever-evolving times through their learning. Nevertheless, the general public continues to perceive scientific learning as revolving around memorization and the teacher as the primary authority on acquiring knowledge (Nuriani & Muliawan, 2020).

Science education teaches students how to master and implement science process skills in the context of a project or daily life in addition to teaching concepts. The capability to convert knowledge into practical skills is possible via the processes of observation, investigation, creation, processing, analysis, and presentation. Students must possess the scientific process skills exemplified by these activities in order to successfully learn the subject (Choirunnisa et al., 2018)

Barantes & Tamoria (2021) and Darmaji et al (2019) stated that the manner in which a teacher executes the learning model in the classroom has an impact on the process skills possessed by students. In other words, students' process skills will be enhanced to the extent that the teacher implements the learning model in a proficient and appropriate manner. The learning model implemented is one of the factors that contribute to the development of students' scientific process skills during the learning process.

The significance of the scientific process skills method in scientific education stems from its direct correlation with practical experience. Life experience gained through direct environmental contact. The scientific process includes observation, evaluation, measurement, classification, establishing preliminary hypotheses, research planning, variable management, data elucidation, hypothesis formulation, practice, presentation, and communication (Khoiri & Fuziyah, 2020).

The learning model is implemented to increase scientific process skills and student learning outcomes in the field of knowledge by having teachers develop learning concepts that can enhance students' knowledge-based learning outcomes in chemistry. As stated by Sudjana (2010), output standards pertain to the proficiency that students attain upon completion of the learning process. Additionally, learning outcomes refer to the declaration that a student reaches as a result of the knowledge acquired throughout the course of study (Martin & Malgorzata, 2019).

PjBL is the 21st century learning model recommended for use in the 2013 curriculum and applicable to efforts to enhance students' scientific process skills. Students are prepared to confront the complexities of real-world issues through the collaborative effort and student-centered learning activity of project-based learning (Abu Bakar et al., 2019; Yang et al., 2021).

This condition aligns with the findings of Natty et al. (2019), which suggest that PjBL can enhance students' information processing capabilities, problem-solving skills, and creative thinking through the creation of products. Additionally, PjBL has been found to increase students' motivation, self-confidence, tolerance, cooperation, and comprehension of the subject matter.

The comprehension and memorization of concepts are necessary for colloidal material (Nisa et al., 2019). Colloidal systems are characterized by tangible and intangible components, procedures (including the colloidal synthesis process), and situational attributes (Herdiawan et al., 2019). In order to attain comprehensive understanding, students must engage in active, engaging, and student-centered instruction that allows them to construct their own knowledge (Ningsih et al., 2018).

Students were active participants in the learning process, according to the observations of MAN 1 Banjarmasin chemistry teachers. However, there were still students who were not engaged in the learning process, particularly when instructed by a small number of teachers. Students continue to lack a comprehensive understanding of chemistry due to the teacher's exclusive reliance on lectures, which place the teacher at the center of the classroom and fail to engage the students. An innovative learning model is therefore required.

Students' lack of active participation in the learning process and inadequate application of scientific process skills contribute to the substandard quality of learning outcomes. The findings regarding the daily test scores of XI MAN 1 Banjarmasin students during the 2021/2022 academic year indicate that only about 55% of the total student demonstrating proficiency in colloid material, particularly in terms of mastery of concepts and scientific process skills, despite the fact that colloid material heavily emphasizes conceptual comprehension and does not necessitate extensive algorithmic knowledge. Therefore, obtaining students' completeness is not a challenging task. Some research on the outcomes of knowledge and scientific process skills acquisition through the implementation of project-based learning models. The research of Nuriani & Muliawan (2020) yielded excellent results in which the students were more engaged in scientific inquiry when the subject matter was applicable to real-world issues. Consistent with the findings of Suryaningsih et al. (2021) presented the results of scientific process skills acquisition with a point total of 4.164, placing the percentage of scientific process skills in the high category at 83.3. Thus, proficiency in the scientific process produced positive outcomes.

The PjBL model may serve as an alternative method for studying chemistry, particularly with regard to colloidal system material as described previously. By encouraging students to actively engage in the learning process and draw insights from their personal experiences, this instructional framework has the potential to optimize students' academic achievements. The purpose of this research is to determine how the PjBL model can enhance the scientific process skills and knowledge acquisition of students in comparison to the Problem-Based Learning (PBL) model.

