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The Influence of the Problem-Based Learning Model Assisted by Electronic Student Worksheets on the Science Learning Outcomes

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Abstract: The problem of this research is the low natural science learning outcomes of elementary school students caused by student-centered learning and the inadequate use of teaching materials. This study aims to determine the effect of the problem-based learning model assisted by electronic student worksheets based on liveworksheet on natural science learning outcomes. This study uses a quantitative approach with a nonequivalent control group design. The research sample consists of fifth-grade students from SD Muhammadiyah 29 Sunggal. Data was collected through pretest and posttest, and analyzed using normality test, homogeneity test, and hypothesis test through Independent Samples t-test. The results show that the average posttest score of the experimental class was 86.08, higher than the control class at 76.33. The t-test resulted in a significant value of $p < 0.001$ with a mean difference of -9.747 and a 95% confidence interval (-14.095 to -5.398), indicating a significant difference. Based on the data analysis results, it is stated that the problem-based learning model assisted by electronic student worksheets has an impact on improving the learning outcomes of 5th-grade elementary school students in science learning. These findings support the development of student-centered science education aligned with the Merdeka Curriculum

Keywords: Electronic student worksheets; Problem Based Learning; Science Learning Outcomes

Introduction

The learning of natural sciences in elementary school is an important foundation in fostering a scientific mindset in children from an early age. Through science education, students are trained to think critically, logically, and systematically in understanding various natural phenomena occurring around them (Ansya & Salsabilla, 2024; Nur'ariyani et al., 2023). The important role of science at the elementary level lies not only in mastering scientific concepts but also in shaping children's scientific worldview, getting them used to asking questions, seeking answers based on evidence, and drawing conclusions through observation (Ha et al., 2024; Valladares, 2021).

The ideal situation expected in science learning is the creation of an interactive, participatory, and contextual learning atmosphere (Kerimbayev et al., 2023; Kew & Tasir, 2022). Interactive means there is dynamic two-way communication between teachers and students as well as among students, while participatory requires the involvement of all learners in every stage of

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the learning process (Yaseen et al., 2025). Contextual learning refers to the use of examples and activities that are close to students' daily lives, making the material being studied more relevant and easier to understand. In this ideal learning process, students are encouraged to engage in scientific activities such as observing, questioning, experimenting, reasoning, and communicating their findings (Ansya & Salsabilla, 2025; Suaidah et al., 2023).

Science learning in elementary schools should not only focus on mastering theory, but also emphasize an exploratory process that allows students to build understanding directly through real experiences (Idris et al., 2022). Students need to be given the opportunity to conduct simple experiments, field observations, or small scientific projects that help them connect science concepts with everyday life (Hiğde & Aktamış, 2022; Weng et al., 2022). Through that experience, students not only acquire knowledge passively but also develop scientific process skills, which include the ability to identify problems, design and conduct investigations, and logically conclude results (Hacıeminoğlu et al., 2022). This approach will create science learning that is not only enjoyable but also leaves a lasting impact in the long term because it integrates cognitive, affective, and psychomotor aspects.

The results of the observation of science learning in the fifth grade at Muhammadiyah Elementary School indicate that the learning process has not been implemented optimally and is still far from the ideal conditions expected. The learning tends to be conventional, centered on the teacher as the sole source of information, using lecture methods and one-way assignment giving that minimally involves students in exploratory activities or in-depth discussions. The learning atmosphere becomes less interactive, thus failing to encourage students' curiosity and critical thinking skills. Furthermore, the use of technology in learning is still minimal; teachers only rely on textbooks and monotonous worksheets, without utilizing visual or digital media that can support the understanding of learning concepts. The lack of technological involvement makes learning less relevant, thereby widening the gap between the subject matter and its application in everyday life.

Learning conditions like this certainly do not support the achievement of comprehensive science learning objectives, both in terms of concept formation and the development of scientific thinking skills. The low quality of the learning process impacts students' learning outcomes, that do not meet the minimum value standards set by the educational institution. Especially among fifth-grade students, their understanding of science material is still superficial and tends to be rote memorization, rather than deep comprehension. The lack of experiential and collaborative learning activities makes it difficult for students to connect theory with natural phenomena in their environment. Therefore, improvements in the science learning strategy are needed by emphasizing a more active, innovative, and technology-based approach so that the learning process becomes more meaningful and can significantly improve students' learning outcomes.

