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Analysis of Science Process Skills: The Impact of Project-Based Learning Assisted by Mind Mapping on Biology Subjects

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ABSTRACT

This study aims to determine the influence of the Project-Based Learning model assisted by Mind Mapping on Science Process Skills in the field of biology. The research method used is a Quasi-Experimental design with a Pretest-Posttest Control Group Design. The population for this study consisted of grade XI students and sampling techniques by means of random sampling techniques. The data collection techniques used in the instrument include multiple-choice questions to assess Science Process Skills and then test the validity, reliability, level of difficulty, and discriminatory power so that the instrument is suitable for use. The data analysis technique used was Analysis of Variance (ANOVA), and the results obtained showed a significance value of $0.000 < \alpha = 0.05$, indicating that H1 was accepted and H0 was rejected. Thus, it can be concluded that there is a significant influence of the use of the Project-Based Learning model assisted by Mind Mapping on the Science Process Skills of student

Analisis Keterampilan Proses Sains: Pengaruh Pembelajaran Berbasis Proyek berbantuan Mind Mapping pada Mata Pelajaran Biologi

ABSTRAK: *Penelitian ini bertujuan untuk mengetahui pengaruh Model Pembelajaran Project Based Learning berbantu Mind Mapping terhadap keterampilan proses sains peserta didik pada mata pelajaran biologi. Metode penelitian yang digunakan yaitu Quasy Experimental dengan desain penelitian Pretest-Posttest Control Group Design. Populasi penelitian ini yaitu peserta didik kelas XI. Teknik pengumpulan data menggunakan instrumen berupa soal tes Multiple Choice Keterampilan Proses Sains yang telah dilakukan uji validitas, reliabilitas, tingkat kesukaran, dan daya pembeda, sehingga instrumen layak digunakan. Teknik analisis data yang digunakan yaitu uji Analysis of varians (Anova), dan didapatkan hasil yang menunjukkan bahwa nilai signifikansi sebesar 0,000 <* α*=0,05, dengan ketentuan* H_1 *diterima dan* H_0 *ditolak. Sehingga, dapat disimpulkan bahwa terdapat pengaruh yang signifikan penggunaan model pembelajaran Project Based Learning berbantu Mind Mapping terhadap Keterampilan Proses Sains peserta didik.*

INTRODUCTION

Life in the twenty-first century requires that students possess abilities and skills (Priadi et al., 2024), such as science process skills, creative thinking, critical thinking, and effective communication, to solve problems in the real world (Firmansyah & Suhandi, 2021). To develop 21st-century skills, teachers should train students in science process skills (King et al., 2021). This effort will result in students with creative, innovative, and critical thinking skills, as well as communication, collaboration, and problem-solving abilities (Fitriyah & Ramadani, 2021);(Sri, 2023);(Khoirunnisa & Habibah, 2020).

Science process skills are students' ability to use scientific methods to understand, develop, and discover science (Guswita et al., 2018). Science process skills prepare students to learn the scientific process that defines biology learning (Novitasari et al., 2023), which will be useful in everyday life. Science process skills are fundamental in learning and emphasize acquiring, comprehending, and communicating what has been learned. Students require science process skills to navigate a world dominated by science and technology (Nurhaliza et al., 2024);(Suryaningsih & Nisa, 2021).

Science process skills play a significant role in classroom learning development, particularly in science (Kamelia et al., 2020). With science process skills, students can apply the scientific method to gain knowledge. Science process skills enable students to develop the skills required to address everyday problems (Lisa, 2019). Science process skills highlight students' learning process, activity, and creativity in acquiring knowledge (Fauziah, 2022), skills, values, attitudes, and the ability to apply them in everyday life (Ilhami et al., 2023);(Karlina et al., 2023).

Researchers acquired the findings of students' science process skills assessments based on preliminary research at one of Bandar Lampung's high schools. The average result for students' science process skills test was 48% in the low category. Furthermore, interviews with one of the biology teachers and observations in eleventh-grade MIPA classrooms revealed that teachers did not teach science process skills to students in the Merdeka curriculum. Science process skills are fundamental skills that serve as the foundation for learning and using 21st-century skills. This is one of the variables contributing to students' low science process skills scores. Training and stimulation are required to increase students' science process skills.