METHOD

This study employed a quasi-experimental design utilizing a nonequivalent control group. Control and experimental groups comprised this quasi-experimental design (Sugiyono, 2019). In this research, two classes were utilized, one serving as the control group and the other as the experimental group. The dependent variable in this study was assessed through a comparison between the experimental class, which received treatment through the PjBL model, and the control class, which received treatment through the PBL learning model.

The sampling methodology employed in this research was random sampling. In order to obtain the sample, XI IPA 1 served as the experimental class, while XI IPA 2 functioned as the control class, each consisting of 33 students. Data collection techniques used were test and non-test methods. The test instrument included the test of scientific process skills and knowledge learning outcomes. On the other hand, observation sheets and response questionnaires were non-test instruments.

The data utilized in this research is quantitative, specifically utilizing statistical analysis. This research employed two distinct methods of data analysis: descriptive analysis and inferential analysis. Descriptive statistics are utilized in descriptive analysis of data. Descriptive analysis was employed in this research to examine student response questionnaires and scientific process skills. Inferential analysis is associated with the formulation of a priori hypothesis, which serves as a means to evaluate the hypothesis (Ramadhani & Bina, 2021). Prior to conducting hypothesis testing, the data requirements are examined through the normality and homogeneity tests. Following that, the comparison test was conducted using the t-test to examine the hypothesis.

Students were divided into 6 groups with members ranging from 5-6 students randomly. Each group followed the stages of project-based learning which included: (1) opening the lesson with a fundamental question, (2) planning the project, (3) developing a schedule, (4) monitoring the progress of the project, (5) assessing the resulting product, (6) evaluating the experience. Indicators of scientific process skills are observing, predicting, classifying, interpreting, and communicating.

RESULTS AND DISCUSSION

Based on the research that has been conducted, data on the results of scientific process skills and learning outcomes in the knowledge domain of students are obtained.

Analysis of Scientific Process Skills

a. Post-test and Pre-test Results

The average level of achievement of students' understanding of the indicators of scientific process skills is shown in Table 1.

Table 1 The Average Level of Achievement of Each Competency and The Indicators

Scientific process skills competency	Scientific process skills indicators	Understanding level (%)			
		Experiment		Control	
		Pretest	Posttest	Pretest	Posttest
Observing	Utilize senses optimally	36.36	81.82	27.27	70.59
	Collect relevant facts and use them	33.33	72.73	27.27	67.65
	Average	34.85	77.28	27.27	69.12
Classifying	Evaluate the attributes	34.85	80.5	27.27	67.65
	Search for the classification base	36.36	78.79	24.24	70.59
	Associate the observation results	37.88	86.37	26.77	69.12
	Average	36.36	81.89	26.09	69.12
Interpreting	Connecting the observation results	39.39	93.94	27.27	76.47
	Determine the observation pattern	36.36	90.91	30.30	75.53
	Drawing conclusion	39.39	75.76	24.24	67.65
	Average	38.38	86.87	27.27	73.22
Predicting	Utilize the observation pattern results	39.39	90.91	25.76	69.12
	Convey the probability of a situation that may occur under conditions that have not observed	39.39	79.80	25.25	70.59
	Average	37.88	85.36	25.51	69.86
Communicating	Read table / diagram	33.33	90.91	30.30	73.53
	Average	33.33	90.91	30.30	73.53

b. N-gain Results

The data on the results of the scientific process skills test obtained from the pre-test and post-test are then processed into N-gain data to determine the extent to which students in each class experience an increase in the value of scientific process skills after learning colloidal system material with each learning model. The N-gain data for experimental and control class students can be seen in Table 2.

Table 2 N-gain Interpretation of The Students' Scientific Process Skills

Class	N-gain Average	Category
Experiment	0.73	High
Control	0.61	Moderate

c. Inferential Results

(1) Normality Test

The results of the normality test calculation for the pre-test and post-test data of students' scientific process skills with the Lilliefors test in the experimental and control classes is presented in Table 3.

Table 3 Normality Test Results of Pre-Test and Post-Test Data of Scientific Process Skills

Result	Class	N	L_0	L_{table}	Kesimpulan
Pre-test	Experiment	33	0.046	0.154	Normal
	Control	33	0.137	0.154	Normal
Post-test	Experiment	33	0.146	0.154	Normal
	Control	33	0.152	0.154	Normal

(2) Homogeneity Test

The results of the homogeneity test of the pre-test and post-test of scientific process skills can be seen in Table 4.

