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THE INFLUENCE OF THE STEAM APPROACH ON THE PjBL MODEL ON STUDENTS' COLLOID LEARNING OUTCOMES

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Abstract

Chemistry learning at SMA Negeri 7 Takalar is still dominated by teacher-centered learning. Students still have difficulty understanding chemistry lessons such as colloids, the material of which is conceptual in nature and requires contextual application of concepts. Therefore, it is very important to carry out learning that involves students actively applying colloid theory and concepts through the *STEAM* approach in the Project Based Learning learning model. This research is quasi-experimental research that aims to determine the colloid learning outcomes of students after learning with the *STEAM* approach in the PjBL Model for Class XI MIPA SMA Negeri 7 Takalar. Posttest only control group design research design. The population is all class XI students consisting of three classes. The results of inferential statistical tests show that student learning outcomes using the t-test at a value of $\alpha = 0.05$ obtained a value of tcount > ttable (2.83 > 1.99) and the research samples for Class XI MIPA 2 and Class XI MIPA 3 as experimental and control groups were randomly selected. The results of the descriptive analysis show that the completeness of learning outcomes for the experimental class is 72.73% higher than the control class, 48.48%. This means that H0 is rejected and H1 is accepted, thus it can be concluded that the *STEAM* approach in the Project Based Learning Model has a significant influence on the colloid learning outcomes of class XI MIPA students at SMA Negeri 7 Takalar.

Keywords: *STEAM*, Project Based Learning, Learning Outcomes, Colloid

INTRODUCTION

The education system implemented while still using the 2013 curriculum is expected to be able to change education so that students can be more active, creative and create critical thinking processes, and be able to keep up with the times. Learning must be carried out based on the principle of active students following Minister of Education and Culture Decree No. 719/P/ 2020, students must be actively and creatively involved in the learning process. When implementing learning, there are many ways to encourage students to learn actively, including the use of learning models or strategies that suit the characteristics of the teaching material, including Discovery Learning, Inquiry, Project Based Learning, and Problem Based Learning.

Project-based learning (PjBL) is a learning model that can provide great opportunities for students to explore their creativity. One of the advantages of the PjBL model is that it can make students more active and creative in learning and able to improve critical thinking and problem-solving skills [1]. PjBL can help and encourage students to understand the material lessons that are rote and theoretical and can analyze problems and find solutions to problems related to the context of everyday life so that they can remember the knowledge they have gained for a long time and motivate them to learn more. The PjBL model is a learning process that focuses students on problems, thereby motivating students to learn the concepts and basic principles of knowledge directly as real experiences [2].

The PjBL model is an innovative learning that encourages students to carry out investigations and work collaboratively to research and create projects that have the potential to explore knowledge so that students can solve problems and help them develop in the 2nd century. When creating a project students must be involved in problem solving, decision making, or investigative activities, so that students have the opportunity to be independent produce a realistic product and presentation. Therefore, learning is based project (PjBL) is one of the best models to achieve educational goals of the 21st century because they are contextual and can help students develop their critical thinking skills [3].

STEAM (*science, teknologi, engineering, arts, mathematics*) is one approach that fits the PjBL model. The STEAM approach can help student improve their capacity for teamwork, problem solving, and thingkin critical [4]. Applying this approach combines each part of *STEAM* into a project-based learning syntax. Art elements are terrific for students and teachers through forms of expression, communication, creativity, imagination, observation, perception, and thought to develop cognitive skills such as listening, solving problems, matching form with function, and decision-making [5]. Learning with the *STEAM* approach is active, involves practical activities, and is directed at real situations [6].

The Project Based Learning model is a learning model that provides projects to students as a solution to a problem. The project in this learning is in the form of colloid products in everyday life (fish sauce, hair gel, cough syrup and virgin coconut oil). In this product manufacturing project, the STEAM approach is briefly represented as follows: the scientific aspect is formulated in the material to be used, namely the understanding and grouping of types of colloids, their properties, lyophilic colloids and lyophobic colloids as well as the manufacture and role of colloids. The technological aspect is the use of technology in the product manufacturing process. The engineering aspect consists of the process of designing trial procedures for making products and editing videos of making products with various applications. The art aspect is shown in the video display about the product as presentation material. The mathematics aspect is demonstrated by students' ability to create a timeline and calculate the materials needed to create the assigned project.

