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Improving Students' Science Process Skills through Level of Inquiry Learning Assisted by Liveworksheet on The Concept of Environment Change

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Abstract: In the 21st century, scientific process skills are highly sought after. Interactive learning models and media can effectively train students in these skills. This research investigates the use of the Levels of Inquiry learning model assisted by Liveworksheet to improve students' science process skills in the context of environmental change. The study employs a quasi-experimental design with a non-equivalent pretest-posttest control group. Purposive sampling was used to select the participants. Data collection relied on a test sheet containing descriptive questions aligned with ten science process skill indicators. The t-test analysis ($p < 0.05$) revealed a significant difference in the improvement of science process skills. Notably, the increase was higher in classes utilizing the Levels of Inquiry Model with Liveworksheet compared to those without. The findings demonstrate that the Levels of Inquiry Model assisted by Liveworksheet has a significant positive impact (large effect size, $d = 0.84$) on developing students' science process skills when studying environmental change.

Keywords: Environmental change, Level of Inquiry, Liveworksheet, Science Process Skills.

Introduction

Effective biology learning should provide students with hands-on experiences to solidify concepts and develop essential skills. Novitasari et al. (2017), identify four key learning approaches in biology: attitude, process, product, and application. Furthermore, Indonesian Ministry of National Education Regulation Number 22 of 2006 (educational content standar) emphasizes developing deductive, inductive, and analytical thinking skills in high school.

Regulations also highlight the importance of fostering student interest, talent, creativity, independence, and initiative during classroom activities (Minister of Education and Culture Regulation No. 65 of 2013). To achieve these goals, learning approaches must cultivate both soft skills, hard skills, and life skills relevant to the 21st century (Maullidyawati & Hidayah, 2022) .One of the most critical scientific skills for the 21st century is scientific process skills (Lepiyanto, 2014).

Scientific process skills (SPS) refer to a student's ability to independently search, experiment, discover, and acquire knowledge or scientific laws through the scientific method (Mardianti et al., 2020). These skills encompass intellectual, social, and physical abilities developed through direct learning experiences, often involving practical activities (Lepiyanto, 2014). Zahroh et al. (2016) emphasize that SPS are crucial learning outcomes – students with well-developed SPS achieve higher quality and quantity of learning

According to Chabalengula et al. (2012), science process skills are in two categories which are basic and integrated skills. Basic process skills include observing, inferring, measuring, communicating, classifying, predicting, using time space relations and using numbers. Integrated process skills include controlling

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variables, defining operationally, formulating hypotheses, formulating models, interpreting data and experimenting.

Fatminastiti (2021) highlights the role of SPS in providing students with the guidance and concrete experiences necessary to develop high-level thinking skills, allowing them to effectively integrate key concepts and facts. Unfortunately, current studies indicate that Indonesian students lack adequate training in SPS during their schooling. This is evident in Indonesia's performance on the 2015 Trend in Mathematics and Science Study (TIMSS), where science process skills were assessed. The average score of Indonesian students was 32, significantly lower than the international average of 50. Indonesia's overall TIMSS score of 270 placed them 45th out of 48 participating countries (Rosyida & Nurita, 2018). Similar trends were observed in the 2018 Program for International Student Assessment (PISA), where Indonesia's average science score was 389, compared to the international average of 489 (Geovana et al., 2023). These data are further supported by real-world observations. Interviews with teachers revealed concerns about student heterogeneity, leading them to favor traditional lecture and memorization methods to strengthen memory, communication, and creativity. Practical activities are often limited to once per semester or even eliminated entirely. Environmental science assessments continue to focus on low-level cognitive domains, primarily testing conceptual understanding. Only 30% of assessment questions incorporate SPS indicators (5% observation, 10% classification, 10% interpretation, and 5% prediction). While 8 of the 20 teacher-provided questions included some level of SPS assessment, the remaining 12 questions only targeted cognitive levels C1, C2, and C3.