Table 4 Homogeneity Test Results of Pre-Test and Post-Test of Scientific Process Skills

Results	Class	df	SD^2	F_{hitung}	F_{table} 5%	Conclusion
Pre-test	Experiment	32	115.73	1.29	1.80	Homogenous
	Control	32	85.44			
Post-test	Experiment	32	161.47	0.44	1.80	Homogenous
	Control	32	367.00			

(3) T-test

The t-test was conducted on the pre-test and post-test data of students' scientific process skills in experimental and control classes that had been tested for homogeneity and normality. Pre-test and post-test data must be normally distributed and homogeneous. The results of the t-test of pre-test and post-test data on scientific process skills are presented in Table 5.

Table 5 T-Test Results of Pre-Test and Post-Test of Scientific Process Skills

Results	Class	df	$\bar{X}$	SD^2	t_{count}	f_{table} 5%	Conclusion
Pre-test	Experiment	64	34.34	115.73	1.437	1.998	Not different significantly
	Control		30.71	85.44			
Post-test	Experiment	64	83.23	161.47	3.565	1.998	different significantly
	Control		70.00	367.00			

Analysis of Knowledge Learning Outcomes

a. Post-test and Pre-test Learning Outcomes

The average values of the knowledge domain learning outcomes for students in the experimental and control groups with regard to colloidal system material across all competency achievement indicators is shown in Table 6.

Table 6 Average of Achievement Level of Each Indicator

No	Competency Achievement Indicator	Achievement level (%)			
		Experimental class		Control class	
		Pre-test	*Post-test*	*Pre-test*	*Post-test*
1	Identify product type in the form of solution dispersion, colloid, and suspense system	32.25	85.00	30.00	78.25
2	Classify and determine the attributes of colloid	28.50	88.00	31.50	74.50
3	Analysis the colloid based on the attributes	30.00	85.00	28.50	76.00

No	Competency Achievement Indicator	Achievement level (%)			
		Experimental class		Control class	
		Pre-test	*Post-test*	*Pre-test*	*Post-test*
4	Apply colloid production and its role in a daily life.	30,00	83,50	31,50	76,00

b. N-gain Results

This analysis aims to determine the extent to which students in each welding have increased knowledge after learning colloidal system material. The data processed into N-gain data is knowledge test data obtained from pre-test and post-test. The N-gain category of experimental and control class students is presented in Table 7.

Table 7 N-Gain Interpretation of The Students' Scientific Process Skills

Class	N-gain average	Category
Experiment	0.79	High
Control	0.68	Moderate

c. Inferential Analysis Results

(1) Normality Test

The results of the normality test calculation for scientific process skills pre-test data and post-test data of students' scientific process skills with the Lilliefors test in experimental and control classes are shown in Table 8.

Table 8 Normality Test Results of Pre-Test and Post-Test Knowledge

Results	Class	N	L_0	L_{table}	Conclusion
Pre-test	Experiment	33	0.131	0.154	Normal
	Control	33	0.139	0.154	Normal
Post-test	Experiment	33	0.128	0.154	Normal
	Control	33	0.150	0.154	Normal

(2) Homogeneity Test

The homogeneity test results of pretest and post-test of knowledge are presented in Table 9.

Table 9 Homogeneity Test Results of Pre-Test and Post-Test Knowledge

Results	Class	Df	SD^2	F_{count}	F_{table} 5%	Conclusion
Pre-test	Experiment	32	208.52	1.35	1.80	Homogenous
	Control	32	154.73			
Post-test	Experiment	32	169.51	0.50	1.80	Homogenous
	Control	32	341.67			

(3) T-test

The t-test was conducted on the pre-test and post-test data of students' knowledge in the experimental and control classes that had been tested for homogeneity and normality. Pre-test and post-test data must be normally distributed and homogeneous. The results of the t-test of pre-test and post-test knowledge data can be seen in Table 10.

Table 10 T-Test Results of Pre-Test and Post-Test Knowledge

Results	Class	df	$\bar{X}$	SD^2	t_{count}	f_{table} 5%	Conclusion
Pre-test	Experiment Control	64	30.91 28.79	208.52 154.73	0.639	1.998	Not different significantly

Results	Class	df	$\bar{X}$	SD^2	t_{count}	f_{table} 5%	Conclusion
Post-test	Experiment Control	64	85.15 76.67	169.51 341.67	2.156	1.998	different significantly

Observation Results of Scientific Process Skills

Observation sheets of students' scientific process skills was carried out at each meeting in experimental and control classes, with the amount of 2 meetings. The observations observed were observing indicators, classifying indicators, predicting indicators, interpreting indicators, and communicating indicators. The assessment was carried out by observers using the Scientific process Skills observation sheet. Each observer observed 1-2 groups totaling 5-6 students, both for experimental and control classes. Scientific process skills observation data can be seen in Table 11.

