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# The Effect of Project-Based Learning Model on Student Learning Outcomes on Colloidal Material

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**Abstract**

Project-based learning can improve student learning outcomes in chemistry learning which is classified as difficult because students are given the opportunity to be directly involved in learning. This study aims to determine effect of the PBL model on student learning outcomes on colloidal material. The method used in this research is quasi experiment. The research sample consisted of two classes including XI IPA 1 and XI IPA 2 which were selected by purposive sampling. The instrument in this study is a multiple choice test of colloidal material that is valid and reliable. Data analysis using the independent sample t-test with a significance level of 5% and obtained an Asymp.Sig (2-tailed) value of 0.00 < 0.05 so that $H_0$ was rejected and $H_1$ was accepted. From the conclusion it can be stated that there is a difference in the average posttest value using the PjBL model with the conventional learning model. From the results of the posttest scores, it was found that the average value of the experimental class was greater, namely 86, 27 while the control class was 76, 73. Therefore, it can be concluded that there is an effect of the PjBL model on student learning outcomes on colloidal material..



## 1. Introduction

Education is an integral part of development (Hamalik, 2019). Education has the aim of directing the development of all the potential possessed by a person towards perfect development, such as physical, intellectual and ethical development (Rasyid, 2019). Quality education, according to UNESCO, is inclusive, relevant and results-oriented (Susilawati, 2024).

Learning outcomes are an achievement of educational goals in students who have gone through a series of teaching and learning activities (Purwanto, 2019). Learning outcomes are also a way of measuring whether students have done deep learning or not (Parwati et al., 2018). The cognitive domain is a domain that is often used in the assessment of learning outcomes. The cognitive domain is the domain that focuses on mental or brain activities. Salsabila et al., (2023) stated that when someone does activities using the brain, the person will use cognitive abilities that will help develop the ability to think rationally.

The cognitive process, according to Nafiati (2021) is a classification of students' cognitive processes as a whole in which there are educational goals. Therefore, the cognitive process in the assessment of learning outcomes is very necessary to see whether the completeness of the material has been successful or not. Chemistry is a difficult subject matter. Based on Johana et al., (2023) chemistry lesson test scores, there are still students who score below the minimum completeness criteria, so it can be said that chemistry is difficult. Colloidal material is a material that is included in chemistry subjects. Hernandes & Yusmaita (2023) said that the test results obtained still have students who score below the minimum completeness criteria. The minimum completeness criteria that are not met are influenced by several factors, one of which, according to Slameto (2010) is the learning method.

In addition, Siahaan et al., (2020) describe that learning colloidal material in SMA and MA is more inclined not to use mathematical calculations like other chemical materials. Therefore, if the colloidal material when learning using a lecture or discussion learning model, it will make students bored and ignore the material. In chemistry subjects, there are still those who use conventional learning models or are teacher-centred. Teacher-centred centered is learning where the teacher focuses on providing direct direction on teaching material so that students will be less likely to explore the material being studied (Sucipto et al., 2023). Awi et al., (2020) also, said that colloidal material that does not focus on students will make students not feel called to be active, and when doing learning in the classroom, students will experience boredom.

According to Djalil et al., (2023) also reflected that colloidal material has moderate and even high learning difficulties. Therefore, if the colloidal material is only focused on the explanation, the learning experience will feel less meaningful. These results are similar to Hernandes & Yusmaita (2023) the results of student tests on colloidal material that did not reach the minimum completeness criteria, of the minimum completeness criteria were 62% of 79 students. Therefore, colloidal material is quite a difficult chemical material.

Colloidal material, to be understood with a long memory by students, requires learning activities that focus on students or called student-centred. These learning activities can involve several students working together to find solutions to the questions provided. Colloidal material is material that is closely related to everyday life, such as perfume and milk. Understanding colloidal material to be remembered in the long term requires learning that involves students directly diving into learning the material in depth. Colloidal material is material that can be learned by making a product because in this material, there is information about the phases. Phases are special treatments before and after the experiment in making a certain product. Colloidal material includes chemical material. Natural science learning emphasises teaching on several elements such as attitude, process, product, and application (Zulfiani et al., 2009). Therefore, a learning model is needed that supports the elements of natural science learning, such as the project-based learning model.

Adnan & Mustolikh (2022) revealed that project-based learning is a learning method that uses projects/activities as media. This method can make students explore, assess, interpret, synthesise, and create information to produce forms of learning outcomes. Then, project-based learning Setiawan et al., (2022) is an innovative learning model where students work independently to work on projects that aim to construct/build their learning.

