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The Effectiveness of Implementing PBL and Susan Loucks Horsley Syntax Combination with the Deep Learning Approach to Science Process Skills in Junior High School

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Abstract: This study aims to determine the effectiveness of the application of a combination of PBL and Susan Loucks Horsley (SLH) syntax with a deep learning approach on students' science process skills in junior high school science learning. This study used a quasi-experimental Nonequivalent Control Group design with a purposive sampling technique, where the school studied was grade VIII students of SMP Negeri 6 Sentani, Jayapura Regency. Data collection techniques were questionnaires and observation sheets. Data analysis was carried out descriptively and quantitatively, using independent sample-test, N-Gain, and effect-size tests. The results showed that the application of a combination of PBL and SLH syntax with a deep learning approach can improve students' science process skills in science learning at SMP Negeri 6 Sentani, Jayapura Regency. The results of the difference test showed a significant difference in the science process skills of students taught using a combination of PBL and SLH syntax with a deep learning approach with students taught using a conventional model. The value of the science process skills of students taught using a combination of PBL and SLH science syntax with a deep learning approach was higher than the value of students taught using a conventional model. The effectiveness of the combination of PBL and SLH syntax with the deep learning approach is in the high category based on the N-Gain value and effect-size test.

Keywords: Deep learning; PBL; Science process skills; Syntax; SLH

Introduction

Science learning in junior high schools (SMP) plays a strategic role in developing students' scientific thinking skills, scientific attitudes, and science process skills. Science learning requires students to be able to carry out scientific processes such as observing, classifying, predicting, interpreting data, formulating hypotheses, and conducting experiments. Science process skills are a key foundation for 21st-century learning, as they are directly related to the critical, creative, collaborative, and problem-solving skills necessary for modern life. However, the reality on the ground shows that junior high school students' science process skills are still relatively low due to the dominance of conventional, teacher-centered learning with minimal investigative activities (Rahmawati et al., 2022; Suryani & Wahyudi, 2021). Research shows that science learning in Indonesia still tends to emphasize memorization of concepts over direct scientific experience. As a result, students are less trained in conducting systematic scientific investigations. This condition has an impact on students' low ability to interpret scientific phenomena and solve contextual problems, most junior high school students experience difficulties in designing experiments and drawing scientific conclusions because learning does not provide adequate exploration space (Pratiwi et al., 2023). The results of the Programme for International Student Assessment (PISA) research show that Indonesian students' scientific literacy skills are still below the international average, especially in the aspects of scientific inquiry and reasoning. Problem-Based Learning (PBL) is a learning model considered effective

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for improving science process skills (Dakabesi, 2025; Sutaryani et al., 2024). PBL places real-world problems as the learning context, encouraging students to think critically and creatively, seek solutions, conduct investigations, and construct knowledge independently. PBL creates an active and meaningful science learning environment because students are directly involved in the scientific inquiry process.

The application of PBL can significantly improve junior high school students' observation, data interpretation, and scientific communication skills (Handayani et al., 2021). PBL effectively improves scientific reasoning and science process skills through experiment-based problem-solving activities (Nurhayati & Arifin, 2024). The implementation of PBL in science learning still faces several obstacles, particularly in the integration of learning syntax with systematic and in-depth investigative activities. PBL, in its application, often focuses only on problem solving without providing students with a comprehensive scientific experience. Therefore, a supporting model is needed that can strengthen the investigative and constructivist dimensions in science learning. One relevant approach is the Susan Loucks-Horsley (SLH) Model, a learning model relevant to the PBL model. The SLH model emphasizes experience-based learning, exploration, concept construction, and the application of knowledge in real-life contexts (Fa'iqoh et al., 2025; Rehiara, 2025). The Susan Loucks-Horsley model is based on a constructivist paradigm that places students at the center of learning. This model consists of the stages of invitation, exploration, explanation and solution, and taking action. Through these stages, students are guided to construct knowledge through direct experience and scientific reflection.