The PjBL model with the *STEAM* approach has the potential to provide meaningful learning that can train students to solve problems through a project because it emphasizes contextual learning through the syntax of the PjBL Model. In the first syntax, namely determining fundamental questions, the elements of science and technology (*S* and *T*) are applied. Students discover it through video shows related to colloidal materials. The second syntax is designing project experiments related to technology and art elements (*T* and *A*), students design simple experiments. In the third syntax related to preparing schedules, elements of mathematics and art (*M* and *A*) are applied, in the fourth syntax regarding monitoring students, elements of technology and art are applied (*T* and *A*), and for the fifth syntax, testing results are related to engineering and science elements (*E* and *S*), as well as in the sixth syntax evaluating experiences related to the art element (A).

The description of the application of *STEAM* elements in the PjBL Model shows that the *STEAM* approach has advantages in prioritizing science, solving problems with technology, and bridging abstract concepts mathematically into science, technology, and art which fosters students' creativity in creating contextual and fun learning tools, so that students can apply the learning results obtained in everyday life [7]. The application of *STEAM* in the PjBL Model is very appropriate for use in chemistry learning such as colloid material because it consists of concepts and theories that require an understanding of concepts that involve students directly processing their understanding which is closely related to everyday life [8]. In this way, students involve all their senses during the learning process, students no longer learn by imagining and memorizing concepts and theories which makes it difficult to understand materials, so the colloid learning outcomes of Takalar State High School students are still very low (65.80%) reaching a score of 75 (completeness standard).

The learning process in the PjBL model, apart from enabling students to learn collaboratively, on the other hand, they are free to express themselves according to their respective abilities to explore, plan learning activities, and carry out projects collaboratively using materials available in their environment to produce a product. Contextually free learning can increase students' curiosity, and strengthen self-esteem and academic honesty, which leads to students' behavior not to cheat during exams [9]. so that the learning results obtained are purely from the results of their thoughts through the PjBL Model learning which uses *STEAM* approach. Students are quite challenging and effective because they are encouraged to read and do not depend completely on the teacher, but are directed to be able to learn independently, their interest in learning is higher and this will have an impact on students' learning outcomes. Therefore, the *STEAM* approach can support science learning and how to implement it in welcoming the era of Industrial Revolution 4.0 through library research methods [10].

The results of observations obtained at SMAN 7 Takalar in 2022/2023 show that the learning process carried out by teachers so far is large group learning in class and giving additional assignments to read colloidal material at home. The type of learning used is still teacher-centered. If in the colloid learning process, students are limited to memorizing without understanding the concept, students will have difficulty connecting with what is happening in the surrounding environment, so they will not feel the benefits of learning colloids. Another factor is the mindset of the students themselves who consider learning colloids difficult because so far they do not understand that colloids are very close to their lives so they are less interested in studying colloid material.

Through PjBL model learning assisted by the *STEAM* approach, students will find learning innovations to help students change the way they learn and think holistically based on learning experiences, and group work experience in processing their thoughts independently. Students are accustomed to learning and thinking independently according to their methods and abilities, especially in understanding colloidal materials. The results of Parampo's research (2022) show that there is an influence of using the Project Based Learning Model with a STEAM approach on the learning outcomes of class XI MIPA students at SMA Negeri 1 Pare-Pare on the main material of colloid systems [11].

Based on the background above, the problem formulation of this research is whether there is an influence of the *STEAM* Approach in the PjBL Model on the Colloid Learning Outcomes of Class XI MIPA Students at SMAN 7 Takalar.

RESEARCH METHODS

This type of quasi-experimental research was used to determine the differences in colloid learning outcomes of students who were taught using the *STEAM* approach to project-based Learning and the Project Based Learning model without the *STEAM* approach. This research was carried out in the even semester of the 2023/2023 academic year at SMA Negeri 7 Takalar, Mangarabombang District, Takalar Regency.