One strategy is to use an innovative learning model to train students to improve their science process skills (Santoso, 2020);(Safaruddin et al., 2020). The application will help teachers deliver the subject matter in a structured manner that will interest students in understanding the subject matter allowing students to use it as a tool for developing aspects of 21st-century skills (Komarudin et al., 2020);(González-salamanca et al., 2020).

Project-based learning is a model that can help students improve their science process skills. According to Ambarsari et al. (2023), Laia et al. (2024) and Mujiburrahman et al. (2023) project-based learning is a student-centered learning model that offers students worthwhile educational experiences (Burhanuddin et al., 2023). Through project-based learning, students are given complex tasks based on difficult questions or problems that require them to engage in problem-solving activities, make decisions, conduct investigations (Safitri et al., 2024);(Ye et al., 2023), and reflect on fostering and improving students' science process skills (Kamid et al., 2022)

Furthermore, when conducting learning activities, teachers must use effective learning strategies to help students participate in activities and comprehend learning materials (Sayed & Afzal, 2021). In this case, the learning strategy is intended to help students develop their scientific process skills. One way to improve this is to include media in learning activities. Mind Mapping is a teaching tool that can help students practice their science process skills. Mind mapping is used to help students organize facts in the form of a comparison of concepts, as well as overcome students' difficulty in connecting multiple concepts they receive (Pribadi & Susilana, 2021). Mind mapping improves one of the indicators of scientific process skills: grouping. Research findings indicate that mind mapping methods or techniques can help students improve their science process skills (Hamad & Ahmed, 2021)

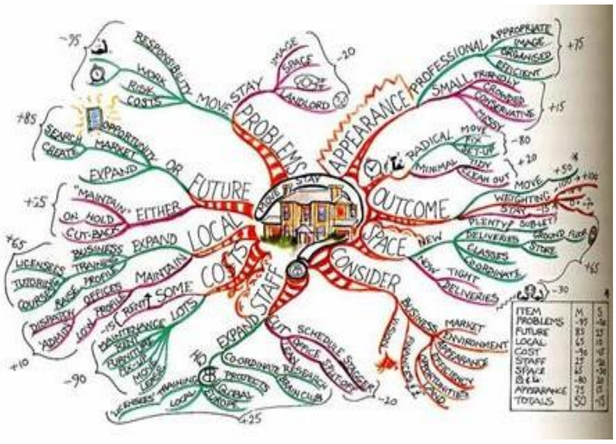

Figure 1. An Example of Mind Mapping (Nurkhin et al., 2020)

Several similar studies have been conducted, beginning with Indriani et al.'s research on the Projec-based learning model assisted by augmented reality, which can improve students' science process skills (Indriani et al., 2023). Second, using a project-based learning model with electronic media can significantly improve students' science process skills (Safaruddin et al., 2020). Third, the project-based learning model can help students improve their science process skills (Anggrella & Sudrajat, 2024);(Nurulwati et al., 2021);(Nurhidayah et al., 2021). However, based on several similar previous studies, it was necessary to create learning innovations. Thus, this study aimed to create a learning innovation in which an element of novelty was found by applying the project-based learning model assisted by mind mapping techniques chosen as a learning medium to assist students in practicing and improving their science process skills in biology.

Therefore, this study aimed to determine the impact of the project-based learning model assisted by mind mapping on eleventh-grade students' science process skills.

METHODS

This study employed quantitative methods and a quasi-experimental approach. This study took place in September 2024 at Muhammadiyah High School 2 in Bandar Lampung. This study included one independent variable (X), namely the project-based learning (PjBL) learning model, and one dependent variable (Y), namely students' science process skills. This study used a pretest-posttest control group design with two sample groups (Table 1). Class XI A, which consisted of 36 students, acted as an experimental group taught using the PjBL model, and class XI C, which comprised 36 students, acted as a control group taught using the discovery learning model. Both classes were chosen as research samples using the cluster random sampling technique.

Table 1. Research Design

Pretest	Treatment	Posttest
O_1	X_1	T_1
O_1	X_2	T_2

Source: (Andini & Rusmini, 2022)

Description:
O_1: Pretest in the experimental class
O_2: Pretest in control class
X_1: Treatment for experimental class (project-based learning)
X_2: Treatment for control class (discovery learning)
T_1: Posttest in the experimental class
T_2: Posttest in control class

In this study, science process skills data were collected via pretest and posttest instruments, which consisted of multiple-choice questions with 20 items on circulatory system material. Figure 3 depicts the seven indicators used to assess science process skills. Before testing the hypothesis, a prerequisite analysis test was performed on the science process skills test results for students in each treated class. The normality and homogeneity tests were used as prerequisite analysis, with a 5% (0.05) significance level. This data analysis technique used was the Analysis of Variance (ANOVA) test.

