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Influence of Project-Based Learning Models and Logic Mathematics on Learning Outcomes in Basic Chemistry

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Abstract: This study aimed to determine the effect of project-based learning models and logical-mathematical intelligence on basic chemistry learning outcomes. This research was conducted at the Department of Chemistry Education FKIP UHO with 68 students selected by random sampling. The research method used is quasi-experimental with a treatment design by level 2x2. Data analysis used ANOVA with significance of 0.05. The results showed that: (1) the learning outcomes of students taught using the project-based learning model were higher than those taught using the direct learning model, (2) there was an interaction effect between the learning model and logical-mathematical intelligence on the learning outcomes of basic chemistry, (3) student learning outcomes of basic chemistry taught using a project-based learning model are higher than those taught using a direct learning model for groups of students who have high mathematical, logical intelligence, (4) learning outcomes of basic chemistry students taught with a project-based learning model are higher lower compared to those taught by direct learning models for groups of students who have low mathematical, logical intelligence.

Keywords: project-based learning, direct learning, mathematical logical intelligence, learning outcomes.

基于项目的学习模式和逻辑数学对基础化学学习成果的影响

摘要：本研究旨在确定基于项目的学习模式和逻辑数学智力对基础化学学习成果的影响。这项研究是在哈鲁奥莱奥的教师培训和教育科学大学化学教育系进行的，随机抽取了 68 名学生。所采用的研究方法是准实验性的，采用 2x2 水平的治疗设计。数据分析使用方差分析，显着性为 0.05。结果表明:(1)采用项目式学习模式教学的学生的学习成果高于采用直接学习模式教学的学生; (2)学习模式与逻辑数学智能之间存在交互作用。基础化学的学习成果，(3) 对于具有较高数学、逻辑智力的学生群体，使用基于项目的学习模式教授的基础化学的学习成果高于使用直接学习模式教授的学生，(4) 学习 对于数学、逻辑智力较低的学生群体来说，采用基于项目的学习模式教授的基础化学学生的成绩高于采用直接学习模式教授的学生的成绩。

关键词：基于项目的学习、直接学习、数理逻辑智能、学习成果。

1. Introduction

The learning model is a systematic and planned way presented by educators in performing the learning process so that the accuracy of the selection of learning models by educators also determines the success of achieving learning objectives. Ideally, every educator should be able to choose a learning model that fits the characteristics of the material and the students. Nevertheless, in reality, many educators need help choosing the right learning model for the learning process. Educators are generally trapped by the word "transferring knowledge to students," so in the learning process, educators only fill students with various lecture materials. Learning is more centered on educators. Students only listen and take notes, so they are passive. This is, of course, not surprising if the current student learning outcomes are, on average not as expected.

As explained above, students' low learning outcomes were also experienced by students majoring in chemistry education, FKIP, Halu Oleo University (UHO), especially in basic chemistry courses. Basic chemistry courses are the focus of the attention of researchers because basic chemistry is a subject that is the main foundation for further mastery of chemical material. The average basic chemistry learning result for the last 3 (three) years has always been below 60. For example, the basic chemistry 1 course for the 2017/2018 academic year had an average of 56.71. For the 2018/2019 academic year, with an average of 56.63. For the 2019/2020 academic year, with an average of 58.41 and a grade distribution of 6.82% A; 44.32% B; 48.86% C. This shows that the results of learning basic chemistry 1 still need to meet expectations and are considered inadequate.

48.86% are roots of the problems that occur in the classroom. The results of reflection with the team of basic chemistry course supervisors at the UHO FKIP Chemistry Education Department revealed that the low basic chemistry learning outcomes were caused by several things: (1) so far, basic chemistry lecturers carry out learning using models direct learning that is only centered on the lecturer, the lecturer provides material systematically and gradually, students listen and take notes, there is no interaction in class either between lecturers and students or between students and students, as a result, student learning outcomes do not increase from year to year, (2) the basic chemistry lecturer did not check each student's initial abilities, so they cannot identify each student's learning readiness, (3) basic chemistry lecturers do not pay attention that student abilities vary greatly both in terms of individual potential and student learning experience, (4) basic chemistry lecturers do not provide training with analytical and synthetic questions, so students' critical thinking skills are less explored. From the results of these reflections, it can be said that in basic chemistry learning, the chemistry lecturers of FKIP UHO did not involve students actively in learning. As a result, their learning motivation was very low, leading to low learning outcomes.