Table 11 Observation Results of Scientific Process Skills

No	Observed aspects	Experimental class		Control class	
		Meeting		Meeting	
		1	2	1	2
1	Observing	75.00	68.00	55.50	59.50
2	Classifying	74.50	69.00	56.50	55.50
3	Predicting	71.00	71.00	54.50	55.50
4	Interpreting	70.50	69.00	56.00	56.50
5	Communicating	67.50	68.50	56.00	55.50
Total		21.73	20.94	16.88	17.22
Average		21.33		17.00	
Category		**Competent**		**Competent enough**	

Response Questionnaire

The students' response questionnaire was given at the final stage of learning. The aim is to determine the extent of interest and acceptance of students on colloidal system material to the treatment given, namely applying the PjBL model in improving Scientific process Skills and learning outcomes in the knowledge domain.

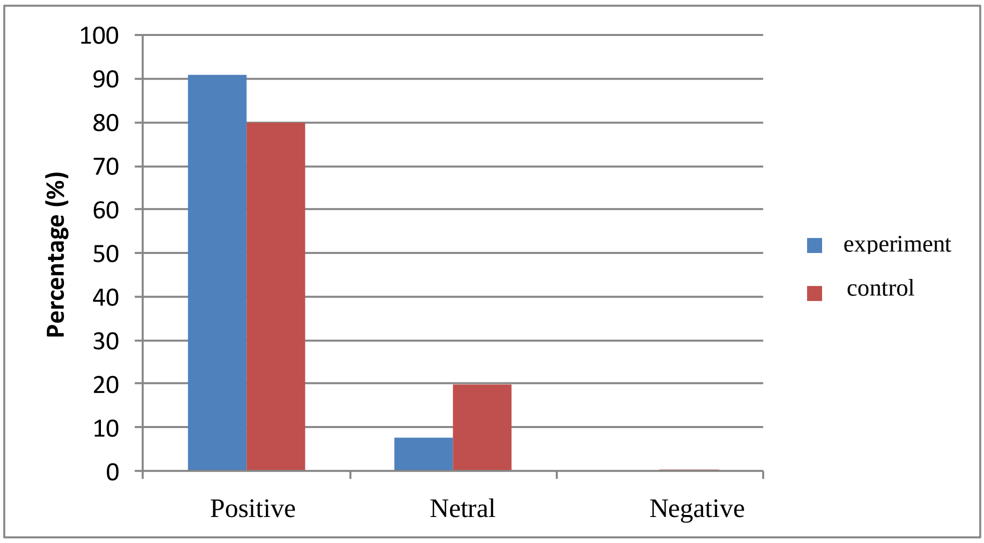

Figure 1 Percentage of Students' Responses

Figure 1 shows the average value of students' responses to the application of the PjBL model in improving scientific process skills and knowledge learning outcomes in the experimental class and the application of the PBL model in improving scientific process skills and knowledge learning outcomes in the control class.

The student responses indicate that the students find it easier to work on post-test questions, which is in accordance with research (Wismaningati et al., 2019). This is evident from the analysis that has been conducted on the student response questionnaire. In the student response questionnaire, a percentage of 73.53% was obtained. With this achievement, it falls into the good category.

Scientific process Skills

There is an increase of the students' scientific process skills on observing indicators from pre-test to post-test scores with the highest average achievement in the experimental class. The scientific process skills of students on observing indicators are presented on Table 2 that there is an increase from the pre-test to post-test scores of students with the experimental class having a higher difference of 42.34 while the control class amounted to 41.85. This indicates that there is an increase in pre-test to post-test scores on predicting indicators with the highest average achievement in the experimental class.

There is an increase of the students' scientific process skills on classifying indicators from pre-test to post-test scores with the highest average achievement in the experimental class. The scientific process skills of students on classifying indicators can be seen in Table 2 that there is an increase from the pre-test to post-test scores of students with a higher difference of the experimental class which is 45.53 while the control class amounted to 43.03, indicating that there is an increase in pre-test to post-test scores on classifying indicators with the highest average achievement in the experimental class.