RESULTS AND DISCUSSION

This study's data were obtained from the results of the science process skills test (Table 2) in the experimental and control classes. These results are presented in Table 2.

Table 2. The result of Pretest and Posttest

Description	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Lowest Score	35	55	30	35
Highest Score	65	90	55	75
Average Score	46,11	77,36	42,64	54,86

Table 2 shows that each class has different maximum, minimum, and average scores for science process skills' pretest and posttest results. The experimental class has a higher post-test score than the control class. The posttest score in the experimental class ranged from a high of 90 to a low of 55, with an average of 77.36. At the same time, the control class's post-test score ranged from 75 to 35, with an average of 54.86. These findings indicate that the experimental class had a greater aptitude for science process skills than the control class. Figure 2 shows the results of the comparison diagram on post-test data from the experimental and control classes.

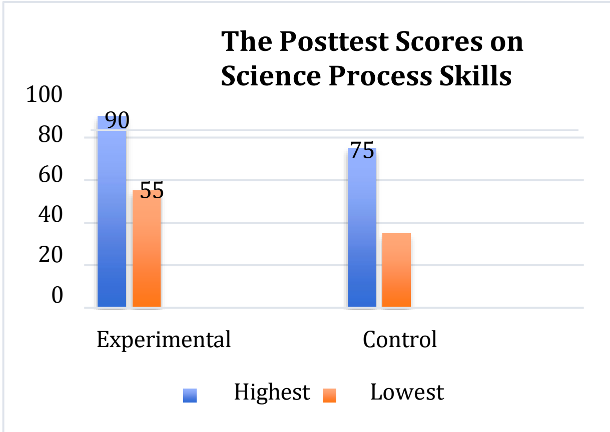

Figure 2. Comparison Diagram of Posttest Data Results of Science Process Skills

Table 3. Posttest Results of Science Process Skills Based on Indicators

Indicators	Percentage			
	Experimental	Category	Control	Category
Observing	81,67	High	61,11	Moderate
Categorizing	84,26	High	59,26	Moderate
Interpreting	80,56	High	58,33	Moderate
Predicting	78,47	High	58,33	Moderate
Communicating	70,83	High	52,78	Low
Hypothesizing	69,44	Moderate	45,37	Low
Planning an Experiment	70,83	High	40,28	Low

Table 3 shows the percentage of values listed in the experimental class for each indicator of science process skills, which is higher than in the control class. The test results of experimental and control class students were analyzed using the normality test, homogeneity test, and statistical hypothesis testing.

The first step was performing a normality test on the results of the students' science process skills. The normality test decision states that the data is normally distributed if the test data is greater than 0.05. Table 4 shows the results of the normality test.

According to Table 4, the normality test of science process skills data in the experimental class yielded a result of 0.155, while in the control class, the result was 0.103, with a significance level greater than 0.05. As a result, we can conclude that the data on science process skills in experimental and control classes was normally distributed. The next step after performing a normality test and obtaining normally distributed data was performing a homogeneity test.

Table 4. Normality Test Results of Science Process Skills

		Kolmogorov-Smirnov^{a}		
	Classes	**Statistic**	**Df**	**Sig.**
Science Process Skills	Eksperimental	,127	36	,155
	Control	,134	36	,103

Table 5 shows the homogeneity test results on the students' science process skills test data.

Table 5. Homogeneity Test Results of Science Process Skills

		Levene Statistic	**df1**	**df2**	**Sig.**
Science Process Skills	Based on Mean	,171	1	70	,680
	Based on Median	,161	1	70	,689

Based on Table 5, the homogeneity test of science process skills data yielded a result of 0.680 with a significance level greater than 0.05. Therefore, we can conclude that the data on science process skills is homogeneous. After testing the data for normality and homogeneity, hypothesis testing can begin.

This study employed the Anova test for hypothesis testing. The ANOVA test assessed the impact of the project-based learning model with mind mapping on the science process skills of the eleventh-grade students at Muhammadiyah High School 2 Bandar Lampung in biology subjects.

