

ANOVA'S TWO-WAY ANALYSIS OF STUDENT LEARNING OUTCOMES BASED ON LEARNING MODELS (PBL AND DISCOVERY LEARNING) AND GENDER IN SOLAR SYSTEM MATERIALS

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Abstract: This study aims to investigate the impact of the Problem Based Learning (PBL) and Discovery Learning learning models, the influence of gender, and the interaction between learning models and gender on students' educational outcomes on the Solar System material for grade VII. This study adopts a quantitative approach and applies a quasi-experimental research method. The sample used in this study consisted of 40 grade VII students at SMP Krispa Silian which were divided into two groups, namely the group that participated in learning with the Problem Based Learning (PBL) model and the group that participated in learning with the Discovery Learning model. Data on learning outcomes were collected through pretest and posttest tests, then analyzed using descriptive statistics, normality tests, homogeneity tests, and Two-Way ANOVA analysis with the help of SPSS software. The results of the study showed that the learning approach had a significant impact on the academic achievement of students with a significant score of less than 0.001 (less than 0.05). The average academic achievement of students taught using the PBL method was 26.60, which was higher than that of students taught using the Discovery Learning method which only reached 17.45. On the other hand, the gender factor did not show a significant impact of academic achievement on the material of the Solar System of students with a score of 0.183 (more than 0.05). In addition, there was no significant interaction between the learning approach and gender on the academic achievement of students with a score of 0.974 (more than 0.05).

Keywords: Two-Way ANOVA; Problem Based Learning; Discovery Learning; Solar System

1. INTRODUCTION

Education in this modern era requires students to develop critical thinking skills, innovate, work together, and face challenges in daily life. In science learning, students are not only required to master concepts, but also be able to understand the scientific process through active and meaningful learning experiences, so that choosing the right learning model is an important factor in improving student learning outcomes. According to Paramitha et al (2022), a creative learning model can have a good impact on students' learning achievements.

An example of an issue that is still often found in teaching science in educational institutions is that student learning outcomes that are below average are caused by teaching methods that are still dominant from the teacher. Tuti (2021) revealed that students are still not used to thinking critically, creatively, and analytically, which has an impact on low science learning outcomes. This situation shows that science teaching requires a way that can actively involve students in learning activities.

Fauzan, Gani, and Syukri explained that the implementation of the PBL model on the topic of the Solar System can increase students' learning achievement when compared to traditional teaching methods. The research that has been conducted by Junaedah and Ibrahim (2020) shows that the application of the PBL model on the topic of the Solar System is able to significantly increase the completeness of students' learning. The Discovery Learning Model is also widely applied in science teaching because it can encourage students to find their own ideas or ways through the process of observation and discovery. Pangesti et al (2021) in their meta-analysis study found that the Discovery Learning model has a positive impact on improving science learning outcomes of students at the elementary school level.

Another study conducted by Anggelina et al (2022) shows that there is a difference in effectiveness between the PBL and Discovery Learning models in improving science learning outcomes of elementary school students. The results of the study show that both models have their own characteristics and advantages in the learning process, so further research is needed to find out which learning model is more effectively applied to certain materials, especially the Solar System material in grade VII of junior high school.

Material about the Solar System is one of the topics in the natural sciences that requires skills in visual skills, concept understanding, and scientific reasoning. Although in its application, students still often find difficulties in understanding abstract concepts in the material. Based on the results of discussions by the education community in online forums, science learning, especially solar system materials, is still often considered less interesting and not optimally taught in schools. This shows the need to implement a learning model that can increase students' involvement and understanding of the Solar System material.

Internal factors of students can also affect learning outcomes, one of which is gender. The difference in learning methods between male and female students allows for differences in terms of understanding the material and following the learning process. Kim et al (2025) stated that gender can affect students' collaborative learning preferences in mathematics learning. Thus, gender is an important variable that needs to be considered in educational research. The analysis technique that can be used in this study is Two-Way ANOVA, because it allows researchers to determine the influence of two independent variables at once, namely learning model and gender, as well as to determine the interaction between these two variables on student learning outcomes.

2. RESEARCH METHODS

The research was carried out at Krispa Silian Junior High School on May 19-20, 2026. The research sample amounted to 40 students in grade VII which were divided into two

experimental groups. The first group received learning using the Problem Based Learning (PBL) model, while the second group received learning using the Discovery Learning model. The distribution of students was carried out based on the class that had been determined by the school.

This study adopts a quantitative method to investigate a specific population or sample with the intention of testing hypotheses through statistical data analysis. Based on the opinion of Sugiyono (2022), the quantitative method is applied to objectively assess the relationship between variables by utilizing data in the form of numbers. The type of research taken is pseudo-experimental research. According to Yusuf (2020), quasi experiment research is used when the researcher does not allow the researcher to randomize subjects purely in the research group. In this study, the researcher compared the achievements of students who used the Problem Based Learning (PBL) and Discovery Learning learning models by considering the gender of students in the Solar System material in grade VII. According to Artha et al (2022), quasi-experimental research is widely used in the field of education because it is suitable for measuring the impact of the application of learning models on student learning outcomes in real classes.