The research design used in this research is Post-test Only Control Design. The population in the study were all students in class XI MIPA SMA Negeri 7 Takalar for the 2023/2024 academic year, consisting of three classes. The class MIPA 2 as the experimental class and MIPA 3 as the control class.

The variables in this study consist of two, namely the independent variable, namely the *STEAM* approach in the PjBL Model, and the PjBL Model without the *STEAM* approach, while the dependent variable is the results of colloid learning.

Observation instruments are used to collect data on students' learning activities, observers use the option yes or no. If the description of the student's activities is active, a checklist mark (√) is given in the "yes" column, if the student's learning is not active, a checklist mark (√) is given in the "no" column.

A test instrument containing 20 multiple-choice colloid material questions was given at the end of the lesson to collect data on colloid learning outcomes. The scores obtained by students are converted into grades by:

$$\text{Grades} = \frac{\textit{gained scored}}{\textit{maximum scored}} \times 100$$

Data analysis techniques used descriptive statistical analysis and inferential statistical data analysis on data resulting from observations of student activities and learning outcomes data. Data from observations of student activities using the formula:

$$\text{Student activities percentage} = \frac{F}{A} \times 100$$

Remarks:
F: Total score of active students
A: Total of students

The percentage of student activity will be averaged. Next, the value intervals are categorized as shown in table 1 below:

Table 1. the PjBL Model Learning Activity Criteria

Score Interval	Criteria
81% - 100%	Very High
61% - 80%	High
41% - 60%	Medium
21% - 40%	Low
5% - 20%	Very Low

Source: [12]

Colloidal learning result data is analyzed descriptively statistically, namely learning result data in the form of scores obtained from posttest results, and then the scores are converted into grades. The data obtained is then categorized into complete and incomplete categories. This completion data includes individual completion, class completion, and colloid material indicator completion.

1) Individual Completeness: $T_p = \frac{JB}{JS} \times 100$

Remarks: Tp = Tuntas Perorangan, J_B = Score of each student, Js = maximum score.

2) Class completion: $T_K = \frac{\Sigma T_p}{n}$ x 100%

Remarks: Tk = Tuntas Kelas, ΣTp = number of invidual completed, n = number of students.

3) Complete indicator, using the following formula: $Ti = \frac{\Sigma TPi}{n}$ x 100%

Remarks: Ti = Tuntas indikator, ΣTpi = number of students completed per indicator, n = number of students

Inferential Statistical Analysis to test the hypothesis using the t-test. Before testing the hypothesis, prerequisite tests are carried out in the form of normality and homogeneity tests.

a). Normality test

Data normality was tested using the following formula:

$$(\chi^2)_{count} = \sum \frac{(oi-Ei)^2}{Ei}$$

Remarks:

$(\chi^2)_{count}$ = chi square

Oi = observation frequency

Ei = expected frequency

Normality test results including data are categorized as normal

b). Homogeneity Test

The homogeneity test can be calculated using the following formula:

$$F_{count} = \frac{Large\ Variance}{Small\ Variance}$$

The criteria for testing homogeneity with a significant level of α = 0,05 and degrees of freedom "derajat kebebasan (dk)" espectively correspond to dk in the numerator (n_1-1) and dk denominator (n_2-1) namely if $F_{count} < F_{table}$ (1,36 < 1,80), The results of the data homogeneity test are homogeneous.

c). Hypothesis testing is carried out using the t-test, namely:

$$H_0: \mu_1 \leq \mu_2 \quad H_1: \mu_1 > \mu_2$$

Remarks:

H_0: There is no influence of the *STEAM* approach in the Project Based Learning Model on the learning outcomes of class XI MIA students at SMA Negeri 7 Takalar studying colloid subject matter

H_1: There is an influence of the *STEAM* approach in the Project Based Learning Model on the learning outcomes of class XI MIA students at SMA Negeri 7 Takalar studying colloid subject matter

μ_1: Average score of students in the experimental class

μ_2: Average score of students in the control class [13].

