



The effect of the INSPIRE learning model on improving students' science process skills on the material of environmental change

Rahayuni Wulantika¹, Paidi Paidi^{1*}

¹Biology Education Study Program, Universitas Negeri Yogyakarta, Indonesia

E-mail: paidi@uny.ac.id

Abstract. This research addresses the problem of low science process skills among students at Gunungkidul Senior High School. It aims to determine the effect of implementing the INSPIRE learning model on improving the science process skills of Grade X students in the environmental change material. This research is quasi-experimental (Quasi-Experimental Research) with a Non-equivalent control group design. The research was conducted at Gunungkidul Senior High School, with a sample of 72 Grade X students obtained through simple random sampling. In the experimental group, students received treatment using the INSPIRE learning model, while in the control group, students used a learning model commonly used by teachers, namely Discovery Learning. Data collection on science process skills on environmental change material used non-test instruments in the form of learning implementation sheets, as well as test instruments in the form of pre-tests and post-tests consisting of essay questions. The data analysis techniques used were learning implementation analysis, descriptive analysis of research data, and inferential statistical analysis of research data, including a homogeneity test of data variance, a normality test of data distribution, and a hypothesis test using the Mann-Whitney Test, with the help of SPSS 26. The results of the study showed that the INSPIRE learning model had a significant effect in improving students' science process skills with an Asymp.Sig (2-tailed) value of 0.000 ($p < 0.05$). Thus, it can be concluded that the application of the INSPIRE learning model had a significant effect in improving students' science process skills in the environmental change material at Gunungkidul High School. Teachers can use this INSPIRE learning model as an alternative learning strategy in the classroom.

Keywords: *Deep learning, Environmental change, INSPIRE, Science process skills*

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INTRODUCTION

The government is encouraging the implementation of a deep learning approach. The deep learning approach consists of three components: meaningful learning, mindful learning, and joyful learning, to improve the quality of learning (Paidi et al., 2025). This learning emphasizes students' ability to relate material to real-life situations and deeply understand concepts, rather than simply memorizing (Fatmawaty, 2024). In the process, students actively construct knowledge and apply it to everyday life, making learning more relevant. Active student involvement in learning raises awareness of the importance of biological concepts.

In line with this principle, learning needs to be facilitated through activities that encourage students to discover concepts independently. Activities such as observing environmental phenomena enable students to build understanding while developing science process skills (SPS) (Nisfa & Putri, 2022; Wulandari & Oktaviani, 2021). Science process skills are scientific skills that support students in acquiring, developing, and applying knowledge through the scientific process (Fauziah, 2022). In addition to science process skills, direct observation activities can also improve students' 4Cs skills. For example, observation activities foster collaboration and communication skills through group activities.

However, field conditions suggest that the Science Literacy Index (SCI) and the 4Cs (critical thinking, communication, collaboration, creativity) have not yet reached optimal

development. PISA 2022 data show that Indonesia's science literacy scores remain below the OECD average, indicating low student SCI (Fahmi & Sari, 2024). This is supported by research showing a positive correlation between science literacy and SCI, so that low literacy reflects low SCI (Azizah et al., 2023; Handayani et al., 2018). Several other studies also indicate that students' 4Cs skills still need improvement.

Low SCI was also found in various schools, including high schools in Sleman and Gunungkidul. Students in Sleman are not yet accustomed to conducting practical work, have difficulty processing and communicating data, and are unable to relate data to concepts (Murni, 2018). A similar situation also occurs in Gunungkidul High School, where students still struggle to create tables, read data, and present observation results. This situation is inseparable from various factors that influence the learning process. Internal factors such as low motivation and curiosity, as well as external factors such as teacher-centered learning and the use of inappropriate models, contribute to low Student Performance Indicators (SPS) (Marviyani & Erman, 2021; Firdaus & Subekti, 2021). As a result, students tend to memorize concepts without understanding the underlying scientific processes (Dewi & Rohmani, 2025).

Given these conditions, innovative learning models are needed to facilitate SPS development. One potential model is the INSPIRE learning model, which includes stages ranging from concept identification to reflection (Paidit et al., 2026a). This model encourages students to actively think scientifically, conduct investigations, and communicate results through a flipped-classroom and deep-learning approach. The application of the INSPIRE learning model becomes even more relevant when linked to environmental change material. This material relates to real-world phenomena but is often taught in a theoretical manner, resulting in low student engagement (Musyadad et al., 2019). However, this material enables the implementation of scientific processes that can directly develop students' scientific process skills (SPS).