Based on this data, it is clear that Indonesian students generally possess underdeveloped SPS. Developing these skills is crucial, as SPS encompass the abilities to acquire new knowledge, engage in self-directed learning, apply scientific principles, and discover scientific laws through investigation (Solpa et al., 2022). Wahyuni et al. (2020) attribute the low level of SPS in Indonesian students to the lack of practical activities. Students accustomed to passively receiving information from teachers struggle with skills like hypothesis development and experiment planning.

One potential solution is adopting the Level of Inquiry (LoI) learning model. LoI encourages students to actively engage in the learning process by searching, experimenting, investigating, and solving problems using scientific methods. The model structures inquiry-based learning through sequential stages, namely discovery learning, interactive demonstration, inquiry lesson, and inquiry labs (Wenning, 2011). Research by Irdawati et al. (2018) supports this approach, demonstrating significant improvement in students' SPS using a guided inquiry laboratory model (pretest score: 61.00, post-test score: 84.98). Research by Tan et al. (2020) show that student′ science process skills increasing after implementation Inquiry-Based flipped classroom environment

Another strategy involves interactive learning media. Teachers can utilize web-based electronic content, such as Liveworksheets, to enhance the learning process (Rosyida & Nurita, 2018). Masruhah et al. (2022) found inquiry learning supported by Liveworksheets to be effective in improving students' SPS, with an N-Gain value of 0.6. This research differs from previous studies in its implementation of the Levels of Inquiry learning model, which incorporates distinct live worksheet media for each inquiry level.

Based on the description above, this research aims to analyze the improvement of students' science process skills using the levels of inquiry model assisted by liveworksheet on environmental change topic.

Method

This research was carried out at MAN 3 Tasikmalaya in the first semester of the 2022-2023 academic year. The time for carrying out this research from the preparatory stage to the final stage starts from January to May 2023. This type of research is quantitative, where all the data obtained is interpreted into numerical data, processed, and then analyzed (Sugiyono, 2018). The method used in this research is quasi-experimental with a non-equivalent pretest-posttest *control group design where* both research classes were given tests before and after treatment. Data collection was carried out through tests using research instruments and an essay test sheet based on 10 indicators of science process skills. The validity, reliability, differentiation, and difficulty levels of the test items were determined through instrument verification, yielding a reliability value of 0.90 (very high).

The research data regarding N-Gain values was analyzed using appropriate statistical tests based on data normality and homogeneity. For normally distributed and homogeneous data, parametric tests like the independent samples t-test were employed. Normality was assessed using the Kolmogorov-Smirnov test, and homogeneity was tested using Levene's test. All analyses were conducted using SPSS version 26 software, with a significance level (α) set at 0.05. The rejection criteria were: If the p-value (Asymp. Sig. [2-tailed]) was less than 0.05, then the null hypothesis (H0) was rejected, and the alternative hypothesis (Ha) was accepted. Assuming hypothesis testing results are available, an effect size analysis can be conducted to determine the magnitude of influence of the Levels of Inquiry Model assisted by Liveworksheet on students' science process skills in the environmental change material. Cohen's d formula can be used to calculate the effect size, which can then be interpreted based on established criteria (Cohen, 1988).

The research stages carried out include the preparation, implementation, and final stages. Details of the research stages are shown through the research flow scheme in Figure 1.