The application of the SLH model can significantly improve the skills of observing, inferring, and communicating experimental results in junior high school science learning (Wulandari et al., 2022). SLH syntax can increase student engagement in the scientific investigation process, making learning more contextual and meaningful (Safitri & Hidayat, 2023). The integration of PBL and Susan Loucks-Horsley syntax is seen as having great potential in improving students' science process skills. PBL provides an authentic problem context that stimulates critical thinking, while the SLH model strengthens the process of exploration and construction of scientific knowledge. The combination of these two models is believed to create science learning that is not only oriented towards cognitive learning outcomes but also develops students' scientific abilities comprehensively. With this syntactic combination, students are expected to be able to actively carry out the scientific process, starting from problem identification, phenomenon exploration, experimentation, and drawing conclusions from investigation results. In addition to integrating learning models, the deep learning approach is also a crucial aspect of modern learning. Deep learning in an educational context is not simply the use of digital technology, but emphasizes in-depth learning that enables students to understand concepts in a meaningful, reflective, and applicable way. This approach encourages students to connect knowledge with real-life experiences and build in-depth conceptual understanding.

According to Muhtadi et al. (2025), deep learning can increase student intellectual engagement through collaborative learning, problem-solving, and critical reflection. This approach is highly relevant in science learning because it can strengthen students' investigative and scientific reasoning skills. The application of a deep learning approach in science learning can also improve the quality of science process skills because students do not simply receive information passively but actively construct understanding through exploration and authentic learning experiences. Deep learning-based learning can significantly improve students' analytical, data interpretation, and problem-solving skills. Furthermore, deep learning also encourages students to reflect on the learning process, making the knowledge gained more durable and meaningful (Taufik et al., 2025). The current state of science learning at SMP Negeri 6 Sentani, Jayapura Regency, indicates that eighth-grade students' science process skills still need improvement. Based on initial observations, learning is still dominated by lectures and assignments, resulting in students' scientific activity not yet developing optimally. Some students experience difficulty in conducting systematic observations, formulating hypotheses, and communicating experimental results.

Furthermore, student engagement in the scientific investigation process remains low because learning has not fully implemented a student-centered, hands-on experience-based model (Woods & Copur-Gencturk, 2024; Martin-Alguacil et al., 2024). Based on these issues, learning innovations are needed that can improve students' science process skills through active, contextual, and in-depth learning (Susilawati et al., 2024). The combination of PBL and Susan Loucks-Horsley syntax with a deep learning approach is considered relevant because it comprehensively integrates problem-solving, scientific investigation, concept exploration, and reflection on learning. This combination is expected to create a more meaningful science learning experience and optimally enhance students' scientific abilities. Therefore, a study entitled "The Effectiveness of Implementing a Combination of PBL and Susan Loucks-Horsley Syntax with a Deep Learning Approach on Science Process Skills in Junior High School Science Learning" is important to determine the effectiveness of this learning model in improving students' science process skills. The results of this study are expected to provide theoretical contributions to the development of innovative science learning models and become a practical reference for teachers in creating science learning that is active, contextual, and oriented towards the development of 21st century skills.

Method

This study employed a quantitative approach with a quasi-experimental approach. The quantitative approach was used because the study aimed to test the effect of implementing a combination of Problem-Based Learning (PBL) syntax and Susan Loucks-Horsley with a deep learning approach on students' science process skills through numerical data analysis and statistical testing. A quantitative approach allows researchers to obtain objective data regarding changes in students' science process skills before and after treatment through systematic measurements. The type of research used was quasi-experimental research because it was not possible to fully randomize the subjects within the classes used in the study. According to Bärnighausen et al. (2017), quasi-experimental research aims to determine the effect of a treatment on a specific variable by using experimental and control groups, but without fully randomizing the subjects. In educational research, a quasi-experimental design is often used because naturally occurring classroom conditions make it difficult to conduct random grouping.