The hypothesis in this research was tested using the t test with the following steps:

1) Find the pooled standard deviation

$$dsg = \sqrt{\frac{(n_1-1)V_1 + (n_2-1)V_2}{n_1 + n_2 - 2}}$$

Remarks:

n_1: Number of experimental class data

n_2: Number of control class data

V_1: Experimental class data variance

V_2: Control class data variance

Dsg: Combined standard deviation value

2) determined t-count: $t = \frac{\bar{X}_1 - \bar{X}_2}{dsg\sqrt{\frac{1}{n_1} - \frac{1}{n_2}}}$

Remarks:

n_1: Number of experimental class data

n_2: Number of control class data

$\bar{X}_1$: Experimental class average

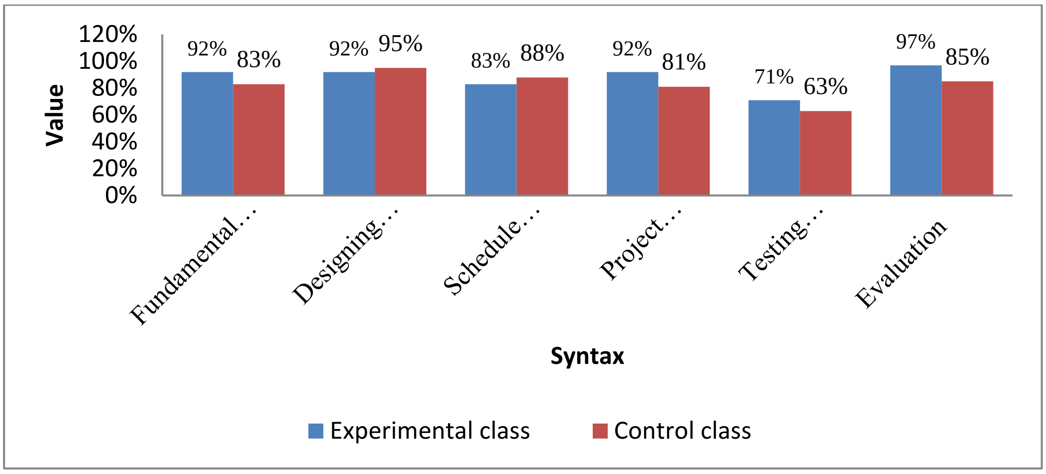
$\bar{X}_2$: Control class average

Dsg: Combined standard deviation value

The criteria for hypothesis testing are α = 0,05 with degrees of freedom "derajat kebebasan (dk)" = (n_1 + n_2 - 2) (Puspita, 2020). Because $t_{count} > t_{table}$, hence H_0 is rejected and H_1 is accepted meaning that there is an influence of the *STEAM* approach in the PjBL Model on student learning outcomes.

DISCUSSION RESULT

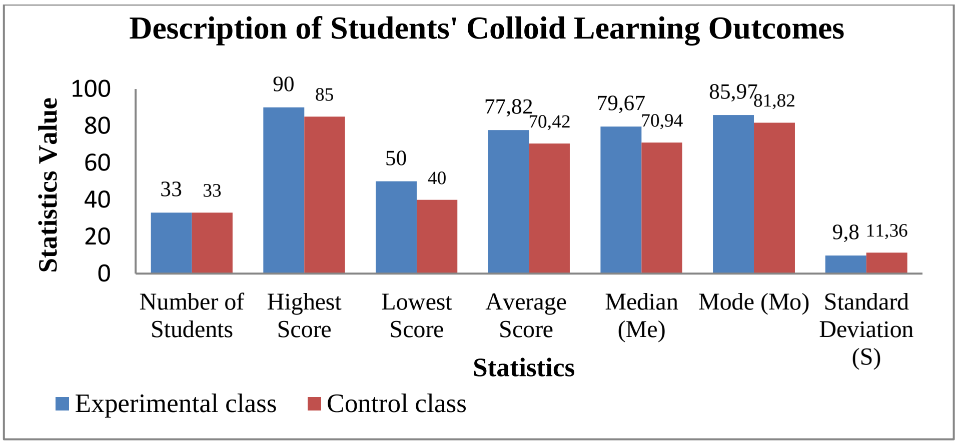
The results of descriptive statistical analysis for observing student activitis involving two observers can be seen in Ficture 1.