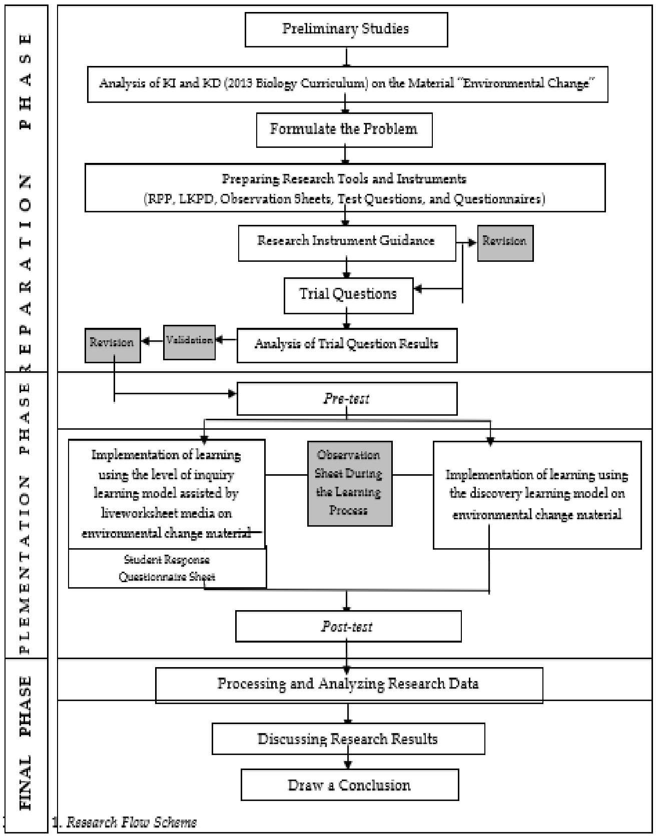

Figure 1. Research stage

Result and Discussion

The improvement of science process skills in both research classes was measured through written tests in the form of pretest and posttest description questions. The written test in this study amounted to 10 description questions and represented seven Competency Achievement Indicators of environmental change material integrated with indicators of science process skills. Pretest and posttest generate quantitative data, which is then analyzed using the N-Gain test. The N-Gain value obtained can indicate an improvement in students' science process skills on environmental change material. Based on the average value of the pretest-posttest, the N-Gain value is presented in Table 1. below:

Table 1. Recapitulation of Pretest, Posttest, and N-Gain Average Scores

Class	Pretest	Posttest	N-Gain	Criteria	Category
Experiment	37.3	86.8	0.79	High	Effective
Control	40.9	77.7	0.62	Medium	Quite Effective

Table 1 demonstrates a greater improvement in science process skills for the experimental class compared to the control class. Students in the experimental group achieved an N-Gain score of 0.79, falling within the "high" criteria and interpreted as "effective." Conversely, the control group exhibited a moderate improvement with an N-Gain score of 0.62, categorized as "medium" and interpreted as "quite effective.

The category of improving students' science process skills in both research classes from high to low level can be seen in Figure 2.

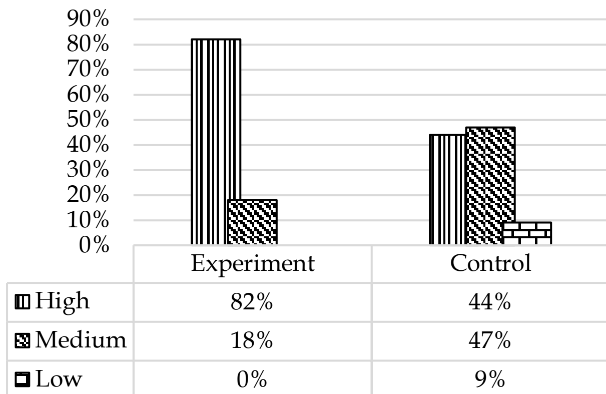

Figure 2. Student Science process skill Category from High Level to Low Level

Figure 2 visually depicts the distribution of N-Gain scores within each class. The majority of students (82%) in the experimental group achieved N-Gain scores in the "high" category, signifying substantial improvement. An additional 18% fell within the "medium" category, while none scored in the "low" category. In contrast, the control class displayed a more balanced distribution: 47% in the "medium" category, 44% in the "high" category, and 9% in the "low" category. While the overall N-Gain scores indicate improvement, it's crucial to analyze the N-Gain values for each individual science process skill indicator. This additional analysis aims to identify any discrepancies in the improvement rates across different skill indicators within the test. Tables 2 and 3 detail the average N-Gain scores per indicator for the experimental and control classes, respectively.