Previous research has shown that the INSPIRE model is effective in improving conceptual understanding and problem-solving (Paidit et al., 2026b). Furthermore, inquiry models, flipped classrooms, and deep learning have been shown to improve SPS. This suggests that the INSPIRE learning model has the potential to improve students' SPS. Therefore, this study aims to examine the effect of the INSPIRE learning model on students' science process skills in environmental change material at Gunungkidul high schools.

METHOD

This study used a quasi-experimental method with a Nonequivalent Control Group Design (Cohen et al., 2018; Abraham & Supriyati, 2022). The research design is presented in Table 1, which shows that both groups were given pre-tests and post-tests. The experimental group received treatment using the INSPIRE learning model, while the control group used Discovery Learning.

Table 1. Nonequivalent control group design

Group	Pre-test	Treatment	Post-test
Experiment	O_1	X	O_2
Control	O_3	-	O_4

Description:

O_1 : Average pre-test score of the treatment (experimental) group

O_2 : Average post-test score of the treatment (experimental) group

O_3 : Average pre-test score of the untreated (control) group

O_4 : Average post-test score of the untreated (control) group

X : Learning using the INSPIRE learning model

- : Learning using the learning model commonly applied by teachers

The research was conducted at Gunungkidul Senior High School in the even semester of the 2025/2026 academic year, February–March 2026. The study population consisted of all 252 tenth-grade students divided into seven classes. The sample was selected using simple random sampling, resulting in two classes: XC as the control group and XG as the experimental group, with 72 students in each.

Data collection was conducted using test and non-test techniques. The test technique consisted of 10 pre- and post-test essay questions to measure science process skills, structured according to the Science Process Skills (SPS) indicators of Rezba et al. (2027), as presented in Table 2. The non-test technique involved observing the implementation of learning using an observation sheet that referred to the learning syntax.

Table 2. Indicators for assessment of learning implementation in the experimental and control groups

No	Science Process Skills Indicators	Question Number
1	Observing	1, 2
2	Drawing Hypotheses	3, 4
3	Planning Investigations	5, 6
4	Interpreting Data and Drawing Conclusions	7, 8
5	Communicating	9, 10

The research instrument consisted of pre- and post-test questions and an observation sheet. Instrument validity was tested through expert judgment and construct testing using Pearson correlation using SPSS, with the criterion of calculated $r > \text{table } r$ (Utami et al., 2023; Tugiman et al., 2022). Instrument reliability was calculated using Cronbach's Alpha with a criterion of > 0.60 , thus declaring the instrument reliable. Based on the analysis results, all pre-test items had a calculated $r > 0.244$ and post-test $r > 0.235$, thus declared valid. Furthermore, Cronbach's Alpha values of 0.614 for the pre-test and 0.715 for the post-test indicated that all instruments were reliable and suitable for research.

The data obtained were then analyzed descriptively and inferentially. Learning implementation was analyzed using percentages based on Arikunto's (2013) criteria (Table 3), while science process skills were analyzed using score percentages and categorized according to Gusnita et al.'s (2025) criteria (Table 4). Before the hypothesis test, prerequisite tests were conducted using SPSS: the Kolmogorov-Smirnov normality test and Levene's homogeneity test (Andini & Amboningtyas, 2020; Purba & Hasibuan, 2025).

Table 3. Criteria for assessing learning implementation

Score Range	Criteria
80 – 100	Very Good
66 – 79	Good
56 – 65	Fair
40 – 55	Poor
30 – 39	Very Poor

Table 4. Interpretation of science process skills

Percentage	Criteria
81 – 100	Very Good
61 – 80	Good
41 – 60	Fair
21 – 40	Poor
0 – 20	Very Poor

After the data met the assumptions of normality and homogeneity, hypothesis testing was conducted using an independent-samples t-test; if the data did not meet the assumptions, a

Mann-Whitney test was used. This test was used to determine differences in science process skills between the experimental and control groups. Therefore, this analysis aims to determine the effect of implementing the INSPIRE learning model on students' science process skills.

RESULTS AND DISCUSSION

Results

Based on the observation results, the categorization of learning implementation in the experimental and control groups is presented in Table 5.