There is an increase of the students' scientific process skills on interpreting indicators from pre-test to post-test scores with the highest average achievement in the experimental class. The scientific process skills of students on interpreting indicators are shown in Table 2 in which there is an increase from the pre-test to post-test scores of students with the experimental class having a higher difference of 48.49 while the control class amounted to 45.95. This indicates that the indicator of interpreting with the highest average achievement is in the experimental class.

There is an increase of the students' scientific process skills on predicting indicators from pre-test to post-test scores with the highest average achievement in the experimental class. The scientific process skills of students on the indicator of predicting which are presented in Table 2 show that there is an increase from the pre-test to post-test scores of students with a higher difference of the experimental class of 45.97 while the control class amounted to 44.35. This indicates that there is an increase in pre-test to post-test scores on the indicator of predicting with the highest average achievement in the experimental class.

There is an increase of the students' scientific process skills on communicating indicators from pre-test to post-test scores with the highest average achievement in the experimental class. The scientific process skills of students on the indicator of communicating which are presented in Table 2 show that there is an increase from the pre-test to post-test scores of students with a higher difference of the experimental class of 57.58 while the control class amounted to 43.23. This indicates that there is an increase in pre-test to post-test scores on the indicator of communicating with the highest average achievement in the experimental class.

The pre-test normality test in the experimental class yields the L_0 value of 0.046 and the L_{table} value of 0.154 with $\alpha = 0.05$ with $n = 33$, so $L_0 < L_{table}$ (0.046 < 0.154). Meanwhile, the control class obtained an L_0 value of 0.137 and an L_{table} value of 0.154

with $\alpha = 0.05$ value with $n = 33$, meaning that $L_0 < L_{table}$ (0.137 < 0.154). This indicates that the distribution of pre-test data on students' scientific process skills in both classes is normally distributed.

The post-test normality test in the experimental class obtained L_0 value of 0.146 and Ltable value of 0.154 with $\alpha = 0.05$ with $n = 33$, meaning that $L_0 < L_{table}$ (0.146 < 0.154). In the control class, L_0 value is 0.152 and L_{table} value is 0.154 with $\alpha = 0.05$ with $n = 33$, so L0 < Ltable (0.152 < 0.154). Based on these results, the distribution of post-test data on students' scientific process skills in both classes is normally distributed.

The results of the pre-test data homogeneity test obtained the F_{table} value of 1.80, so the $F_{count} < F_{table}$ (1.29 < 1.80). This shows that the experimental class and control class are homogeneous, meaning that the variants of the two classes before being treated are relatively the same. Meanwhile, the results of the post-test data homogeneity test obtained the F_{table} value of 1.80, so the F_{count} value < F_{table} (0.44 < 1.80), meaning that the experimental class and control class are homogeneous and the variants of the two classes after being treated are relatively the same.

The inferential analysis using t-test on the pre-test results of students' scientific process skills yields the result that there is no significant difference between the knowledge learning outcomes of the experimental class and the control class. The average pre-test value of scientific process skills of experimental class students is 34.748 while the average pre-test value of scientific process skills in the control class is 30.707. Based on the value of t_{count} and t_{table}, it is obtained that $t_{count} < t_{table}$ (1.425 < 1.998), meaning that H_0 is accepted and H_1 is rejected.

The average post-test value of scientific process skills of the experimental class is greater than the control class, which is 84.444 and 69.898 respectively. Based on the value of t_{count} and t_{table}, it is obtained that $t_{count} > t_{table}$ (3.565> 1.998). Thus, H_1 is accepted and H_0 is rejected, meaning that there is a significant difference between the average value of students' scientific process skills in the experimental class and the control class after treatment.

The results show that the pretest and posttest results of PBL and PjBL class students' scientific process skills both showed an improvement which is in accordance with research (Pratiwi et al., 2020). Before being taught with PBL, the average value of students' scientific process skills was 49.3 in the less skilled category. Nevertheless, the students' scientific process skills increased to 82.5 in the highly skilled category after being taught with PBL. Before being taught with PjBL, the average value of students' scientific process skills was 46 with the less skilled category. After being taught with PjBL, students' scientific process skills increased to 70.57 with the skilled category. After being taught with PBL and PjBL, all students possess the scientific process skills. The application of PBL and PjBL to improve students' scientific process skills in this study is in accordance with the concept of constructivism learning theory, stating that learning activities require students to play an active role in constructing their own knowledge through authentic-problem solving in the real world. Anggriani et al. (2019) stated that Project-Based learning can also foster various characters, such as the characters of discipline, responsibility and mutual cooperation. This affects the achievement and activity of students' scientific process skills in learning.