Based on the identified problems, the problem-based learning model is considered relevant to be applied as a learning approach that can effectively address these issues. The problem-based learning model is chosen because it encourages students to actively build knowledge through problem-solving that is relevant to everyday life (Aslan & Duruhan, 2021; Smith et al., 2022). This approach allows students to develop critical, analytical, and reflective thinking skills in understanding science concepts. Through activities such as identifying problems, formulating hypotheses, seeking information, and devising solutions, students not only learn cognitively but also engage emotionally and socially in the learning process (Rodriguez Sandoval et al., 2022).

To ensure that the problem-based learning model runs optimally, interactive learning media is needed, such as electronic student worksheets based on Liveworksheet, which is a digitization of conventional student worksheets to make them more engaging, flexible, and in line with the characteristics of today's students (Agustina et al., 2024; Syar et al., 2023). This media allows students to interact with content through video, audio, animation, and automated exercises, thereby encouraging active participation and independent learning (Defira et al., 2024; Faaiqoh & Ratnaningrum, 2024; Novike Bela Sumanik et al., 2023; Tika Fahmi Afifah & Junaedi, 2024). The combination of electronic problem-based learning worksheets for students aligns with the Merdeka Curriculum and 21st-century learning because it supports 4C skills and makes it easier for teachers to monitor and provide real-time feedback (Adam et al., 2024; Aly, 2024; Biswas & Bhattacharya, 2024; Suryati et al., 2023).

Previous research has not extensively examined problem-based learning assisted by electronic worksheets for students based on Liveworksheet in an integrated manner. Most studies only investigate one aspect separately. Like the research conducted by Safitri et al. (2023) and Suciati et al. (2024) shows that the application of the problem-based learning model is effective in improving the learning outcomes of science students. Meanwhile, the research conducted by Ghaisani & Setyasto (2023) and Syafar et al. (2024) highlighting the use of liveworksheet as an interactive digital learning medium that has been proven to improve students' learning outcomes.

Based on the background of the problems that have been outlined, this study aims to determine the effect of applying the problem-based learning model assisted by electronic worksheets based on Liveworksheet on the natural science learning outcomes of fifth-grade elementary school students.

Method

The research method used in this study is a quantitative method with a quasi-experimental approach. This approach was chosen because it allows researchers to test the cause-and-effect relationship between independent and dependent variables in conditions that cannot be fully controlled, unlike pure experiments (Daryanto, 2025; Sugiyono, 2016, 2022). In this study, the independent variable examined is the use of the problem-based learning model assisted by electronic student worksheets based on Liveworksheet, while the dependent variable is the students' natural science learning outcomes. The quantitative approach is used to obtain numerical data that can be statistically analyzed to objectively determine the effect of the treatment.

The research design used is the Nonequivalent Control Group Design, which is an experimental design involving two groups — the experimental group and the control group — that are not randomly selected but are given different treatments (Coe et al., 2025). The experimental group received learning with a problem-based learning model assisted by electronic student worksheets based on Liveworksheet, while the control group received learning using the conventional method usually employed by the teacher in that class. Both groups were given a pretest before the treatment and a posttest after the treatment to measure the improvement in natural science learning outcomes. This design allows researchers to compare the effectiveness of the treatment given with the control over the changes that occur in each group.

Table 1: Research Design Nonequivalent Control Group Design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

Explanation:
O_1: Pretest in the experimental group
O_2: Posttest in the experimental group
O_3: Pretest in the control group
O_4: Posttest in the control group
X_1: Treatment given to the experimental group
X_2: Treatment given to the control group

Based on Table 1, the flow of the nonequivalent control group design research begins with administering a pretest to the control group and the experimental group to determine the initial abilities of the students before the treatment is given. After that, the experimental group is given treatment in the form of a problem-based learning model assisted by electronic student worksheets, while the control group uses conventional teaching methods. Next, both groups were given a posttest to determine the difference in learning outcomes after the treatment, which was then analyzed to assess the effectiveness of the learning model used in the experimental group.