The research results of McCormick et al. [1] found that learning that involves active students can increase: 1) motivation and interest in learning, 2) interaction between educators and students, 3) critical thinking skills and problem-solving, and 4) student performance. The results of the research above show that learning models that actively involve students in learning will improve their abilities to think, work and act scientifically.

One of the efforts offered by researchers, which is expected to improve the quality of learning in the classroom, is to apply a project-based learning model. The Project Based Learning (PjBL) model is a learning model that uses projects/activities as media. Learners explore, assess, interpret, synthesize and synthesize information to produce various forms of learning outcomes. PjBL is an approach that uses problems as the first step to collect and integrate new knowledge based on experience in real activities. PjBL is designed for complex problems that students must investigate and understand [2].

The research results by Lestari et al. [3] show that applying project-based learning with article products can improve student learning outcomes. The research results of Na'imah et al. [4] concluded that implementing project-based learning assisted by e-learning can improve student learning outcomes. Furthermore, Rati et al. [5] found that applying a project-based learning model significantly increases the creativity of student learning outcomes.

Based on the results of previous research above, the application of project-based learning models is very effective in improving student learning outcomes.

In the project-based learning model, students are required to have the ability to analyze concepts, investigate, and provide conclusions so that the lecturer must identify the potential intelligence possessed by students. Every human being has the potential for intelligence called multiple intelligences. Each student has a certain tendency (dominant) from the intelligence potential he has. One of the intelligence potentials possessed by students is mathematical logic intelligence.

The basis of logical-mathematical intelligence emphasizes thinking measurable activities, quantitative, and analytical. In learning based on mathematical logic intelligence, it emphasizes the ability to reason, educate, think in causal patterns, create hypotheses, look for conceptual regularities or numerical patterns, characterize something based on causation, and grouping, through a process of classification or identification [6].

Based on the description described above, it is essential to examine whether project-based learning models and logical-mathematical intelligence affect student learning outcomes.

Thus far, the application of project-based learning models is considered effective in improving student learning outcomes but does not pay attention to the potential intelligence of students.

The novelty of this research is to apply a project-based learning model by paying attention to the intelligence potential of students. Research supports strategic issues to improve the quality and access to learning.

2. Materials and Methods

The method used in this study is quasi-experimental. The research variables measured in this study include two main variables, namely the independent variable and the dependent variable. The dependent variable is the result of learning basic chemistry and the independent variable consists of two variables: a) the treatment variable, which consists of the project-based learning model (A1) and the direct learning model (A2); b) the moderator variable is logical-mathematical intelligence, which consists of high mathematical, logical intelligence (B1) and low mathematical, logical intelligence (B2). Low mathematical logic (c) conducts learning with a project-based learning model and direct learning adjusted to the results of sample selection, and (d) conducts tests of basic chemistry learning outcomes.

The sampling of this research was done by a random sampling technique. This technique is used because the taking of sample members from the population is done randomly without regard to the strata in that population [7].

The selection of samples for experimental and control classes was made by drawing lots from two parallel classes (class A and class B). Before being treated for the two classes, students were first given a mathematical, logical intelligence test using validated instruments.

Then, the mathematical and logical intelligence test results are sorted from the highest score (top rank) to the lowest score (lower rank). In this study, the determination of student groups with high and low mathematical and logical intelligence used a 27% division of the high group and 27% of the low group as a sample [8].

Based on this division, for the experimental class, which totaled 32 people, the high and low mathematical logic intelligence groups obtained each amounted to 27% x 32 = 9 people, and for the control class, which consisted of 36 people, the high and low mathematical, logical intelligence groups were obtained, respectively. Each amounted to 27% x 36 people = 10 people. Thus, the experimental and control classes were 18 and 20 people, respectively.

2.1. Data Analysis Techniques

2.1.1. Descriptive Analysis

Descriptive analysis was used to find the average price and standard deviation.

2.1.2. Analysis Prerequisites Testing

In this study, the data analysis requirements test used was the normality test and variant homogeneity test.

2.1.3. Normality Test

Normality testing was carried out using the Liliefors test. If the test results show that $L_{count} < L_{table}$, then the data tested comes from a normally distributed population with a significant level of $\alpha = 0.05$.