Table 6. Anova Test Results of Process Skills

Science Process Skills					
	Some of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	9112,500	1	9112,500	88,000	,000
Within Groups	7248,611	70	103,552		
Total	16361,111	71			

Table 6 displays the Anova test results for the science process skills data. The science process skills data has a statistically significant value of 0.000, less than 0.05. As a result, we can conclude that H_0 is false and H_1 is true. These findings show a significant difference in students' science process skills between the experimental class using the project-based learning model and the control class using the discovery learning model.

According to Wulandari et al. (2023), the research findings using the project-based learning model assisted with mind mapping in the experimental class significantly affected students' science process skills compared to the discovery learning model in the control class. This finding was caused by the learning process that employed the project-based model assisted by mind mapping. The media selection is an effective way to promote learning (Meliyani et al., 2022).

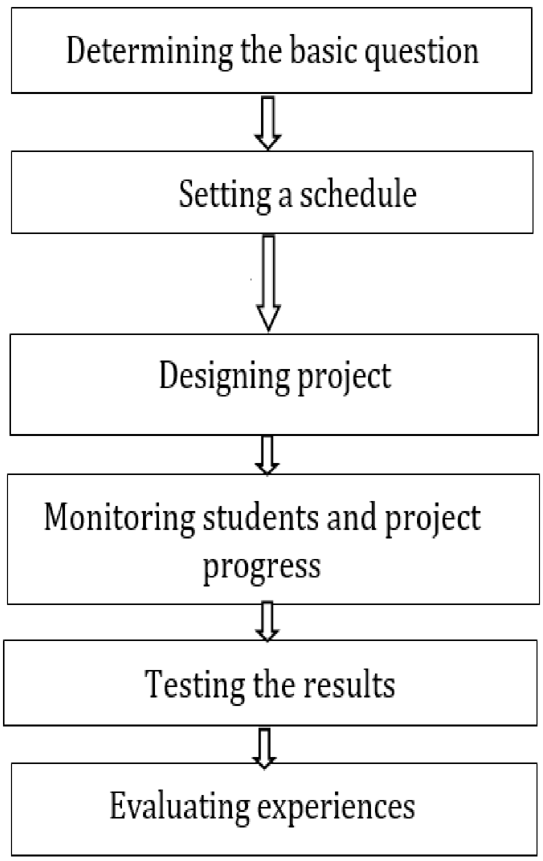

Figure 3. The Syntax of the PjBL Model (Akhyar et al., 2024)

In the first step of implementing the project-based learning model (Figure 4), the teacher provides initial stimulation and captures students' attention by using circulatory system-related media, such as torsos and images. As a result, it can either train or observe. Furthermore, the teacher instructs students to record and categorize each result of their understanding from observing and understanding activities related to the material presented by the teacher using mind mapping to help them remember learning material (Hamad & Ahmed, 2021);(Dianti et al., 2020)