This study aimed to determine the effectiveness of implementing a combination of PBL syntax and Susan Loucks-Horsley with a deep learning approach on the science process skills of eighth-grade students at SMP Negeri 6 Sentani, Jayapura Regency. Therefore, the science process skills between the experimental and control classes were different. The research design used in this study was a Nonequivalent Control Group Design. This design involved two groups, an experimental group and a control group, who were given a pretest and a posttest. The experimental group was given a treatment that combined the application of Problem-Based Learning (PBL) syntax and Susan Loucks-Horsley with a deep learning approach, while the control group received conventional learning. Nonequivalent Control Group Design is used to determine the effect of the treatment by comparing changes in outcomes between the experimental and control groups before and after the treatment.

Data analysis was performed using SPSS or Microsoft Excel. A normality test was performed to determine whether the data were normally distributed using the Kolmogorov-Smirnov or Shapiro-Wilk test. If sig > 0.05, the data are normally distributed; if sig < 0.05, the data are not normally distributed. A homogeneity test was used to determine the equality of variance between the two groups using the Levene's test. If sig > 0.05, the data are homogeneous; if sig < 0.05, the data are not homogeneous. Hypothesis testing used a t-test. The t-test was used to determine differences in science process skills between the experimental and control classes. If sig < 0.05, H_0 is rejected; if sig > 0.05, H_0 is accepted. The N-Gain test was used to determine improvements in students' science process skills before and after treatment.

Table 1. Criteria for N-Gain test results

N-Gain value	Categories
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2
Control	O_3	–	O_4

Figure 1. Research design

Description:
O_1: Pretest for experimental class
O_2: Posttest for experimental class
O_3: Pretest for control class
O_4: Posttest for control class
X: Treatment using a combination of PBL and Susan Loucks-Horsley syntax with a deep learning approach

Through this design, researchers can determine the improvement in students' science process skills after implementing the learning model in the experimental class and compare it with the control class. Research variables are everything that becomes the object of observation in the research. Research variables are attributes or characteristics that vary and are the focus of measurement in the research. The independent variable in this research is the application of a combination of Problem Based Learning (PBL) and Susan Loucks-Horsley syntax with a deep learning approach. This learning model was implemented in the experimental class through the following stages: Invitation; Problem Orientation; Exploration; Explanation and solution; Taking action; and Reflection on deep learning. The dependent variable in this study was the science process skills of eighth-grade students at SMP Negeri 6 Sentani, Jayapura Regency.

The science process skills indicators measured included: observing, classifying, measuring, interpreting data, formulating hypotheses; designing experiments; and communicating results. The sampling technique used in this study was purposive sampling. Purposive sampling is a sampling technique based on specific considerations in accordance with the research objectives. The experimental and control classes were selected based on: similar student characteristics, equal academic ability, relatively equal student numbers, and recommendations from science teachers. This technique was chosen because the researcher could not perform full class randomization within the school environment.

Results and Discussion

Results

Descriptive Analysis

In the experimental class, the pretest score for the KPS showed an average of 1.893 with a SD of 0.298, while the posttest score increased to 3.860 with a SD of 0.085. This average increase of 1.96 points indicates a significant improvement in KPS skills after the implementation of the learning model in the experimental class. The posttest score range was also within the upper range, from 3.66 to 4.000, so student achievement was relatively close to the maximum score.

Table 2. Descriptive statistics of science process skills scores

Class	Test	N	Mean	SD	Median	Min	Max
Experiment	Pretest	30	1.89	0.29	1.93	1.40	2.33
	Posttest	30	3.86	0.08	3.86	3.66	4.00
Control	Pretest	30	1.47	0.19	1.46	1.26	2.40
	Posttest	30	2.42	0.05	2.43	2.267	2.53

In the control class, the pretest score averaged 1.47 with a SD of 0.198, then increased to 2.42 with a SD of 0.05. The average increase of 0.94 points still indicates improvement, but the final achievement was lower than that of the experimental class. Therefore, descriptively, the experimental class exhibited a stronger KPS improvement profile, both in terms of the posttest average and the magnitude of the pretest-posttest change.