2.1.4. Homogeneity Test Homogeneity

The test was carried out using F or Bartlett tests. If the test results show $F_{count} < F_{table}$ or $c^2_{count} < c^2_{table}$, the data in all cells have a homogeneous variance.

2.1.5. Inferential Analysis

Testing of the research hypothesis was carried out through the analysis of variance (ANAVA).

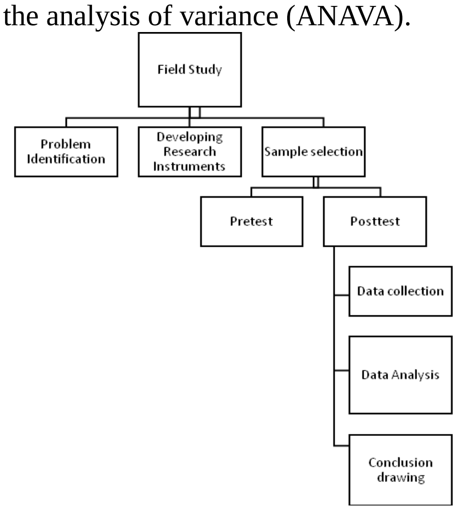

Fig. 1 Research flowchart

3. Results

3.1. Data Description

The results of the description of the data on Basic Chemistry Learning Outcomes of Students of the Chemistry Education Study Program FKIP UHO are as follows (Table 1).

Table 1 Results of descriptive analysis of research data

Mathematical logic intelligence (B)		**Learning outcomes (Y)**	
		Learning Model	
		Project-Based (A_1)	**Direct (A_2)**
Height (B_1)	n	9	10
	Mean	94.22	82.80
	SD	3.27	5.37
Low (B_1)	n	9	10
	Average	82.67	87.90
	SD	4.36	3.07

Continuation of Table 1

N	18	20
Average	88.44	85.35
SD	7.02	5.00

3.2. Testing Requirements Analysis

3.2.1. Normality Test

Based on the table, it can be seen that all prices of $L_{count} < L_{table}$, which means accepting Ho. Thus, all samples from each analysis group come from normally distributed populations.

Table 2 Summary of calculation results: the Lilliefors test

No.	Group	N	L_{table}	L_{count}	Conclusion
1	A_1	18	0,209	0,081	Normal distribution
2	A_2	20	0,198	0,144	Normal distribution
3	A_1B_1	9	0,295	0,087	Normal distribution
4	A_1B_2	9	0,295	0,224	Normal distribution
5	A_2B_1	10	0,280	0,188	Normal distribution
6	A_2B_2	10	0,280	0,098	Normal distribution

3.2.2. Variance Homogeneity Test

See Table 3.

Table 3 Summary of variance homogeneity test

No.	Dk	α	Group	χ^2_{count}	χ^2_{table}	Conclusion
1	1	0.05	A_1 and A_2	1,889	3,841	Homogeneous
2	3	0.05	4 Cells	3,5988	11,1	Homogeneous

3.2.3. Hypothesis Test

See Table 4.

Table 4 The analysis of interaction test

Sources of Variation	Free Degrees	Sum of Squares	Average squared	Fo	Ft
Average	1	90,72	90,72	5,299	4,130
row	1	73,92	73,92	4,318	4,130
Average	1	657,02	657,02	38,379	4,130
column	34	582,06	17,12		
Interaction					
Error					
Total	38	1403,71			

1. Fo = 5.299 > Ft 0.05 (1; 34) = 4.130, then Ho is rejected. It was stated that the learning outcomes of basic chemistry students who were taught with the project-based learning model were higher than those taught with the direct learning model

2. Fo = 38.39 > Ft 0.05 (1; 34) = 4.13, then Ho was rejected. It was stated that there was an interaction effect between the learning model and mathematical logical intelligence on the learning outcomes of basic chemistry.

Because there is a significant interaction effect between the learning model and mathematical logical intelligence on the learning outcomes of basic chemistry, it is continued with the Scheffe test (Table 5).