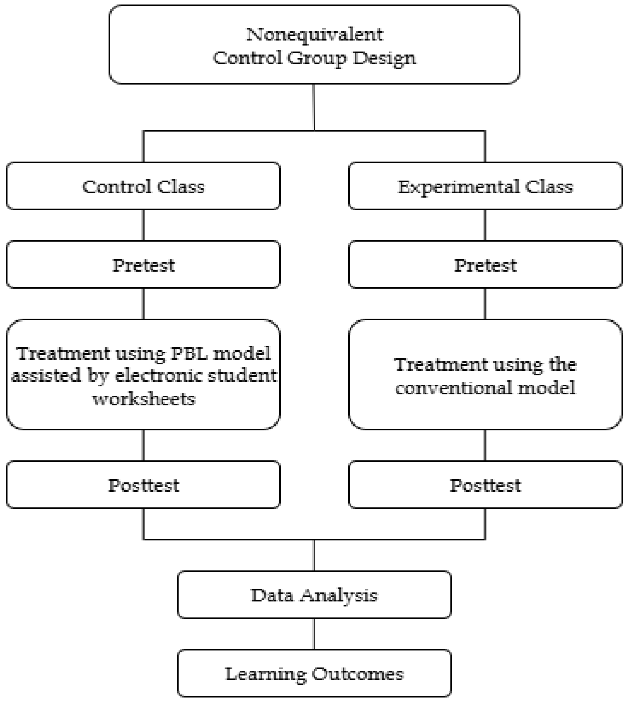

Figure 2. Research Stage

The population in this study consists of all fifth-grade students at SD Muhammadiyah 29 Sunggal for the 2024/2025 academic year, totaling 60 students. This school was chosen because it implemented the Merdeka Curriculum and has student characteristics with relatively low average science learning outcomes, making it suitable for the focus of the research problem. In addition, SD Muhammadiyah 29 Sunggal also has learning facilities that support the implementation of the models and learning media used in the research. The sampling technique was conducted using non-random sampling, specifically by using two existing classes. The research sample consists of class V-A with 25 students as the experimental class, and class V-B with 24 students as the control class. The selection of these two classes considers equality of students' academic characteristics as well as the learning schedule that allows for optimal treatment implementation.

The data collection technique in this study was conducted using test instruments in the form of pretests and posttests. Arikunto (2017) stating that this test is used to measure students' learning outcomes before and after the implementation of the learning model, in order to determine any significant improvement in the understanding of natural science material. The questions in the test cover indicators that align with the learning objectives and are structured based on the applicable curriculum. Before being used, the test instruments have undergone validity tests, reliability tests, item difficulty tests, and item discrimination tests to ensure the instruments' suitability as appropriate evaluation tools in the research. The pretest was given to both groups (experimental and control) before the treatment was conducted, while the posttest was given after the treatment was completed to compare learning outcomes and assess the effectiveness of the applied learning model.

In the data analysis process, the researcher first conducts prerequisite tests for analysis, which include normality tests and homogeneity tests. The normality test is used to determine whether the students' learning outcome data is normally distributed, while the homogeneity test aims to ensure that the variances of the two groups are the same or homogeneous. Both tests are prerequisites for conducting hypothesis testing using parametric statistical techniques. If these conditions are met, the analysis continues with the Independent Samples t-test to determine whether there is a significant difference in student learning outcomes between the experimental class and the control class after the treatment is given.

The Independent Samples t-test was conducted with the help of statistical software to obtain accurate and objective results (Salim, 2019). The results of this test serve as the basis for drawing conclusions regarding the impact of implementing the Problem Based Learning Model assisted by Electronic Student Worksheet based on Liveworksheet on students' natural science learning outcomes. If there is a statistically significant difference between the average posttest scores of the experimental class and the control class, this indicates that the applied learning model positively affects the improvement of students' learning outcomes. Thus, this research method is expected to provide a clear and valid picture of the effectiveness of learning interventions in the context of basic education.