Table 2. Recapitulation of Average Attainment of N-Gain Value Per Science Process Skills Indicator in experimental Class

Indicators Science Process Skills	Expermental Class N-Gain	%	Criteria
Observasion	0.80	80%	High
Classification	0.67	67%	Medium
Interpretation	0.86	86%	High
Prediction	0.69	69%	Medium
Asking a Question	0.66	66%	Medium
Hypothesize	0.84	84%	High
Plan an Experiment	0.89	89%	High
Using Tools/Metrials	0.86	86%	High
Applying the Concept	0.69	69%	Medium
Communicate	0.91	91%	High

Tabel 3. Recapitulation of Average Attainment of N-Gain Value Per Science Process Skills Indicator in control class

Indicators Science process Skills	Class Control N-Gain	%	Criteria
Observasion	0.51	51%	Medium
Classification	0.59	59%	Medium
Interpretation	0.76	76%	High
Prediction	0.73	73%	High
Asking a Question	0.40	40%	Medium
Hypothesize	0.75	75%	High
Plan an Experiment	0.80	80%	High
Using Tools/Metrials	0.35	35%	Medium
Applying the Concept	0.32	32%	Medium
Communicate	0.84	84%	High

Table 2 and 3 reveals that the "communicate" indicator exhibited the greatest improvement in both classes. Students in the experimental class achieved an N-Gain score of 0.91 (high criteria), while the control class reached 0.84 (also high criteria). Conversely, the "asking questions" indicator demonstrated the lowest average improvement in the experimental class, with an N-Gain score of 0.66 (medium criteria). In contrast, the control class showed the lowest improvement in the "applying concepts" indicator, with an N-Gain score of 0.32 (medium criteria).

To determine a statistically significant difference in science process skill improvement between the two groups, inferential statistical testing will be conducted to verify the research hypothesis. This analysis involves two stages: prerequisite tests and hypothesis testing. The data analyzed will be the posttest scores from both research classes. Prerequisite Tests include normality testing and homogeneity testing . Normality test assesses whether the data originates from normally distributed populations (Nuryadi et al., 2017). Homogeneity Testing is a test to determines whether the variances of multiple populations are considered homogeneous (Usmadi, 2020). Following successful completion of the prerequisite tests, the next stage involves hypothesis testing. The detailed results of posttest data analysis, including normality, homogeneity, and hypothesis test calculations, are presented in Table 4.

Table 4. Posttest Data Analysis

	Posttest Data Analysis	Experimental Class	Control Class
Normality (*Kolmogorov Smirnov*) (*Sig.* > 0,05)	*Sig.*	0.053	0.136
	Significance Level	0.05	0.05
	Description	Normal Distribute Data	Normal Distribute Data
Homogenity (*Levene*) (*Sig.* > 0,05)	*Sig.*		0,039
	Significance Level		0,05
	Description	Both Populations Have homogeneous Variances	
Independent Sample T Test/T' (*Equal Variances Not Assumed*) (*Sig. 2-tailed* < 0.05)	*Sig. 2-tailed*		0.002
	Significance Level		0.05
	Description	H_0 Rejected and H_a Accepted	
	Conclusion	There are differences in students' process science skills	

Noted:
Null Hypothesis (H_0): There is no statistically significant difference in science process skills improvement between students in classes using the Levels of Inquiry Model assisted by Liveworksheet on environmental change material and those who do not.
Alternative Hypothesis (Ha): There is a statistically significant difference in science process skills improvement between students in classes using the Levels of Inquiry Model assisted by Liveworksheet on environmental change material and those who do not.