Ficture 1. Results of Average Observation of Activity of the PjBL Model Students

The average activity of students (four meetings) in both classes (Table 1) is in the very high category. This means that the *STEAM* Approach in the PjBL Model only contributes 5.36% of activity in the learning process. In the Syntax test, the results of both classes were in the high category. Teachers are still lacking in guiding students to test project results. However, this can be used as a reference for further learning if you use the *STEAM* approach and the PjBL Model. The experimental and control classes were taught by the same teacher and the model used was the same, the only difference was that the experimental class used *STEAM* strategy, the learning outcomes of these two classes were not much diferent. However, the control class did not use the *STEAM* strategy so that the teacher was not able to manage the expected time well and the students still lacked the skills to determine the right schedule. Present result and make conclusions.

The results of descriptive analysis for learning outcome data through giving post-tests to students in both experiments and controls can be seen in Ficture 2.



Ficture 2. Description of Students' Colloid Learning Outcomes

If the colloid learning results for the experimental class are consulted with the completeness criteria (≥ 75), then in general the experimental class is in the complete class category and the control class does not meet the class complete criteria. If these scores are grouped based on the criteria for completeness, the learning outcomes of SMAN 7 Takalar students can be seen in Ficture 3.

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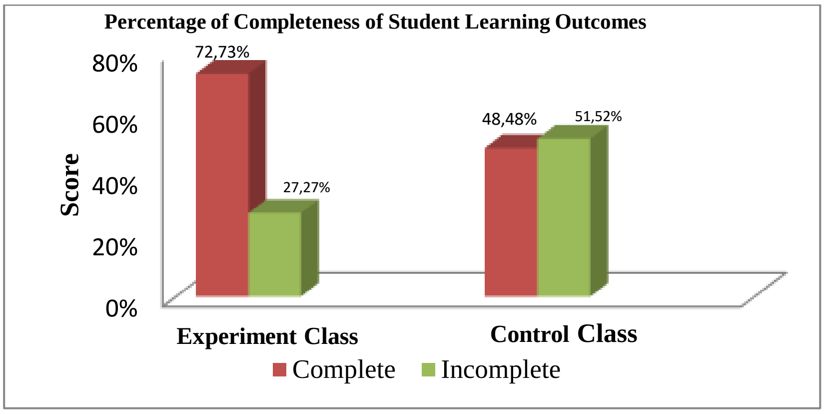

Ficture 3. Percentage of Completeness of Student Learning Outcomes

This ficture shows that the learning outcomes achieved by students in the experimental class are higher than those in the control class. A detailed description of the completion of each indicator of competency achievement in colloid system materials is as shown in Table 2.

Table 2. Completeness Category and Percentage of Achievement of Each Indicator

No	Indicator	Experimental class		Control class	
		Percentage	Remarks	Prcentage	Remarks
1	Explain the differences between crude suspensions, true solutions and colloids	75,76%	Complete	75,76%	Complete
2	Grouping colloid types based on dispersed phase and dispersing phase	54,55%	Incomplete	45,46%%	Incomplete
3	Analyze the properties of colloids (Tyndall effect, Brownian motion, adsorption, dialysis, electrophoresis, coagulation)	45,46%	Incomplete	30,30%	Incomplete
4	Relate the role of colloids in life based on their properties	45,46%	Incomplete	39,39%	Incomplete
5	Comparing between lyophobic and lyophilic colloids	78,79%	Complete	36,36%	Incomplete
6	Conclude the properties of colloids through experiments	75,76%	Complete	72,73%	Incomplete
7	Describe the process of making colloids through experiments	24,24%	Incomplete	42,42%	Incomplete
	Level of Difficulty	42,85%		14,28%	

The average percentage of completeness for each indicator in the students' colloid system material for the experimental class is higher than the control class. Of the seven GPAs, three indicators are completed and four indicators that are not completed in the experimental class. In the control class, only one indicator was completed, and six indicators were incomplete.