Table 5. Categorization of learning implementation in the experimental and control groups

Class	Meetings			Average	Criteria
	1	2	3		
X G (Experiment)	88.8%	100%	90.9%	93.2%	Very Good
X C (Control)	100 %	81.8%	90%	90.6%	Very Good

The categories above indicate that the learning process in both groups was structured in accordance with the In-Depth Learning Plan. A more detailed description of the implementation of learning in both groups is presented in Table 6.

Table 6. Results of the implementation of experimental group learning

INSPIRE learning model syntax	Implementation			Explanation
	NI	NWI	NI	
Identifying Basic Concepts	√	-	-	-
Nurturing Problem	√	-	-	-
Setting Up Hypothesis	√	-	-	-
Planning Investigation	√	-	-	-
Investigating Empirical Evidence	-	√	-	It was implemented, but the time allocated for the investigation was insufficient, so the students continued their independent investigation.
Reasoning and Concluding	√	-	-	-
Ending with Reflection	√	-	-	-

Information: WI (Well Implemented), NWI (Not Well Implemented), NI (Not Implemented)

Based on Table 6, it can be concluded that learning using the INSPIRE model has generally been implemented well, in accordance with the In-Depth Learning Plan, except for the Investigating Empirical Evidence step (conducting the investigation). This step was implemented, but the investigation activities conducted in the school environment took longer than planned because students had to move between locations to collect data. Therefore, the teacher directed students to continue the investigative activities independently so that data collection could proceed and the problem formulation could be addressed. The implementation of learning in the control class using Discovery Learning is shown in Table 7.

Table 7. Results of the implementation of control group learning

Discovery Learning Model Syntax	Implementation			Explanation
	NI	NI	NI	
Stimulation	√	-	-	-
Problem Statement	√	-	-	-
Data Collection	√	-	-	-
Data Processing	√	-	-	-
Verification	-	√	-	Implemented, but with limited time, so it is necessary to adjust the presentation mechanism.
Generalization	√	-	-	-

Information: WI (Well Implemented), NWI (Not Well Implemented), NI (Not Implemented)

Based on Table 7, the Discovery Learning model was generally implemented well in accordance with the In-Depth Learning Plan, except for the verification step. This verification step was implemented, but the reduction in learning hours led to the presentation activity, originally planned for all group members, being simplified to two members. However, the teacher still directed the other four members to provide feedback and questions, as well as answer questions from other groups. This adjustment was made to address the limited learning time but did not reduce student engagement in the discussion or the proof of concept.

A detailed description of the pre- and post-test results for science process skills related to environmental change in the experimental and control groups is provided in Table 8.

Table 8. Pre-test and post-test results of science process skills in the experimental group and control group

Statistics	Results of Science Process Skills Measurement			
	Experimental Group (INSPIRE)		Control Group (Discovery Learning)	
	<i>Pre-test</i>	<i>Post-test</i>	<i>Pre-test</i>	<i>Post-test</i>
Mean	57.56	80.17	53.76	64.63
Minimum Value	40	32	24	46
Maximum Value	74	94	78	82
Standard Deviation	8.572	13.760	12.153	9.997
N			28	

Table 8 shows that the pre-test scores between the experimental and control groups were not significantly different, indicating that students' science process skills were relatively similar before the treatment. After the learning process, the average post-test scores for both groups increased, with the experimental group showing greater improvement than the control group.

Based on the previous descriptive analysis, the experimental group tends to perform better than the control group. To determine the significance of the differences between the two groups, inferential statistical analysis is required to conclude whether the hypothesis is correct using SPSS version 26. Prior to conducting this test, prerequisite tests are required, including tests for homogeneity of variance and normality of the data distribution. The results of the prerequisite tests are shown in Tables 9 and 10.

Table 9. Results of the Homogeneity Test of Science Process Skills

Variable		Levene's Test Significance	Category
Science Process Skills	<i>Pre-test</i>	0.064	Homogeneous
	<i>Post-test</i>	0.595	Homogeneous

Table 10. Results of the Normality Test of Science Process Skills

Variable	Group		Significance of Kolmogorov-Smirnov	Category
Science Process Skills	Experiment	<i>Pre-test</i>	0.200	Normal
		<i>Post-test</i>	0.200	Normal
	Control	<i>Pre-test</i>	0.200	Normal
		<i>Post-test</i>	0.018	Abnormal

Based on the prerequisite test results in Tables 9 and 10, the data are homogeneous but not normally distributed, so they do not meet the requirements for parametric statistical tests. Therefore, data analysis was continued using non-parametric statistical tests, specifically the Mann-Whitney test, for both unpaired sample groups. The results of the analysis are presented in Table 11.