Based on Table 4, the significance value (p-value) obtained from the hypothesis test is less than 0.05 (t' = 0.002 < 0.05). This indicates a rejection of the null hypothesis (H_0) and supports the alternative hypothesis (Ha). In simpler terms, the results statistically confirm a significant difference in science process skills improvement between the two groups. To determine the magnitude of this difference, an effect size test was conducted using the pretest and posttest scores from both research classes. Table 5 displays the effect size analysis results.

Table 5 reveals a Cohen's d effect size value of 0.84, which falls within the "large" effect category (d ≥ 0.80). This large effect size suggests a substantial impact of using the Levels of Inquiry Model assisted by

Liveworksheet on improving students' science process skills in the context of environmental change material.

Table 5. Effect Size Test Analysis Results

Analysis of Effect Size Test	Experiment	Control
($\vec{x}_t$ and $\vec{x}_c$)	49.5	36.8
$Sd_1{}^2$ *and* $Sd_2{}^2$	195.5	268.5
$\vec{x}_t - \vec{x}_c$		12.8
S_{pooted} Combined		15.2
Effect Size Value		0.84 → 84%
Categories		Large

As shown in Table 1 and Figure 2, the experimental class using the intervention achieved a "high" improvement criterion with an "effective" interpretation (N-Gain = 0.79). Additionally, most students in this class demonstrated significant improvement in their science process skills. This suggests that learning through the Levels of Inquiry Model assisted by Liveworksheet is effective in enhancing students' science process skills.

While the control class showcased a "medium" improvement criterion with a "quite effective" interpretation (N-Gain = 0.62), it's important to note that three students (9% of the total) remained in the "low" skill category. This highlights that discovery learning, while generally effective, may not be equally beneficial for all students. These findings support cognitivism theory (Rahmaniar et al., 2021). Which acknowledges that individual cognitive abilities influence the development of different science process skills

The observed difference in N-Gain scores between the two classes can be attributed to variations in the learning models employed and the resulting emphasis on different science process skills. Both classes participated in three face-to-face sessions. However, the experimental class utilized a tiered Levels of Inquiry Model, where each session focused on a progressively more complex level of inquiry (discovery, interactive demonstration, and inquiry lesson & labs). This approach facilitates a more gradual development and deepening of science process skills, as supported by research (Karim et al., 2021). In contrast, the control class relied solely on the discovery learning model throughout the sessions.

The experimental class utilized liveworksheet activities and questions designed to stimulate students' engagement with environmental problems. These activities aligned with the specific syntax of each level of inquiry. Students provided input by responding to stimuli and generated output in the form of answers (behaviorism theory). This approach fosters improvement in both soft and hard skills (Suardipa et al., 2021). Additionally, the Levels of Inquiry Model allows students to build knowledge through grappling with the problems presented, aligning with constructivism theory (Saputro & Pakpahan, 2021). This is further supported by Nosela et al. (2021), whose research demonstrates positive impacts on science process skills through inquiry learning with LKPD assessments (Liveworksheets, likely).

Based on the research results presented in Table 2 and 3, it is evident that all indicators of science process skills were addressed, though not all sub-indicators were fully trained. For the observation skill indicator, the N-Gain score for the experimental class was significantly higher at 0.80 ("high") compared to the control class at 0.51 ("medium"). This indicates stronger training in observing and identifying environmental problem phenomena. Observation activities encourage students to utilize all five senses to analyze objects, organisms, and various environmental occurrences, with or without explicit teacher guidance (Mahmudah, 2016).

For the classifying skills indicator, the experimental class also scored higher, with an N-Gain value of 0.67 ("medium") compared to the control class at 0.59 ("medium"). Students were trained to classify items based on specific conditions. Classification activities help students understand the process of knowledge formation (Mahmudah, 2016).

Regarding interpretation skills, the experimental class's N-Gain score was 0.86 ("high"), surpassing the control class, which scored 0.76 ("high"). This suggests that students in the experimental class developed stronger skills in correlating observations and drawing conclusions. Interpretation activities enhance students' ability to readily comprehend data (Murni et al., 2017).