The results of tracing the answers to the posttest questions of experimental class students for indicators number 2, 3, 4, and 7 obtained answers that were still confusing. For example, colloid types are always confused in terms of distinguishing them from suspensions. In terms of indicators, the role of colloids is less clear because their answer considers colloids only in materials that produce sediment. In the process of making colloids, most students' completion is low because when they make projects with very different questions, they only understand what the project is about. This means that students already understand the material through PjBL learning, they just need time to understand the concept further so that examples outside the project being created can be understood.

The completeness of indicators in the experimental class can be traced through the implementation of learning, namely at each stage of the syntax in the PjBL model related to the STEAM aspects as follows:

The first syntax begins with basic questions which are used as material for exploring understanding of concepts that will be instilled by conducting questions and answers in class. Questions function to help students understand and relate the project to be created combined with aspects of science and technology which are illustrated through images and videos as well as formulating problems related to the videos shown. At this stage students are quite enthusiastic; this is made clear by the results of observations on student activities (92%).

The second syntax is designing a project plan related to the science aspect, namely knowledge about the process of making colloidal products with the indicator of compiling a list of tools and materials needed. The Engineering aspect is in the form of students' techniques in designing a project by utilizing surrounding materials, namely using cell phones to access the internet looking for information about examples of colloids, types of colloids, and properties of colloids, thereby providing their initial knowledge about the colloid products they will make. The results showed that student activity was 92%

The third syntax is to compile a schedule. Students are directed to create a timeline schedule related to aspects of mathematics, engineering, and technology which aims to manage time, carry out a design for making one of the agreed colloidal products, and utilize the use of a smartphone or camera as material for making videos of the products that have been made. Art aspects that show the suitability of time, design, and quality of video recording results. Student activity obtained by 83%.

The second meeting continued with the implementation of the fourth syntax (monitoring project progress) in the form of information literacy results about colloid products. Based on the results of observations, the percentage of student activity data was 92%.

The third meeting continued with the implementation of the fifth syntax (testing results) related to the engineering aspect of students testing the properties of colloids contained in the product. In the science aspect, students apply the concept of the properties of colloids and the process of making colloids that have been studied, the results of student activities are 71%. Followed by the syntax of concluding. All students worked on these two indicators, but the results were not optimal.

The type of project carried out by students is designing a water purification project in groups using the STEAM-based concept of coagulation and adsorption (KD. 14.4) in the PjBL model for the experimental class and a project according to the PJBL model (without STEAM) for the control class. Students are given the authority to determine the water purification project that will be carried out, based on the type of project proposed by the teacher, namely filtering techniques and sedimentation techniques. Project options for filtration techniques are: filtration with cotton cloth, filtration with cotton, and filtration with wood charcoal (activated charcoal). For deposition techniques, the project choices are to use alum, chlorine and limestone. The result is that all project options can be carried out in both experimental and control classes.

The results of project work that are assessed are: (1) accuracy in selecting tools and materials, (2) understanding their function, (3) time used, and (4) ability to explain project results related to colloids, suspensions and solutions.

The results of the assessment showed that for the experimental class which consisted of five groups, there were two groups who chose the filtration technique using cotton cloth, and three groups who chose the deposition technique using alum and chlorine. Meanwhile, for the control class, there were three groups who chose the three filtering techniques and two groups who chose the alum deposition technique. From the assessment results for the experimental class and control class, the following results were obtained for skills: (1) selecting tools and materials had a score of 78.6% and 71.3%, (2) understanding the function of the selected tools and materials had a score of 70.4 % and 52.2%, (3) time used value 87.5% and 76.2%, (4) ability to explain project results, value 53.6% and 48.4%.