Based on Table 11, the Mann-Whitney test results for the pre-test scores show an Asymp. Sig (2-tailed) of 0.163. This value is greater than 0.05, indicating that H_0 is accepted. This means there was no significant difference in pre-test scores for science process skills

related to environmental change between the experimental and control groups. This indicates that students' initial science process skills in both groups were relatively similar.

Table 11. Mann-Whitney Test Results for Pre-test and Post-test Data on Science Process Skills

	Mann-Whitney Statistical Test			
	Mann Whitney U	Wilcoxon W	Z	Asymp sig. (2-tailed)
<i>Pre-test</i>	422.000	983.000	-1.394	0.163
<i>Post-test</i>	173.000	803.000	-5.263	0.000

Meanwhile, the Mann-Whitney test results for the post-test scores show an Asymp. Sig (2-tailed) of 0.000, indicating that H_0 is rejected. This means there was a significant difference in post-test science process skills scores between the experimental and control groups. Therefore, it can be concluded that the learning implemented in the experimental group influenced the improvement of students' science process skills.

The science process skills of the experimental and control groups were analyzed in more detail descriptively, based on the average scores for each indicator, as shown in Tables 12 and 13.

Table 12. Average Value of Each SPS Indicator for the Experimental Group

Science Process Skills Indicators	Average Value			
	Pre-test	Category	Post-test	Category
Observing	43.7	Fair	80.8	Good
Formulating Hypotheses	58.1	Fair	87.2	Very Good
Designing Investigations	43.7	Fair	64.1	Good
Interpreting Data and Drawing Conclusions	69.3	Good	85	Very Good
Communicating	72.5	Good	83.6	Very Good
Average Mastery	57.4	Fair	80.1	Good

Table 13. Average Score of Each Science Process Skills Indicator in the Control Group

Science Process Skills Indicators	Average Value			
	Pre-test	Pre-test	Pre-test	Pre-test
Observing	49.3	Fair	67.7	Good
Formulating Hypotheses	62.4	Good	73.4	Good
Designing Investigations	30.3	Poor	35.4	Poor
Interpreting Data and Drawing Conclusions	65.4	Good	73.7	Good
Communicating	61.2	Fair	72.8	Good
Average Mastery	53.7	Fair	64.6	Good

Based on Tables 12 and 13, all indicators increased in both the experimental and control groups. In the experimental group, the increase was seen from the change in categories, which were originally dominated by the "Sufficient" and "Good" categories, to "Good" and "Very Good". This means the INSPIRE learning model improved all SPS indicators, not just certain ones. Meanwhile, in the control group, the increase was not significant because some indicators remained in the "Good" category, and the indicator for designing investigations remained in the "Poor" category.

Discussion

Based on the results of the hypothesis test, the implementation of the INSPIRE learning model significantly improved students' science process skills (SPS), as indicated by a higher post-treatment average score for the experimental group than for the control group. This demonstrates the effectiveness of the INSPIRE learning model because it facilitates all SPS indicators through a systematic learning syntax: Identifying Basic Concepts, Nurturing

Problems, Setting Up Hypotheses, Planning Investigation, Investigating Empirical Evidence, Reasoning and Concluding, and Ending with Reflection, thereby enabling students to engage in the entire scientific process actively.

In the initial stage, Identifying Basic Concepts, students engage in in-depth observation activities through videos and articles. This step has proven effective in optimizing the comprehensive use of the senses, significantly improving observation skills, in line with the findings of [Nuvitalia et al. \(2016\)](#). This stage also makes a significant contribution in facilitating students' connection between prior knowledge and new learning experiences ([Priyayi et al., 2022](#)). The use of visual multimedia in the early stages of science learning is crucial. This is supported by the findings of [Hwang et al. \(2020\)](#) in the journal *Computers & Education*, which confirmed that integrating multimedia and interactive video can reduce students' cognitive load while improving their focus and retention of observations of scientific phenomena before moving on to more abstract analysis.