The research design adopted in this study is Pretest-Posttest Nonequivalent Control Group Design. This type of design is included in the quasi-experimental category that utilizes two groups in the study without conducting complete randomization. According to Mafruudloh et al (2023), the pretest-posttest nonequivalent control group design is used to measure changes in learning outcomes before and after treatment in different experimental groups. This is in line with the view of Bayhaki et al (2023) that the use of pretest and posttest aims to measure the development of students' learning outcomes after receiving a certain learning treatment.

The data obtained from the research was then analyzed using the Two-Way ANOVA method. Sihotang (2022) stated that analysis with Two-Way ANOVA is very relevant for research in the field of education involving two independent variables and one dependent variable. Research conducted by Zainuddin (2023) also revealed that Two-Way ANOVA is often used to analyze the impact of learning models and student characteristics on their learning outcomes. Assessment with this research design is considered appropriate because it can measure differences in student learning outcomes based on learning models and gender at the same time. Bevans (2023) also emphasized that Two-Way ANOVA is useful for determining whether there is an interaction between the learning model and individual factors, such as gender or early ability, related to their educational outcomes. In addition, Harahap et al (2025) stated that the use of Two-Way ANOVA helps researchers obtain more comprehensive analysis results than one-way analysis because it considers two factors at once. Sukdee et al (2021) also

explained that this analysis is very suitable for use in experimental and quasi-experimental research because it is able to test several factors at once.

The instrument used aims to measure students' science learning outcomes on the Solar System material after applying the Problem Based Learning (PBL) and Discovery Learning learning models. The learning outcome test is used to measure students' cognitive abilities after participating in the learning process. The test is given in the form of a *pretest* and *posttest* which has been prepared in the form of multiple-choice questions as many as 30 questions based on the indicators and learning objectives to be measured.

The information collection techniques applied consist of exams, observations, and recordings. As stated by Arikunto (2021), an exam is a collection of questions or tasks used to assess an individual's capacity, knowledge, or ability. According to Sugiyono (2022), observation is a method of collecting information that is carried out by directly looking at the object of study. According to Yusuf (2020), documentation is a data collection technique through documents, archives, photos, or records related to research.

Data analysis in this study was carried out using descriptive and inferential statistical methods supported by IBM SPSS Statistics software. The descriptive statistical method serves to provide an overall illustration of student learning outcomes. Before carrying out the Two-Way ANOVA analysis, prerequisite tests were first carried out to ensure that the data met statistical assumptions, including a normality test to evaluate the distribution of research data before parametric analysis (Ghozali, 2021) and a homogeneity test to assess whether the variance of data between groups is homogeneous, because the homogeneity of variance is one of the crucial requirements in the application of ANOVA analysis (Priyatno, 2022).

3. RESULTS AND DISCUSSIONS

Descriptive Statistics of Student Learning Outcomes

This study involved 40 students from grade VII of Krispa Silian Junior High School who were grouped into two, namely the group using the Problem Based Learning (PBL) model and the group using the Discovery Learning model. The learning outcomes of the students were measured by the final test (*posttest*) after the application of the treatment with the results shown in Table 1.

Table 1. Average Learning Outcomes Based on Learning Model

Learning Model	Number of Students	Average Pretest	Posttest Average	Improvement
PBL	20	12,25	26,60	14,35

Discovery Learning	20	15,05	17,45	2,40
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Based on the data in Table 1, it shows that the average academic achievement of students who participate in learning with the PBL model is superior to that of students who use the Discovery Learning model. This average variation indicates that the type of teaching method applied has an impact on students' learning outcomes related to the Solar System material.

Normality Test

The normality test (Table 2) was created using the Shapiro–Wilk test to find out whether the learning outcome data is normally distributed or not.

Table 2. Normality Test Results

Learning Model	Shapiro-Wilk	Sig.
Problem Based Learning (PBL)	0,758	< 0.001
Discovery Learning	0,936	0,203

The results of the normality check showed that the data for the Discovery Learning group were distributed normally, as the significance value exceeded 0.05. On the other hand, the PBL group showed a significance value of less than 0.05, so the data was not completely distributed normally. Nevertheless, the analysis continued because the sample count in each group was balanced and Two-Way ANOVA was quite resilient to mild normality violations.

Homogeneity Test

The homogeneity test (Table 3) was made using Levene's Test to determine the similarity of variance between groups.

Table 3. Results of the Variance Homogeneity Test (Levene's Test)

Testing Policy	Living Statistic	df1	df2	Sig.
Based on Mean	4,976	1	38	0,032
Based on Median	3,760	1	38	0,060
Based on Median and with Adjusted df	3,760	1	37,808	0,060
Based on Trimmed Mean	5,487	1	38	0,024

A significance value of 0.032 showed that the variance between groups was not completely homogeneous. Nevertheless, the Two-Way ANOVA analysis was still carried out taking into account the relatively balanced number of samples in each group.

Results of ANOVA's Two-Way Analysis

Hypothesis testing was made using Two-Way ANOVA analysis (Table 4) to determine the influence of learning model, gender, and interaction between the two on student learning outcomes.