Normality Test

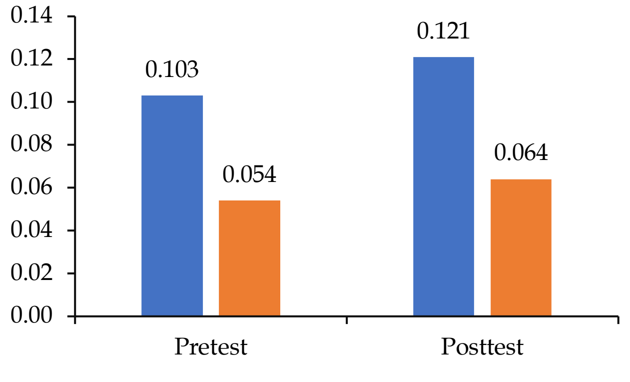

Figure 2. Percentage of Shapiro-Wilk normality test (pretest-posttest)

The results of the Shapiro-Wilk normality test, displayed in the bar chart, indicate that the pretest and posttest data in both the experimental and control classes met the assumption of normality ($p > 0.05$). The significance value in the experimental class was higher than in the control class, both in the pretest (0.10 vs. 0.05) and posttest (0.12 vs. 0.06). This finding confirms that the data is suitable for analysis using parametric tests and indicates that the score distribution in the experimental class is more stable than in the control class.

Shapiro–Wilk Normality Test

The Shapiro–Wilk normality test for the experimental class showed that the pretest data had a significance value of 0.10 and the posttest data had a significance value of 0.12, indicating that both were normally distributed at the 0.05 level. In the control class, the pretest and posttest data all showed significance values above 0.05, namely 0.05 and 0.06, respectively. This means that the distribution of the control data meets the assumption of normality. Therefore, the results of the paired sample t-test can be presented as parametric information.

Table 3. Shapiro–Wilk normality test

Class	Data	W	Sig.	Criteria
Experiment	Pretest	0.94	0.10	Normal
	Posttest	0.94	0.12	Normal
Control	Pretest	0.93	0.05	Normal
	Posttest	0.94	0.06	Normal

Paired Sample T-Test

The bar chart of the Paired Sample T-Test and the KPS Descriptive Statistics show that both the experimental and control classes experienced significant improvements in learning outcomes. However, the experimental class had a higher pretest percentage (47% compared to 38%) and a significantly higher posttest percentage (95% compared to 60%). This finding confirms that the innovative learning strategies implemented in the experimental class had a stronger impact on improving students' science process skills than conventional learning in the control class.

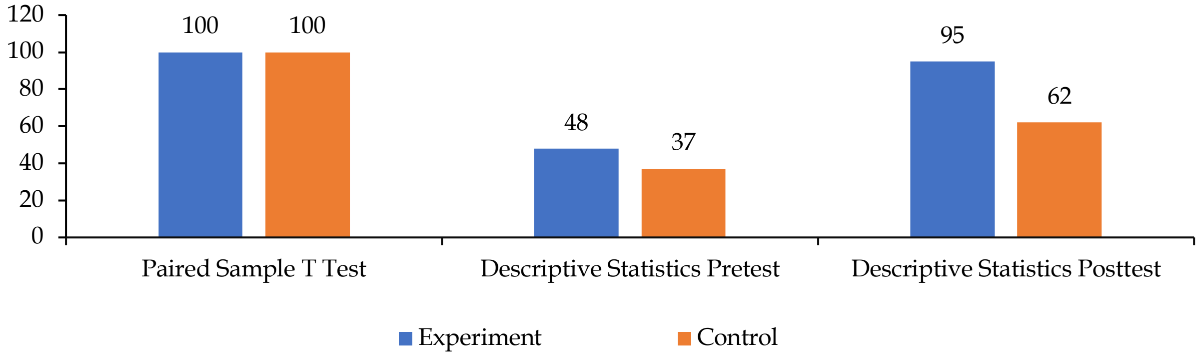

Figure 3. Percentage of Paired sample T test and descriptive statistics of science process skills

Paired Sample T-Test

The paired sample t-test results in the experimental class yielded a t value of -25.224 with a significance level of < 0.001. Because the significance level is less than 0.05, there is a significant difference between the pretest and posttest scores. Therefore, the learning implemented in the experimental class effectively improved students' science process skills, based on parametric testing.