According to Zhou (2023) project-based learning has a positive impact on students' learning activities such as active thinking skills, hands-on skills and teamwork skills. In addition, Project-Based Learning is a learning model that can help students develop more thoroughly and adapt to future projects. Meanwhile, according to (2021)(Anwar et al., 2021), project-based learning makes students active, enthusiastic, and happy in learning, and projects can also improve student learning outcomes. Based on the background previously described, it can be said that the project-based learning model is expected to have a positive impact on student learning outcomes on colloidal material, which contains more reading material than calculations, with direct learning experiences.

## 2. Materials and Methods

This research was conducted in the even semester of the 2023/2024 academic year at Triguna Utama High School, which still applies conventional learning models. The research method used in this study uses quantitative research methods with quasi-experimental design as the method used. The population in this study was $11^{th}$ the Grade of the Science Program. The sample consisted of two classes, namely 37 students of class XI IPA 2 as the experimental class and 37 students of class XI IPA 1 as the control class. Purposive sampling is a technique used in sampling.

The data collection technique used in the study is 26 26-question choice test. Before the test is given to students, a prerequisite test of items is carried out first such as validity, reliability, difficulty level of questions and differentiating power. Content validity testing of learning outcome test items was carried out by 2 lecturers who were material expert validators, and the empirical validity test obtained there are 26 valid questions using product moment correlation in SPSS v. 22 with a significance 5%. The reliability test used is Cronbach's alpha in SPSS v. 22. And for the difficulty level test obtained 17 questions of the medium category and 9 questions in the easy category. The last step of a prerequisite test is differentiating power, which involves 23 questions, including the sufficient category and 3 questions in the good category.

Data analysis carried out there are two, namely the pre-requisite test and the t-test (hypothesis). The prerequisite test is based on two tests, namely the normality test and the homogeneity test. The t-test (hypothesis) using the independent sample t-test.

## 3. Results and Discussions

This study aims to see the effect of the learning model used in this study, project-based learning is a model that aims to see the effect. The research used two classes, namely the control class XI IPA 1 and the experimental class XI IPA 2, with each class consisting of 37 students. The test instrument used is a cognitive knowledge test using multiple-choice questions. The test carried out in this study was carried out twice, namely during the pretest (conducted before treatment) to determine the initial ability of students and the posttest (conducted after treatment). However, before the implementation of the pretest and posttest instrument, questions need to be validated by expert lecturers and tested. The multiple choice question instrument was empirically tested on class $12^{th}$ grade science. The results obtained from the empirical test were then tested for validity and reliability as stated by Supardi (2017)which states several requirements for questions to be suitable for use in research, some of which must be valid and reliable. The empirical test was conducted in a class $12^{th} of$ science students with a total of 36 students. From the validity test results, 26 valid multiple-choice questions were obtained. Then, the reliability test was processed using SPSS v. 22 and displayed reliability statistics results with a Cronbach's alpha of 0.806. From these results, it is said that the degree of reliability is in a high category, so it is feasible to use in research. Questions that pass the instrument test can be used for pretest and posttest questions.

From the research results obtained based on the pretest results in Table 1.

**Table 1.** Pretest result data

| Data | *Pretest* | |
|---|---|---|
| | Control Class | Experimental Class |
| Sample | 37 | 37 |
| Minimum Value | 12 | 8 |
| Maximum Value | 62 | 50 |
| Mean | 32,62 | 28,22 |

Based on Table 1, the pretest results show that the average experimental score is 28, 22 while the control class obtained an average score of 32, 62. After completing the pretest, the results were analysed with a pre-requisite test whose normality test results (sig. 0.200 > 0.05 and sig. 0.200 > 0.05) in the control and experimental classes and had homogeneous data variance (sig. 0.56 > 0.05). Then, based on the t-test (Independent sample test), the pretest data can be seen in Table 2.

**Table 2.** T-test pretest Result

| **significance level ($\alpha$)** | **Sig.(2-tailed)** | **Conclusions** |
|---|---|---|
| 0,05 | 0,110 | Sig (2-*tailed*) > 0,05 ($H_0$ accepted) |

Based on the pre-test data in Table 2, it can be seen that the two classes do not have a significant difference in the average learning outcomes. From the sample prerequisite test, the results showed that the pretest obtained showed that the two classes used as samples had similar initial abilities, so they were suitable for use as research samples. The basis for determining the control and experimental classes is seen through the average pretest score. Based on the pretest value, XI MIPA 2 class is a class that obtains a smaller pretest average value, and XI MIPA 1 is a class that obtains a larger pretest average value. Therefore, the XI MIPA 2 class was taken as the experimental class, and the XI MIPA 1 class was taken as the control class.