Knowledge Learning Outcomes

The inferential analysis using the t-test on the pre-test results of students' knowledge learning outcomes yields the result that there is no significant difference between the knowledge learning outcomes of the experimental class and the control class. The average pre-test score of students' knowledge in the experimental class is 30.91%, while students in the control class is 28.79%. All students have knowledge learning outcomes that are still in the very low category. In that case, all students in both the experimental class and the control class were failed, meaning that students in both classes have the same low initial knowledge of colloidal system material.

The pre-test normality test in the experimental class yields the L_0 value of 0.131 and the L_{tabel} value of 0.154 with $\alpha = 0.05$ and $n = 33$, indicating that $L_0 < L_{tabel}$ (0.131 < 0.154). Meanwhile, the control class obtained an L_0 value of 0.139 and L_{tabel} value of 0.154 with $\alpha = 0.05$ and $n = 33$, so $L_0 < L_{tabel}$ (0.139 < 0.154). This means that the distribution of pre-test data on students' knowledge in both classes is normally distributed.

The post-test normality test in the experimental class obtained L_0value of 0.128 and L_{tabel} value of 0.154 with $\alpha = 0.05$ and $n = 33$, so $L_0 < L_{tabel}$ (0.128 < 0.154). Meanwhile, the control class shows that the L_0 value is 0.152 and the L_{tabel} value is 0.150 with a value of $\alpha = 0.05$ with $n = 33$, meaning that $L_0 < L_{tabel}$ (0.150 < 0.154). Based on these results, the distribution of student knowledge post-test data in both classes is normally distributed.

The results of the pre-test data homogeneity test obtained the F_{count} of 1.35. Based on the data in the table of F values, the F_{table} value of 1.80 is obtained, so the F_{count} value < F_{table} (1.35 < 1.80). This shows that the experimental class and control class are homogeneous, meaning that the variants of the two classes before being treated are relatively the same. The results of the post-test data homogeneity test obtained the F_{count} of 0.50. Based on the data in the table of F values, the F_{table} value of 1.80 is obtained, so the F_{count} value < F_{table} (0.50 < 1.80). This shows that the experimental class and control class are homogeneous, meaning that the variants of the two classes are relatively the same.

The inferential statistics with homogeneous variants and normally distributed data yields the result that the average difference between the experimental class and the control class is significantly different after being calculated using the t-test. In the table, it is evident that $t_{count} > t_{table}$ (2.156> 1.998). Thus, H_1 is accepted, meaning that there is a significant difference between the average value of students' knowledge in the experimental class and the control class after treatment.

The results of the N-gain analysis in the table show a difference in knowledge improvement between the experimental and control classes. The category of increasing students' knowledge learning outcomes in the experimental class has reached a high category with an N-gain value of 0.79, while students in the control class reached a moderate category with an N-gain value of 0.68. This shows that the percentage increase in knowledge learning outcomes in the experimental class is 80%, while in the control class it is 67%. Thus, the students in the experimental class have a higher increase in knowledge learning outcomes than the experimental class on colloidal system material.

This also affects the achievement of the Minimum Completion Criteria obtained by each student in the experimental and control classes. The percentage of students' achievement in the experimental class is 85.15% while the achievement in the control class is 76.36%. These results show that the experimental class has a higher achievement of Minimum Completion Criteria than the control class. Based on several relevant sources and research findings that have been conducted, it can be concluded that the PjBL model plays a role in improving students' knowledge learning outcomes on colloidal system material.

Response Questionnaire

The results of the response questionnaire show that the percentage of students who have a positive response to PjBL model in the experimental class is 90.91% while the percentage of the control class with the PBL model is 80.00%. Thus, it is evident that the students have a better response in the experimental class than in the control class. This is because the PjBL model encourages the students to participate in learning, so they are motivated to take part in learning.

CONCLUSION

Based on the results and discussion of the research, it is concluded that the PjBL model can improve the scientific process skills and knowledge learning outcomes of students on colloidal system material. This improvement occurs because the use of the PjBL model is able to make students actively participate, and learn from experiences carried out directly by students in project work. The results of improving scientific process skills based on the following indicators: observing, predicting, classifying, interpreting, and communicating with the value of 43.95, 50.90, 55.76, and 59.10. The percentage of knowledge learning outcomes is 85.15% and the results of the questionnaire response is 90.91% with a positive category.

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