Table 4. Result of Paired sample t-test

Class	Mean	SD	t	df	Sig.	Categories
Experiment	-28.70	6.23	-25.22	29	<0.001	Significant
Control	1.76	1.76	-46.76	29	<0.001	Significant

In the control class, the paired sample t-test also showed a significant difference with a t value of -45.766 with a significance level of < 0.001. Although significant, the magnitude of the improvement in the control class was descriptively smaller than that in the experimental class. Therefore, statistical significance should not only be interpreted from the p-value but also compared with the magnitude of the improvement, N-Gain, and effect size for a more comprehensive interpretation of learning effectiveness.

N-Gain Test

The average N-Gain score for the experimental class was 0.937, categorized as high. This finding indicates that the increase in the KPS score was not only statistically significant but also meaningful in terms of learning, as students successfully achieved most of the available room for improvement from their initial score to the maximum score. The minimum N-Gain score for the experimental class, 0.80, also categorized as high, indicating consistent improvement for almost all students.

The average N-Gain score for the control class was 0.60, categorized as medium. This means that the control class still experienced improvement after the learning process, but the level of effectiveness was not as high as that of the experimental class. This difference in N-Gain categories provides practical evidence that the treatment in the experimental class contributed more strongly to the development of science process skills than the learning in the control class.

Table 5. Result of N-gain test

Class	N	Mean N-Gain	Min	Max	Categories
Experiment	30	0.93	0.80	1.05	High
Control	30	0.60	0.63	1.00	Medium

Effect Size Test

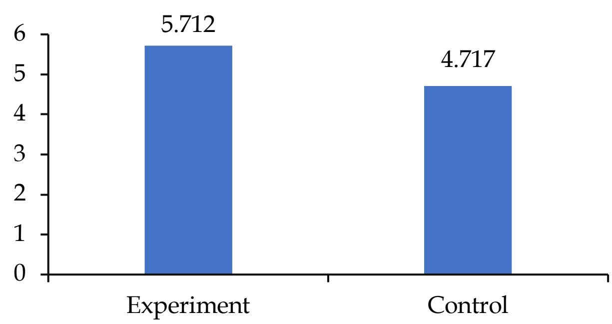

Figure 4. Percentage effect size of pretest-posttest improvement

The effect size for the pretest-posttest improvement shows that the experimental class achieved higher scores than the control class. The effect size for the experimental class was 6, while the effect size for the control class was 5. This finding confirms that although both groups experienced significant improvement, the innovative learning strategy implemented in the experimental class provided a stronger improvement effect than conventional learning. Thus, the treatment in the experimental class proved to be more effective in improving students' science process skills.

The effect size for the experimental class, based on Cohen's dz, was 5.71, categorized as large, while the r coefficient of 0.986 indicated a very strong effect. This large effect size confirms that the difference between the pretest and posttest is not only statistically significant but also has substantive significance in the context of improving students' science process skills (Nazifah, 2022; Martin et al., 2025). The effect size for the control class was also large, with Cohen's dz of 4.77 and r of 0.97. However, interpretation of the effect size should be read in conjunction with descriptive statistics and the N-Gain. In the control class, the standard deviation of the difference was relatively small, resulting in a large dz, but the average absolute increase and N-Gain remained lower than those of the experimental class. Thus, the experimental class still demonstrated superior learning effectiveness in practical terms.