The next research results seen are the posttest scores of students, which can be seen in Table 3.

**Table 3.** Posttest result data

| Data | Posttest | |
|---|---|---|
| | Control Class | Experimental Class |

| | | |
|---|---|---|
| Sample | 37 | 37 |
| Minimum Value | 62 | 65 |
| Maximum Value | 96 | 100 |
| Mean | 76,73 | 86,27 |

Based on Table 3, it can be seen that the experimental class has an average value of 86.27, in contrast to the average value of the control class, which has an average value of 76.73, which can be interpreted to mean that the control class has a smaller average value compared to the value of the experimental class. In the control class, although the model used is a conventional learning model during learning, the teacher applies interaction learning with students so that students can digest the information conveyed by the teacher, even though during the learning, the teacher dominantly provides explanations to students. The interaction that occurs between teachers and students is carried out through a fluid question-and-answer communication process, based on Rosarian & Dirgantoro (2020) which states that a comfortable and pleasant classroom atmosphere is the hope for all class members, so that learning objectives can be achieved. So that when the posttest is given, students experience an increase in learning outcomes. In the experimental class, the model used is the project-based learning model in the learning process, where students are more dominant in building and searching for information related to the project planned by the teacher. Thus, students have a very large increase in learning outcomes. However, the learning model used in the experimental class has a greater improvement than the learning model used in the control class.

Posttest data obtained from both classes that have been processed found that the data is normally distributed with a significance value (sig. 200 > 0.05 and 0.066 > 0.05) in the control and experimental classes, and the data variance is also homogeneous (sig 0.706 > 0.05). Then, for the posttest data hypothesis test can be seen in Table 4.

**Table 4.** Hypothesis post-test result

| Significance level ($\alpha$) | Asymp sig (2-*tailed*) | Kesimpulan |
|---|---|---|
| 0,05 | 0,000 | Sig (2-*tailed*) < 0,05 ($H_0$ rejected) |

Based on table 4, it can be said from the value of the significance level which is smaller than 0.05, it is said that there is a difference in the average learning outcomes of both the experimental class and the control class. Therefore, it can be stated that there is an effect of the project-based earning model on student learning outcomes on colloidal material.

The learning outcomes obtained in the experimental and control classes are different due to the provision of different learning activities. The Learning Implementation Plan is a tool used as a reference in learning activities in both classes. The learning activities of the two classes were four meetings. The control class is a class whose learning activities focus on the teacher as the centre in providing colloidal learning material to students by displaying PowerPoint slides to students, regarding related material that is important to convey in colloidal material. During the learning process in the classroom, it was seen that the atmosphere of the class where students was not very active; in other words, passive. This is because some students are still trying to process the explanation explained by the teacher and some are silent, and there are also students who seriously listen to the teacher's explanation and take notes. So, in this learning process, students tend to only listen and record the teacher's explanation, in digest the knowledge of colloidal material explained by the teacher. This is in line with Muna (2020) what states that the natural science learning model that uses conventional methods will make the learning process ineffective because it focuses on the teacher's explanation, and Muna (2020) also said that the natural science learning model is suitable for methods that make students enthusiastic in participating in learning. Educators in this case try to conduct ordinary tests to see the extent to which students understand the colloidal material that has been explained by the teacher by asking questions and answers, which is based on Harefa & Widiastuti (2022) who explain that questions and answers can foster student activity from passive to active.

The experimental class used refers to the steps used by Hikmah (2020) which have the following stages starting with determining the fundamental question, creating a project design, scheduling, monitoring project progress, assessing results and evaluating the experience. The control class was treated differently by using a conventional learning model. The experimental class begins by determining the basic questions that have been presented in the student worksheet. The basic questions in the learner worksheet contain questions for students about how the steps in the process of making a colloidal product that has been planned, such as making dish soap, doughnuts, ink, mayonnaise and agar-agar. In addition to the steps, students are also given questions to find the dispersed and dispersing phases of the colloidal system, the properties of colloids that exist in colloidal systems and how to make colloidal systems in these products. After that, students are also asked questions about the conclusions of the products in each group regarding the relationship between the dispersed and dispersing phases, properties and how to make colloids for these products. Mayasari et al., (2016) stated that fundamental questions can make students actively motivated to transform information so that it can bring retention and personal development. Determining this fundamental question, the teacher monitors students in the process of solving the fundamental question by motivating students so that students' enthusiasm increases to find answers related to determining this fundamental question.