Table 4. ANOVA Two-Way Analysis Results

Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.
Learning Model	584,926	1	584,926	22,330	<0.001
Gender	48,241	1	48,241	1,842	0,183
Model $\times$ Gender	0,028	1	0,028	0,001	0,974
Error	943,018	36	26,195		

Based on Table 4, the teaching model shows a significance value below 0.05 which reflects a significant impact on students' learning achievements. On the other hand, the gender factor and the interaction between the teaching model and gender have a significance value above 0.05 so that it does not have a significant influence on students' learning achievements.

The Influence of Learning Models on Learning Outcomes

The results of the study indicate that the PBL method has a prominent impact on students' academic achievement related to the Solar System material. Students who use the PBL method record superior average achievement compared to students who apply the Discovery Learning method. This evidence underlines that PBL is more successful in improving students' academic achievement.

The advantage of the PBL model lies in its ability to encourage students to actively solve problems, discuss, and connect concepts with real situations. This is in line with Purba (2021) who stated that the Problem Based Learning model is problem-based learning that is able to improve students' thinking skills and science learning outcomes. Through these activities, students not only receive information from teachers, but also build their own knowledge through a process of investigation and collaboration. This condition makes learning more meaningful and has an impact on improving learning outcomes. This is in line with the views of Siregar, T et al (2025) who revealed that the application of the PBL model can improve student learning outcomes. In addition, research conducted by Junaedah and Ibrahim (2020) indicates that the implementation of the PBL model in Solar System materials can significantly increase the completeness of students' learning outcomes. Aprilianingrum et al (2021) also emphasized that the PBL model is very effective in improving critical thinking skills and understanding of

elementary school students' concepts in science lessons. Another study conducted by Saputra et al (2024) explains that problem-based learning can increase students' motivation and learning participation so that it has a positive effect on students' learning achievements.

Although the Problem Based Learning approach is more effectively applied in teaching about the solar system, the discovery learning method can still be used in other learning materials. This is as stated by Lestari et al (2022), where the Discovery Learning approach facilitates students to understand abstract concepts in science education through learning experiences directly obtained from the discovery process. Nugraheni et al (2023) also added that the application of the Discovery Learning model can increase student involvement in science learning activities. Fitania et al (2022) also mentioned that in Discovery Learning, students are expected to be active in discussing, asking questions, and concluding the results of learning. Thus, the interaction between teachers and students in this model is cooperative and focuses on student involvement in the learning process. The explanation presented by Mayuni et al (2021) also supports this, stating that the use of Discovery Learning contributes to improving science learning outcomes because students are more involved in finding the core of learning.

The Influence of Gender on Learning Outcomes

The results of the analysis prove that gender does not have a significant effect on students' learning outcomes. This indicates that male and female students have the same opportunity to achieve optimal learning outcomes in the Solar System material. The absence of gender influence shows that learning success is more influenced by the quality of the learning process than gender differences. In this study, all students received the same learning treatment, learning resources, and learning opportunities so that no significant differences in learning outcomes were found between male and female students.

Although Nurhayati et al (2021) explained that female students are generally more disciplined in completing assignments and more active in class discussion activities, meanwhile, male students prefer learning that involves hands-on activities and problem-solving. In line with the opinion of Rahmawati et al (2022), who stated that female students tend to be more meticulous, diligent, and have better verbal skills than male students. On the other hand, male students tend to be more active, competitive, and more interested in practical and exploratory activities Yusuf et al (2024) show that the influence of gender on learning outcomes can be minimized through the use of active and collaborative learning models such as PBL and Discovery Learning. In addition, the OECD (2023) has also stated that differences in science learning outcomes based on gender can be influenced by psychological factors, the learning

environment, and the learning methods used by teachers. Suryani et al (2022) also explained that differences in learning outcomes based on gender are influenced by motivational factors, learning interests, and learning strategies used by teachers

The Interaction of Learning Models and Gender on Learning Outcomes

The results of the study show that there is no prominent interaction between the learning model and gender on student learning outcomes. These findings show that the effectiveness of the learning model does not depend on the gender of the students. Both male and female students show relatively similar patterns of learning outcomes when participating in learning using PBL and Discovery Learning. Thus, the influence of learning models on learning outcomes is consistent in both gender groups. These results indicate that the selection of the right learning model is more important in improving learning outcomes than considering the gender differences of students. Therefore, teachers can apply the PBL and Discovery Learning models without the need to differentiate treatment based on gender, but rather focus on creating active, interesting, and meaningful learning for all students.

4. CONCLUSIONS AND SUGGESTIONS

CONCLUSIONS

The Problem Based Learning (PBL) model obtained higher learning outcomes on solar system materials than students who learned using the Discovery Learning model, and gender did not have a significant effect on student learning outcomes.

SUGGESTIONS

Based on the results of the research obtained, the Problem Based Learning (PBL) model can be considered as one of the effective learning alternatives to improve students' learning outcomes in Solar System materials and other science materials that emphasize critical thinking and problem-solving skills. Further research can also examine the influence of learning models on the affective and psychomotor domains so that a more comprehensive picture of student learning outcomes is obtained.

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