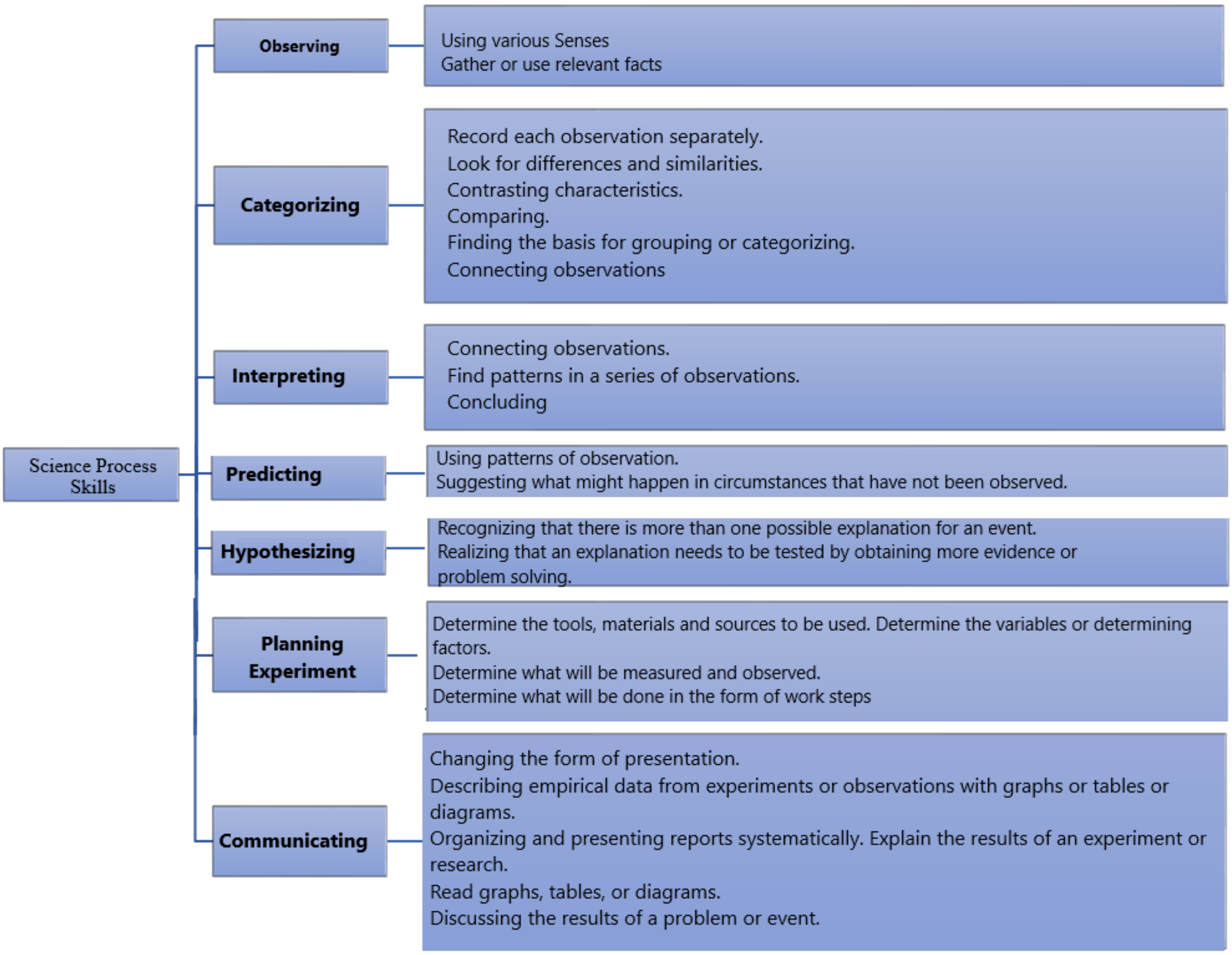

Figure 3. The Indicator of Science Process Skills (Rini & Aldila, 2023)

In its application, students create mind maps about subjects that connect one concept to another. This is consistent with research by Puspita, who found that using the mind mapping technique allows students to create an overall picture of the subject matter while seeing detailed information easily by connecting one concept to another. This activity can help train grouping skills using mind mapping (Sari et al., 2021);(Wafa' A & Moath Khalaf, 2023).

The average score on grouping skills was higher than on other indicators. In the second step, designing planning, the teacher divided students into groups of 5-7 and provided worksheets before guiding them to plan projects based on the given topic (Mayasari & Usmeldi, 2023). In this stage, students were guided to predict the events that have not yet been observed or will be observed in practicum activities. This activity can help train prediction skills. Furthermore, students are also led to analyze the teacher's questions or problems and then propose temporary answers or hypotheses based on the analysis results. In learning, students were encouraged to propose arguments or ideas for answer options. By providing multiple answers and solutions to a problem in an attempt to solve it, this activity can help students develop their hypothesizing skills (Da Costa et al., 2020).

At the planning design stage, students planned practicum activities or projects. The student must be active during the practicum or project and prior to the activity to train their skills in planning experiments using the project-based learning model (Sholahuddin et al., 2021). When the students are asked to determine the tools and materials and work steps to be carried out in conducting practicum activities experimental planning skills are developed (Tasmedir & Gumusok, 2023).

In the third stage, the teacher created a schedule and consulted with the students about the project implementation schedule and completion time. In the fourth stage, the teacher monitored student and project progress. Teachers assisted students in carrying out projects by predetermined plans and monitored the progress of projects students completed. In the fifth stage, the teacher gave students opportunities to communicate and present the outcomes of group project work. At this stage, the students were taught to communicate the process and experimental results to other students (Khasna & Nuriyah, 2023). Students were required to present the results of their practicum activities in front of the class through presentation activities (Ennouamani et al., 2020). They present their arguments, opinions, and questions to other groups during the presentation. Thus, these activities can improve communication skills.