Result and Discussion

Instrument Test

A total of 25 items in the test instrument have been tested for validity and all have been declared valid because they meet the criteria for measuring students' understanding of the material being tested. Next, the reliability test was conducted using the product moment correlation formula, where the table value r referenced at the significance level $\alpha = 0.05$ with a sample size $N = 25$ is 0.3961. The calculation results show that the calculated r value is 0.8647, which is greater than the table r value ($0.8647 > 0.3961$), thus it can be concluded that the instrument meets the reliability criteria and is declared reliable. Additionally, the results of the difficulty level test indicate that the questions in the instrument fall into the "moderate" category, with difficulty indices ranging from 0.31 to 0.70, which shows that the questions have a balanced level of difficulty. For the discrimination power test, the analysis results indicate that the instrument falls into the "good" category with discrimination indices between 0.41 and 0.70, meaning that each question can effectively distinguish between students with high and low understanding. Thus, all items in the test instrument are suitable for use in the research.

Research Data Description

Results of Pretest Calculations for Control Class and Experimental Class

In the control class, the pretest score was obtained with a total score of 1,154, with an average score of 48.08. Meanwhile, in the experimental class, the pretest score was obtained with a total score of 1,124, with an average score of 44.96. This data provides important information regarding the initial conditions of both groups, which will serve as the basis for comparison to evaluate the effectiveness of the treatment given in the subsequent stages of this research. Here are the details of the pretest value calculations in Table 2.

Table 2. Pretest Results of the Control Class and the Experimental Class

Control Class			Experimental Class		
Value	Frequency	Average	Value	Frequency	Average
36	1		32	1	
40	3		36	1	
44	7		40	4	
48	4		44	9	
52	4		48	6	
54	1	48.08	52	3	44.96
56	2		56	1	
60	1				
64	1		Amount	25	
Amount	24				

In the control class that followed conventional learning, the pretest was attended by 24 students with an average score of 48.08, and the score distribution ranged from 36 to 64, with the highest frequency at scores of 44 (7 students) and 40 (3 students). Meanwhile, the experimental class that received treatment using the Problem Based Learning model assisted by E-LKPD based on Liveworksheet was attended by 25 students with an average pretest score of 44.96, with scores ranging from 32 to 56, and the highest frequency at scores of 44 (9 students) and 48 (6 students). These results indicate that the initial abilities of students in both classes are relatively balanced, so the pretest results can serve as a valid basis for comparing the effectiveness of the two learning models after the treatment is given.

Results of Posttest Calculations for Control Class and Experimental Class

Based on the posttest data obtained, it is known that the total score of students in the control class is 1832, with an average score of 76.33. Meanwhile, the experimental class shows a total score of 2152, with an average score of 86.08. This difference reflects a variation in learning outcomes between the two classes after undergoing different treatments. The complete posttest results data, both for the control and experimental classes, are presented in detail in the results table and can be further reviewed in the appendix, which contains all individual student scores for a more in-depth analysis.

Table 3. Posttest Results of the Control Class and the Experimental Class

Control Class			Experimental Class		
Value	Frequency	Value	Frequency	Value	Frequency
64	1	76.33	68	1	86.08
68	4		72	1	
72	4		76	1	
76	6		80	4	
80	4		84	5	
84	3		88	7	
88	1		92	2	
92	1		96	1	
Amount	24		100	3	
			Amount	25	

Based on the distribution of posttest scores, an overview of student learning outcomes after following the learning with different approaches was obtained. In the control class that used the conventional learning model, the average posttest score was 76.33 from 24 students, with most scores falling within the range of 68 to 80, and the highest frequency at a score of 76 (6 students). Meanwhile, in the experimental class that applied the problem-based learning model assisted by electronic student worksheets based on liveworksheet, the average posttest score reached 86.08 from 25 students, with scores predominantly between 80 and 88, the highest frequency at a score of 88 (7 students), and 3 students achieving a perfect score (100). This difference in achievement indicates a more significant improvement in learning outcomes in the experimental class, particularly in the topics of Respiratory Organs, Mechanism of Breathing, and Disorders of the Respiratory System. This reflects the effectiveness of a more innovative, interactive, and problem-based learning approach in enhancing student engagement and understanding.