Table 5 Summary of advanced stage ANOVA results with the Scheffe test

Groups compared	Observation	dk	Criteria	Information
A_1 and A_2	5,299	1;34	4,13	Significant
Interaction	38,39	1;34	4,13	Significant
A_1B_1 and A_2B_1	12,03	2;17	2,03	Significant
A_1B_2 and A_2B_2	5,51	2;17	2,03	Significant

1. The results of the follow-up test with the Scheffe test in groups of students who have high mathematical logical intelligence show that t-count (12.03) > t-table (2.03), so that H_0 is rejected. There are differences in chemistry learning outcomes for groups of students who have high logical-mathematical intelligence between groups of students taught by the project-based learning model (A_1B_1) and groups of students taught by the direct learning model (A_2B_1)

2. Test Results Continuing with the Scheffe test on groups of students who have low logical-mathematical intelligence shows that t-count (5.51) > t-table (2.03), so that $H0_{is}$ rejected which means there are differences in chemistry learning outcomes for groups of students who have low logical intelligence mathematics between groups of students taught by the project-based n learning model (A_1B_2) and groups of students taught by the n direct learning model (A_2B_2)

4. Discussion

The results of the calculation of covariance analysis show that Fcount (5.299) > Ftable (4.13), which means that there are differences in basic chemistry learning outcomes between groups of students who are taught with a project-based learning model (A1) and groups of students who are taught with a direct learning model (A2). Based on the descriptive analysis, the learning outcomes of basic chemistry students taught with a project-based learning model had an average of 88.44. At the same time, the basic chemistry learning outcomes of students taught by direct learning has an average of 85.35. This shows that the learning outcomes of students whose project-based learning model teaches basic chemistry are higher when compared with the learning outcomes of students whose direct learning model teaches basic chemistry. The project-based learning model is a constructivist learning theory that focuses on developing students' abilities to build or construct new knowledge through project experiences. In the direct learning model, the lecturer conveys the subject matter directly, step by step, and the role of the lecturer is more dominant; thus, the lecturer is the only source of information in learning. Meanwhile, the involvement of students in the direct learning model is very less or tends to be passive because in the immediate learning process, students tend to record lessons in a form that has been arranged systematically. The learning format in the direct learning model is the lecturer delivering the subject matter structured by explaining concepts and procedures. To check student understanding, lecturers provide guided and independent exercises. Learning with the direct learning model does not facilitate students to find knowledge on their own based on experience. It is enough to wait for the information conveyed by the lecturer, and then they must understand it.

Based on Table 4, it is also found that Fcount (38.39) > Ftable (4.13), which means that there is a significant interaction effect (A x B ≠ 0) between the learning model and logical-mathematical intelligence on basic chemistry learning outcomes. In other words, learning models and mathematical, logical intelligence influence each other, and both affect basic chemistry learning outcomes.

The results of the Follow-up Test with the Scheffe Test in groups of students who have high logical-mathematical intelligence show that t-count (12.03) > t-table (2.03), so that H0 is rejected, which means there are differences in basic chemistry learning outcomes for groups of students who have high mathematical, logical intelligence between groups of students who are taught with a project-based learning model (A1B1) and groups of students who are taught with a direct learning model (A2B1). For groups of students with high logical-mathematical intelligence, basic chemistry learning outcomes of students who are taught with the project-based learning model has an average of 94.22. In contrast, the basic chemistry learning outcomes among students taught with the direct learning model has an average of 82. 80. Thus, it can be concluded that the learning outcomes of basic chemistry taught by the project-based learning model are higher than those taught by the direct learning model for groups of students who have high mathematical and logical intelligence

Students with high mathematical and logical intelligence tend to enjoy learning activities related to material calculations or those that require high critical thinking skills, such as stoichiometry, chemical thermodynamics, reaction rates, solutions, and chemical equilibrium. In order to master solution material, for example, especially the pH of the solution, students must not only understand the concept of solution chemistry but also master the properties of logarithms and solve other mathematical operations. Because it can make it easier for students to learn materials related to numbers or materials that require a very high understanding. Learning that applies a project-based model follows the characteristics of the material presented, namely stoichiometry, chemical thermodynamics, and chemical equilibrium, which can foster the ability to think logically, develop problem-solving skills, use mathematical operations, and analyze causal relationships. Thus, the results of basic chemistry learning for students who are taught using a project-based learning model are higher than the outcomes for basic chemistry students who are taught using a direct learning model for students with high logical-mathematical intelligence. This is because in the learning process with the direct learning model, the role of the lecturer is more dominant, and students tend to receive more information. This means that students with high logical intelligence are more suitable to be taught with a project-based learning model than a direct learning model. Meanwhile, the project-based learning model is an inductive learning model that fits students with high logical-mathematical intelligence characteristics.