In the sixth stage, the teacher asked students to communicate obstacles encountered while working on projects and to summarize project activities during presentation activities in front of the class. Students were required to interpret the outcomes of practicum or learning activities. These activities can improve interpreting abilities (Juuti et al., 2021);(Harefa et al., 2023). Additionally, teachers provide feedback on the implementation and outcomes of student-led projects.

Figure 5. Project Results on Circulation System Mechanism

The implementation of the project-based learning model includes students learning actively and learning material meaningfully (Hsbollah & Hassan, 2022); (Distyasa et al., 2021). Students gain knowledge through their experiences, allowing new information to be associated with what they already know (Amerstorfer & Freiin 2021);(Rossoni et al., 2024). As a result, the project-based learning model has a strong link to students' science process skills.

According to the pretest and posttest data, the pretest scores of science process skills in the experimental and control classes were not significantly different, indicating that the two classes had not mastered the circulation system material. The posttest score for science process skills increased more in the experimental and control classes (Jenaf et al., 2023). The posttest score in the experimental class was 90, while in the control class, it was 75. Each indicator of science process skills increased, with the experimental class using the project-based learning model showing a greater increase than the control class using the discovery learning model (Amanda et al., 2024).

The ANOVA test yielded significant results. These findings result from students actively participating in the learning process, which includes asking, answering, expressing opinions, proposing and testing hypotheses, interpreting data, and observing. The project-based learning model can help students develop science process skills through various activities, one of which is determining basic questions requiring them to observe an object using their five senses. These observing activities produce results in the form of special properties of an object, which students then classify using mind mapping. The students become more active and remember learning materials better when the project-based learning model is used with the assistance of Mind Mapping. Through project and practicum activities, the students can train and improve their abilities and skills in the learning process, allowing them to participate more actively in learning activities and increasing their interest in learning.

After applying creative note-taking techniques, such as mind mapping, it is clear that mind mapping can be used to make learning material easier to remember by categorizing material based on its unique properties (Efendi & Ambarita, 2021). As a result, it can help students improve their grouping or classification skills. With Mind Mapping, the results of understanding the material become more interesting and meaningful, making it easier for students to remember. Therefore, mind mapping can be used as one of several solutions to improve students' science process skills.

According to Hidayati et al. (2021), learning media in the form of note-taking techniques with mind mapping can improve students' science process skills by increasing their indicators of classifying and applying concepts. This innovation aims to ensure that students continue to receive meaningful learning through engaging creative note-taking techniques, which should help them apply concepts and remember biology learning material.

Overall, students who used the project-based learning model with mind mapping had better science process skills than the control class who used the discovery learning model because it trains students to solve problems using their science process skills. The research findings revealed that the experimental class students had a higher value for science process skills than those in the control class. This finding demonstrates the effect of the project-based learning model in the experimental class. The findings of this study are consistent with previous research Novitasari et al. (2023), Mutlu (2020), Astuti et al. (2020) and Juniar et al. (2021), which found that using the project-based learning model significantly improved students' science process skills.

The successful implementation of the Project-Based Learning model is expected to benefit education in the current era as one of the innovations in teaching models that teachers can use. Furthermore, science process skills, which are critical competencies today, must be taught to students indefinitely.

CONCLUSIONS AND SUGGESTIONS

The research questions were answered after conducting the research and analyzing the data using hypothesis testing with ANOVA. This is evident from the significance result of 0.000, which is less than $\alpha = 0.05$. Therefore, H_0 is rejected, and H_1 is accepted. It can be concluded that the project-based learning model, assisted by mind mapping, significantly affects the science process skills of eleventh-grade high school students in biology.

Suggestions from this study include expanding the implementation of the project-based learning model assisted by mind mapping to other biology topics or subjects to evaluate its broader effectiveness in enhancing students' science process skills. It is also recommended that teachers receive specialized training to ensure the consistent and optimal application of this model. Future research should focus on exploring its long-term impact and specific influences on various aspects of science process skills, such as observation, experimentation, and data analysis. Additionally, the development of supporting tools, such as interactive modules or digital applications integrated with mind mapping, is encouraged to enhance the model's adaptability and effectiveness across different educational contexts.

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