Analysis Requirement Test

Normality Test

The results of the data normality test using the Shapiro-Wilk test show that all data groups, both in the experimental class and the control class, have significance values (p-values) above 0.05. In the experimental class, the significance values for the pretest data were 0.231 and for the posttest data were 0.286, while in the control class, the pretest significance value was 0.357 and the posttest value was 0.503. Since all p-values are greater than the established significance level ($\alpha = 0.05$), it can be concluded that the data in all four groups are normally distributed. Therefore, there are no significant deviations from normal distribution, and the students' learning outcomes, both before and after treatment, in both classes are stated to meet the normality assumption. This indicates that the data are suitable for further analysis using parametric statistical techniques, such as the t-test, because they have met one of the important prerequisites in hypothesis testing.

Table 4. Results of the Normality Test

		Kolmogorov-Smirnov[a]			Shapiro Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
Learning Outcomes	Pretest Control	.183	24	.037	.956	24	.357
	Posttest Control	.144	24	.200*	.963	24	.503
	Pretest Experiment	.188	25	.022	.948	25	.231
	Posttest Experiment	.166	25	.073	.953	25	.286

Homogeneity Test

The homogeneity of variance test on the learning outcome data was conducted using Levene's Test through four approaches, namely based on mean, median, median with adjusted degrees of freedom, and trimmed mean, to ensure the stability of the test results under various data distribution conditions. The significance values (p-values) of each approach were

0.584 (mean), 0.604 (median), 0.604 (median with adjusted degrees of freedom), and 0.568 (trimmed mean), all of which exceed the significance threshold of 0.05. This indicates that there is no significant difference in variance between the experimental and control groups, so the data is considered to have uniform or homogeneous variance. The homogeneity of variance is an important prerequisite in the use of parametric statistical analysis such as the t-test, which will be used to test the differences in learning outcomes between groups. Although the significance value in the trimmed mean approach is slightly lower compared to other approaches, it remains within an acceptable range.
Hypothesis Testing.

Table 5. Results of the Homogeneity Test

		Statistic	df1	df2	Sig
Learning Outcomes	Based on Mean	.304	1	47	.584
	Based on Median	.273	1	47	.604
	Based on Media and with adjusted df	.273	1	44.525	.604
	Based on trimmed mean	.332	1	47	.568

Table 6. Results of the Hypothesis Test

Independent Samples Test											
		Lavene's … of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence … Difference	
						One-Sided p	Two-Sided p			Lower	Upper
Learning Outcomes	Equal variances assumed	.304	.584	-4.509	47	<.001	<.001	-9.747	2.162	-14.095	-5.398
	Equal variance not assumed			-4.523	46.468	<.001	<.001	-9.747	2.155	-14.083	-5.410

Based on the results of the Independent Samples Test, the analysis begins with Levene's Test for Equality of Variances to test the equality of variances between the two groups. The F value of 0.304 with a significance (Sig.) of 0.584 indicates that Sig. > 0.05, thus it can be concluded that the variances of the two groups are homogeneous (equal variances assumed), and the t-test interpretation is conducted using the first row. The t-value of -4.509 with 47 degrees of freedom (df) resulted in both one-tailed and two-tailed significance values of < 0.001, indicating a significant difference in student learning outcomes between the two groups. The mean difference in posttest scores between the control and experimental groups is -9.747 with a standard error of 2.162, and the 95% confidence interval ranges from -14.095 to -5.398. Because all values within the confidence interval range are below zero, this difference is statistically significant and indicates that the learning outcomes of students in the experimental group are significantly higher than those in the control group. Based on the two-sided significance value that is much smaller than 0.05, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_a) is accepted. Thus, it can be concluded that the implementation of the Problem Based Learning model assisted by Electronic Student Worksheets based on Liveworksheet has a positive and significant effect on the improvement of natural science learning outcomes for fifth-grade elementary school students. These results support the research hypothesis that problem-based learning combined with interactive digital media can enhance student engagement, strengthen conceptual understanding, and have a tangible impact on their academic achievement.