Based on the project results obtained for both experimental and control classes, it shows that students in the four assessment criteria were higher in the experimental class which was given the opportunity to learn through *STEAM* in the PjBL model and the control class without giving STEAM. The results of this project work are an application of concepts or theories learned by students previously, and it can also be seen from the results of the achievement of colloid material indicators, that in the experimental class of the seven achievement indicators, only three indicators were incomplete. In the control class, it turned out that only one indicator was completed. However, both classes received an assessment regarding the explanation of project results as below complete (75%). This is because students are still awkward, have difficulty expressing opinions in good language and are not able to relate the results obtained to the properties of colloids, suspensions and solutions.

The fourth meeting continued with the implementation of the sixth syntax (evaluation of experience). GPA in this syntax is presenting the results of observations, listening to presentations made, asking/responding to presentations from other groups, and answering/responding to questions. The science aspect is demonstrated by a project report that has been created based on the colloid system concept that has been studied. The technological aspect is the use of laptops and LCD projectors to display product-making videos that have been made by students. The art aspect is in the form of the best presentation video about the product that has been made. Observation results showed that student activity data was 97%.

In the control class, only indicator one achieved 75.76% completeness. The other six indicators of completion are very low or do not meet completion standards. Even though in the implementation of learning the results obtained through syntax work are higher, around an average of 89%, students still lack the skills to determine the right schedule, present the results, and make conclusions. This is related to increasing the ability to remember so that the cognitive score is very low, this situation shows that students still have difficulty working on questions at a high level, especially at cognitive level C5-C6, only about five people can do them correctly.

Another cause is that the time for implementing learning is limited so that there is material that has not been completed properly during the learning process and students are sometimes confused about what is instructed by the teacher.

The results of inferential statistical analysis were used to test the research hypothesis, namely whether or not there was an influence of the STEAM approach in the PjBL Model on student learning outcomes on the subject matter of colloid systems. Before testing the hypothesis, a prerequisite test is first carried out consisting of a normality test and homogeneity test on data from both experimental and control classes for student learning outcomes.

The prerequisite test uses the chi-square test statistic (χ^2), where data is categorized as normal if $\chi^2_{\text{count}} < \chi^2_{\text{table}}$. The calculation results show that the data comes from a normally distributed sample, because $\chi^2_{\text{count}} < \chi^2_{\text{table}}$. Experimental class (7,602 < 7,815), for the experimental class $\chi^2_{\text{count}} < \chi^2_{\text{table}}$ (7, 156 < 7, 815).

Homogeneity test with test criteria, namely if $F_{count} < F_{table}$ then the experimental class variance or control class variance is homogeneous. The calculation results show that both the experimental class and the control class (1.36 < 1.80) come from a homogeneous population.

Homogeneity test with test criteria, namely if $F_{count} < F_{table}$ then the experimental class variance or control class variance is homogeneous. The calculation results show that both the experimental class and the control class (1.36 < 1.80) come from a homogeneous population.

Hypothesis testing is used to test H_0 and H_1, based on the prerequisite test results it is known that data from the experimental group and control group are normally and homogeneously distributed. So, hypothesis testing is carried out using the t-test.

It can be seen that the results of the t-test, obtained a thitung of 2,83 and ttable 1,99 at a significance level (α) = 0,05 where tcount > ttable. Which H0 is rejected and H1 is accepted. The results of the analysis of these data can be concluded that there is an influence of the STEAM approach in the PjBL Model on the colloid learning outcomes of students in class XI MIPA 2 SMA Negeri 7 Takalar. This result is also clarified by the research results of [14]. Learning with the PjBL model where students in groups are asked to create a project together and present the results of the project created further activates students' thinking [15].

CONCLUSION

Based on the results of data analysis and discussion. The average learning result of the experimental group was 77.82 in the good category and the control group was 70.42 in the good category, and tcount was 2.83 and ttable was 1.99 at the significance level (α) = 0.05, which means tcount > ttable. H_0 is rejected and H_1 is accepted, which means that there is an influence of the STEAM approach in the PjBL Model on the colloid learning outcomes of students in class XI MIPA 2 SMA Negeri 7 Takalar.

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