Entering the Nurturing Problem and Setting-Up Hypothesis stages, students are intensively trained to formulate problems and develop logical hypotheses grounded in conceptual foundations. This structured exercise successfully boosted the hypothesis-building indicator from "Fair" to "Excellent." This increase in analytical capacity is strongly supported by the implementation of a flipped classroom approach combined with e-modules, which allow students independent time to develop an understanding of prerequisite concepts before face-to-face class ([Wajdi et al., 2024](#); [Gumilar, 2021](#)). The effectiveness of this strategy aligns with research by [Zhai et al. \(2020\)](#) published in the *Journal of Science Education and Technology*, where flipped learning was shown to provide students with space to process initial information at their own pace, making them much more prepared, critical, and confident when formulating scientific predictions or hypotheses in the classroom.

Despite showing significant progress, at the Planning Investigation stage, students' skills in designing investigations only improved from "Fair" to "Good." This lack of achievement ("Very Good") is understandable, as students are generally unfamiliar with, and still struggle to design, scientific investigation procedures independently without strict guidance ([Sumarra et al., 2020](#)). This cognitive barrier is a global phenomenon that can be explained through a comprehensive study by [Pedaste et al. \(2015\)](#) in the *Educational Research Review*. The study concluded that the planning phase is the most cognitively demanding stage of inquiry. Therefore, scaffolding, or gradual guidance from educators, is necessary until students are truly autonomous in designing experimental variables.

Furthermore, at the Investigating Empirical Evidence stage, this model made a massive contribution to improving Science Process Skills (SPS). Specifically, the indicators of observing precisely, interpreting experimental data, and communicating findings successfully reached the "Very Good" category. This success was driven by students' direct and authentic involvement in hands-on activities and real data processing ([Febriani et al., 2026](#); [Taryati & Tarsidi, 2025](#)). The importance of this activity is reinforced by international literature, such as research by [Kruit et al. \(2018\)](#) in the *International Journal of Science Education*, which proved that students' physical involvement in collecting empirical evidence (hands-on activities) not only instills deeper conceptual understanding but also instantly hones motor and analytical skills, which are key instruments in science process skills.

In the final stages of learning, namely Reasoning and Concluding and Ending with Reflection, students demonstrated rapid progress in their ability to draw logical conclusions. Indicators for interpreting data and presenting discussion results increased sharply to "Very Good" because the presentation, interactive discussion, and reflection phases forced students to engage in collaborative scientific reasoning ([Rositawati, 2018](#); [Wiyogo et al., 2025](#); [Boroallo et al., 2025](#)). In line with these findings, studies by [Zohar & Barzilai \(2013\)](#) and [Osborne \(2010\)](#) on scientific argumentation suggest that the stages of scientific debate and reflection play a

vital role in developing students' metacognition. When students are required to communicate and defend arguments based on data, they internalize higher-level problem-solving skills.

Overall, it can be concluded that the significant improvement in SPS in the experimental group was due to the INSPIRE learning model's syntax, which facilitates all stages of the scientific method in a structured, comprehensive, and sustainable manner. These findings support various studies indicating that guided inquiry learning is highly effective in enhancing scientific practices and attitudes (Febriani et al., 2026; Pertiwi et al., 2017). Furthermore, a large-scale meta-analysis by Lazonder and Harmsen (2016), published in the Review of Educational Research, also found that inquiry-based learning, complemented by appropriate instructional guidance (guided inquiry), is the most effective pedagogical strategy for facilitating students of various intellectual ability levels. Thus, the INSPIRE learning model has been proven not only to boost cognitive learning outcomes but also to equip students with meaningful, contextually grounded scientific skills.

CONCLUSION

The application of the INSPIRE learning model has a significant influence on improving students' science process skills on environmental change material. This improvement occurs because students go through a series of learning activities, namely: (1) Identifying Basic Concepts, (2) Nurturing Problems, (3) Setting Up Hypotheses, (4) Planning Investigation, (5) Investigating Empirical Evidence, (6) Reasoning and Concluding, and (7) Ending with Reflection, which systematically train and develop better science process skills. The results of this study can serve as a reference for teachers when implementing learning models in the classroom. However, this study has shortcomings because it was conducted with a small sample and at a specific school. Suggestions for further research include conducting it with a larger sample and additional dependent variables to determine the effectiveness of the INSPIRE model as a whole.

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