Discussion

The research results show that the application of the Problem Based Learning model assisted by Electronic Student Worksheets based on Liveworksheet has a significant positive impact on the science learning outcomes of fifth-grade students at SD Muhammadiyah 29 Sunggal. This is evidenced by the difference in average posttest scores between the experimental class and the control class. The average posttest score in the experimental class was 86.08 with a score range of 80–100, while the control class had an average of 76.33 with a score range of 68–88. This average difference reached 9.75 points, indicating a significant improvement in learning outcomes in the class that applied the Problem Based Learning model assisted by Electronic Student Worksheet. Additionally, in the experimental class, there were 3 students (12%) who achieved a perfect score (100), while no students in the control class reached that maximum score. This indicates that the problem-based learning approach and interactive digital media are capable of driving more optimal learning outcomes.

To support the analysis of the differences in learning outcomes, a statistical test was conducted using the Independent Samples t-test. Previously, the normality test of the data was conducted using the Shapiro-Wilk method, which showed that all data, both pretest and posttest from both classes, had a normal distribution (p-value > 0.05). Next, the homogeneity of variances test using Levene's Test for Equality of Variances yielded a significance value of 0.584, which means both groups have homogeneous variances (since > 0.05). A t-test was then conducted assuming equal variances, resulting in t = -4.509, df = 47, and a 2-tailed p-value = 0.000. Because the significance value is less than 0.05, it can be concluded that there is a significant difference between the learning outcomes of students in the experimental class and the control class. The mean difference of -9.747 is supported by a 95% confidence interval (CI) between -14.095 and -5.398, all of which are below zero, reinforcing the evidence of a significant difference between the groups.

This finding is in line with the opinion Anggraeni et al. (2023) and Adhelacahya et al. (2023) which states that Problem Based Learning is an effective learning model to encourage students to think critically and understand concepts deeply through the resolution of contextual problems. The research conducted by Manuaba et al. (2024) and Kim et al. (2022) also found that the use of problem based learning in science education can enhance students' active participation and significantly improve their understanding of scientific concepts. In the context of this research, the results obtained indicate that when students are faced with real problems and given the freedom to collaboratively seek solutions, they become more motivated and engaged in the learning process. This is reflected in the increased average posttest scores and the distribution of scores that tend to be high and evenly spread in the experimental class.

In addition to the implementation of the problem-based learning model, the use of electronic student worksheets based on liveworksheet also contributes significantly to students' learning outcomes. Interactive features such as drag-and-drop questions, automatic exercises, educational videos, and easy digital navigation enhance student engagement and interest in natural science learning. This is reinforced by research Zakiyyah et al. (2025) and Mayasari et al. (2023), which states that technology-based electronic student worksheets can enhance learning effectiveness by presenting material visually and attractively for elementary school students. In this study, the experimental class students showed high enthusiasm in using the electronic student worksheets, and they demonstrated better learning outcomes compared to the control class students who only used conventional teaching materials. Thus, the use of well-designed digital media can be a significant aid in enhancing students' understanding.

The results of this study affirm that the implementation of the problem based learning model assisted by electronic student worksheets based on liveworksheet has a positive impact on improving the science learning outcomes of fifth-grade students. The combination of problem-based learning approaches with the use of educational technology supports the principles of active and contextual learning in accordance with the demands of the Merdeka Curriculum. The statistically significant improvement, accompanied by a distribution of scores indicating high and even achievements, serves as an indicator of the success of the learning model used. However, the implementation of this model also requires teachers' readiness in designing learning scenarios, preparing appropriate digital Student Worksheets, and guiding students in the problem-solving process. Therefore, teacher training and the development of digital learning media need to be enhanced so that this strategy can be implemented more widely and sustainably in various primary education units.

Conclusion

Based on the explanation in the results and discussion section, it can be concluded that the Problem Based Learning model assisted by Electronic Student Worksheets based on Liveworksheet has an effect on improving the learning outcomes of fifth grade elementary school students in science. This is indicated by the average posttest score of the experimental class of 86.08 which is higher than the control class of 76.33. The results of the Independent Samples t-test show a very significant difference (p < 0.001) with an average difference of -9.747 and a 95% confidence interval (-14.095 to -5.398), which strengthens that this model is more effective than conventional learning. Thus, the Problem Based Learning model assisted by Electronic Student Worksheets based on Liveworksheet is highly recommended to improve the learning outcomes of science in elementary schools.

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