The second step after determining the basic question is to make a project design. At this stage, students list the needs of goods or materials used in making projects through the information available in the learner worksheet by discussing with fellow group members. The process of making project design is a core activity to build the concept of the formation of a project, such as determining the tools and materials. If the tools and materials are not provided, the product of a project will not exist. Therefore, the project-based learning model is a model as an alternative learning strategy that teachers can use in classroom learning and is also effective in helping students develop ideas, ideas and thinking skills to solve problems (Nuraini, 2023).

The third step is compiling schedules. In compiling these schedules, students negotiate in advance with the directions given by the teacher to their groupmates in completing the project they will make. This third step is a stage that makes students try to do problem solving to find a solution that must be resolved, and not to forget to learn to collaborate and work on projects with enthusiasm. The method used in this third step is to make students inevitably direct to arrange their scheduling from the planning step to presenting the project that students have made. Arranging scheduling is one of the important parts to pay attention to because, from the stages of arranging scheduling it provides benefits for the project-based learning model itself, as said by Jusita (2019), namely if implemented properly project based learning will make students learn practice in managing projects, allocating time properly, and being able to use equipment to complete tasks efficiently. In preparing this schedule, the educator participates in each group to ensure that the making of a project runs smoothly or there are If there are obstacles, the teacher provides solutions to be able to complete the project on time.

The fourth step is project completion, along with teacher monitoring. This step is a stage where students have brought the tools and materials needed to make projects according to what projects that have been assigned to each group. The tools and materials used have been prepared from home some and there are some materials that have been prepared by educators to be used by students in making the project. In this step, educators only have the authority to monitor students' activities in completing the projects they make. Lucas (2007) makes it clear that if students have difficulty in completing the project, they can ask the educator, so that the educator can provide solutions to the students. Educators also ensure that the projects they make are by the step available so that the results are also as expected. This is by the statement that Arfandi & Samsudin (2021) which states that the task of educators as facilitators is to have a function to provide academic services in the form of facilities needed in learning activities.

The fifth step is the assessment of the results at the same time as the presentation made by each group. The assessment of these results was carried out by looking at the results of the presentations made by each group regarding the findings obtained in each group. The findings relate to matters related to colloids, about the properties of colloids, both dispersed and dispersing phases and how to make colloid systems in each group. Then, students are welcome to ask questions and get answers about things that have not been understood about what has been explained during the presentation from their friends. During the question and answer process, the teacher gives directions and maintains the students' enthusiasm to listen and record important points that have been explained by their friends, so that the output feels very useful and is remembered for a very long period. Then, after all groups have made presentations, they go to the last stage, namely the evaluation of project results.

The final step of the learning model project-based learning is an evaluation of the experience. Wicaksono et al., (2023) said that evaluations aim to help educators and students understand learning success, assess individual and group progress, as well as identify areas that need improvement and change. At this stage of experience evaluation, each group can express their feelings during the implementation project, both the difficulties and the benefits that students get in learning by making a project in the learner worksheet that has been provided. If this stage of experience evaluation is missed, there will be several consequences, such as a lack of accurate feedback, errors in decision-making and low motivation (Wicaksono et al., 2023). Therefore, it is important to evaluate this experience to be conveyed in as much detail as possible. This experience evaluation can be a handle for teachers in conducting evaluations to improve the quality of teaching that can be carried out by students.

This project-based learning makes students enthusiastic about participating in learning activities in the classroom, because it is closely related to something common in daily life, such as making dish soap, ink, doughnuts, gelatin and mayonnaise, and it turns out to be easy to apply directly to colloidal materials so that they can be remembered by students. Colloidal material, if not included in factual concepts, will make it difficult for students to understand colloid material itself. So, with the implementation of learning activities based on making a project make students more excited to learn and solve problems. As said by Guo et al., (2020) About the Advantages project, based learning, that is to present a process that will eventually make students' knowledge and also be able to get ideas from what students want, so that they can promote the innovation competence of the students themselves.

## 5. Conclusions

Based on the results of the research and data analysis, it can be concluded that the project-based learning model can affect student learning outcomes in colloidal materials. This is because the results of the hypothesis test using the independent sample t-test show that the value of Sig (2-tailed) is 0.00. Therefore, with a significance value of $0.00 < 0.05$, it can be said that it is

$H_1$ accepted and $H_0$ rejected which can be interpreted as a difference in the average value of treatment *with* the project-based learning model and the conventional learning model.

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