Table 6. Effect size of pretest–posttest increase

Class	Cohen dz	Categories	r	Interpretation
Experiment	5.71	Big	0.98	The enhancement effect is very strong
Control	4.71	Big	0.97	The enhancement effect is very strong

Discussion

The analysis results show that students' science process skills improved in both classes after the learning, but the experimental class' improvement was significantly stronger. This aligns with the problem-based learning framework, which positions students as active participants in observing, classifying, measuring, communicating, and concluding scientific information (Heinimäki et al., 2021; Chengere et al., 2025). In the context of science learning, PBL encourages students to confront authentic problems, so that scientific thinking activities do not stop at memorizing concepts but develop into evidence-based inquiry and argumentation (Cahyani et al., 2025; Kasuga et al., 2022). The experimental class achieved a high average N-Gain, indicating that the combined application of PBL and Susan Loucks-Horsley syntax with a deep learning approach optimized the distance of improvement from the initial score to the maximum score.

The problem-oriented and exploratory syntax provides students with space to experience the scientific process repeatedly (Hartono et al., 2022; Qodri et al., 2026). These findings align with recent research reports that PBL has a positive impact on science process skills because students are trained to identify problems, collect data, conduct investigations, and draw conclusions systematically (Mystakidis, 2021; Yanto et al., 2026). The deep learning approach in a pedagogical context also fosters meaningful learning because students are not only asked to know the answers, but also to understand the relationships between concepts, explain reasoning, and connect science concepts to real-world situations (Zhang, 2020; Luo et al., 2025). The integration of deep learning and PBL has been reported to improve conceptual understanding and critical thinking skills in science learning, especially when students are provided with learning experiences that require reflection, collaboration, and contextual problem-solving (Marsam et al., 2026; Kurniawan et al., 2024; Ainun et al., 2024). Thus, the increase in the experimental class's SQ can be explained as a result of deeper cognitive engagement during the learning process.

Although the control class also showed significant improvement, the moderate N-Gain indicates that the improvement has not yet reached optimal effectiveness (Cao et al., 2025; Holzmeister et al., 2024). Significance in the control class could be influenced by practice, repetition of material, or increased basic understanding after regular learning. However, regular learning tends to provide more limited opportunities for exploration than models that intentionally design students to formulate problems, investigate, prove, and communicate results. Therefore, the difference in N-Gain between the experimental and control classes is an important indicator that the quality of the learning experience determines the depth of KPS development. The large effect size results, especially in the experimental class, indicate that the treatment had a strong impact on score changes. In educational research, effect size is important because the p-value is strongly influenced by sample size and data variation, while effect size provides a practical indication of the strength of the effect (Gan, 2026; Schäfer, 2025).

Therefore, the findings of this study not only confirm that learning has an effect but also demonstrate that this influence is substantial on junior high school students' KPS achievement. These results support the recommendation that science learning in junior high schools utilize more problem-based strategies, investigation, and in-depth reflection to foster 21st-century scientific skills (Aripin et al., 2025; Doyan et al., 2024). Overall, the combination of PBL and Susan Loucks-Horsley syntax with a deep learning approach can be considered effective in improving the science process skills of eighth-grade students at SMP Negeri 6 Sentani. This effectiveness is evident in the increase in the posttest average, the significance of the paired-end test, the high N-Gain category, and the very large effect size. Practical implications: Science teachers need to design learning that incorporates local contextual problems, real-world observation and measurement activities, collaborative discussions, and data-based reflection on conclusions so that students experience the full process of science, not just learn the products of science (Morris, 2025; Ramli et al., 2025).

Conclusion

Based on the analysis, the experimental and control classes both experienced significant increases in KPS between the pretest and posttest. However, the experimental class showed stronger improvements with a higher posttest average, a high N-Gain category, and a large effect size. Thus, the application of PBL syntax and Susan Loucks-Horsley with a deep learning approach was declared effective in improving students' science process skills.

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Conflicts of Interest
The authors declare no conflict of interest.

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