The results of the Advanced Test with the Scheffe Test in groups of students who have low mathematical logic intelligence show that t-count (5.51) > t-table (2.03) so that H0 is rejected, which means there are differences in Chemistry learning outcomes for student groups who have low mathematical, logical intelligence between groups of students who are taught by the project-based learning model (A1B2) and groups of students who are taught by direct learning models (A2B2). Find out which is higher can be seen from the average learning outcomes. For the group of students who have low mathematical and logical intelligence, the learning outcomes of basic chemistry students who are taught the project-based learning model have an average of 82.67. In contrast, the learning outcomes of basic chemistry among students whom the direct learning model teaches have an average of 87.9. Thus, it can be concluded that the learning outcomes of basic chemistry taught by the project-based learning model are lower than those taught by the direct learning model for groups of students with low mathematical and logical intelligence. This is due to the characteristics of students with low mathematical and logical intelligence who tend to be more dependent on the direction and explanation of the lecturer in the learning process. Students with low mathematical and logical intelligence in the learning process with direct learning models benefit more because learning material will be received directly without having to construct new knowledge. Meanwhile, students with high logical-mathematical intelligence who tend to be active and like constructive and exploratory activities will easily get bored and unmotivated in the learning process when the learning model is directly applied so that it has an impact on the learning outcomes obtained.

The findings above agree with what was stated by Gersten et al. [9] in that "direct instruction to be more effective for students with learning disabilities, direct learning is more effectively given to students who have learning disabilities. This means that the lower the ability of students to explore their knowledge, the more effective direct learning is applied [10]-[13]. In other words, students who have low mathematical and logical intelligence will be more effectively taught with the direct learning model than the project-based learning model; therefore, the results agree with the findings that the basic chemistry learning outcomes taught with the project-based learning model are lower than those taught with the direct learning model for students who have low mathematical logic intelligence.

5. Conclusions

Based on the results of research and discussion, it can be concluded that the basic chemistry learning outcomes of students taught with project-based learning models are higher than those taught with direct learning models. There is an interaction effect between learning models and logical-mathematical intelligence on basic chemistry learning outcomes. The basic chemistry learning outcomes of students taught with project-based learning models are higher than those taught with direct learning models in groups of students who have high logical-mathematical intelligence. The basic chemistry learning outcomes of students taught with project-based learning models are lower than those taught with direct learning models for groups of students with low mathematical-logical intelligence.

This finding is in line with what was stated by Gersten et al. [9] that "direct instruction to be more effective for students with learning disabilities, direct learning is more effective given to students who have learning disabilities. This means that the lower the ability of students to explore their knowledge, the more effective direct learning is applied. In other words, students who have low mathematical and logical intelligence will be more effectively taught with direct learning models than with project-based learning models, so the results agree with the findings that basic chemistry learning outcomes taught with project-based learning models are lower than students taught with direct learning models for students who have low mathematical logical intelligence.

This research provides practical implications for teachers and educators in teaching basic chemistry. Project-based learning models and mathematical logic can be used as an effective alternative to improve student learning outcomes. Teachers can integrate chemical concepts with real projects and provide reinforcement of mathematical logic in basic chemistry learning.

The strength of this study is the use of a controlled and structured research method, namely experimentation. This allows researchers to control variables that affect student learning outcomes and ensure the validity of research findings. The limitation of this research is that the limited research time may affect the range of materials covered in the study. This study may only cover some topics or concepts in basic chemistry, so it does not cover the entire basic chemistry curriculum.

The recommendation for future research is to involve a larger sample of students from various schools or regions. This can help in generalizing the research results to a wider population of students. Future research can expand the scope of subject matter covered in the learning. For example, the research could involve more in-depth basic chemistry concepts or more complex subject matter. In addition, research can compare the effectiveness of project-based learning models and mathematical logic with other learning methods, such as conventional learning. This can provide a more comprehensive understanding of the advantages and disadvantages of each method.

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