For prediction skills, the control class achieved a slightly higher N-Gain score (0.73, "high") compared to the experimental class (0.69, "medium"). This difference might be explained by the emphasis in the experimental class on detailed explanations for predictions. Students in this class received training on using research patterns to formulate predictions about unobserved situations. The benefit of prediction activities lies in enabling students to solve problems by connecting new knowledge with existing knowledge (Dewi et al., 2015).

For the questioning skills indicator, the experimental class exhibited a higher N-Gain score (0.66, "medium") compared to the control class (0.40, "medium"). However, this skill demonstrated the lowest improvement within the experimental class. This could indicate that students still struggle with formulating initial ideas during investigations (Abriyanto et al., 2022). The value of questioning activities lies in fostering the development of intellectual skills by encouraging students to articulate problem phenomena. Research highlights the benefits of inquiry-based learning for both knowledge acquisition and its practical application (Borrull & Valls, 2021). This approach fosters the development of science process skills (SPS) as students actively engage in inquiry activities such as question formulation.

For hypothesizing skills, the experimental class's N-Gain score was 0.84 ("high"), compared to the control class's 0.75 ("high"). Students were trained to test laws or regulations through data collection activities. The benefit of hypothesizing is that students can easily gather data to clarify ambiguous situations (Rani et al., 2019).

Similarly, the experimental class achieved a higher N-Gain score (0.89) in experimental planning compared to the control class (0.80). The practicum activities in the experimental class likely equipped students to design experiments that controlled for potential variables (Dewi et al., 2021). According to Sudigdo & Setiawan (2020) through the LOI learning model students are trained to design and carry out experiments. This aligns with Hartini's research (2017), which found that learning through the level of inquiry with practicum activities significantly improves science process skills.

Regarding using tools and materials, the experimental class achieved a higher N-Gain score (0.86, "high") compared to the control class (0.35, "medium"). This improvement is attributed to students learning the proper use and care of tools through practicum activities, enhancing their proficiency (Khairunnisa et al., 2019).

For the applying concepts indicator, the experimental class had an N-Gain value of 0.69 ("medium"), higher than the control class at 0.32 ("medium"). This suggests that even with practicum activities, students may still require additional support in mastering the learned concepts. However, applying concepts fosters curiosity and a deeper understanding of the learning material (Ernawati, 2018).

Communication skills showed the most significant improvement in both classes, with the experimental class achieving a higher N-Gain score (0.91, "high") compared to the control class (0.84, "high"). This is likely due to the emphasis on communication through discussions and presentations throughout the learning process (Rani et al., 2019). Effective communication allows students to share information more proficiently.

The data in Tables 7 and 8 further support the effectiveness of the level of inquiry model with live worksheets on environmental science. Statistical tests ($t' = 0.002 < 0.05$) confirmed significant differences in science process skill improvement between the two groups. Additionally, the effect size test ($d = 0.84$) indicated a substantial positive influence of the intervention.

The significant impact of the level of inquiry learning model, assisted by live worksheets, on science process skills is attributed to the classroom learning process. Through discovery learning activities, students develop basic skills such as observing, formulating concepts, inferring, communicating, and classifying. At the interactive demonstration level, students acquire skills like predicting, collecting and processing data, and improving logical and evidence-based concepts. At the inquiry lesson level, students develop intermediate skills such as measuring and planning experiments. At the inquiry labs level, students gain integrated skills such as conducting experiments, using measurement tools, and creating empirical laws (Rizal & Suhandi, 2017). The inquiry-based learning model fosters a dynamic learning environment where students develop essential skills like explaining concepts, making predictions, conducting experiments, and reaching informed decisions (Panjaitan & Siagian, 2020). This approach goes beyond rote memorization by encouraging students to investigate their own questions and delve deeper into topics or problems they encounter.

Learning through levels of inquiry is closely related to the intellectual level and the control of the learning process (Wenning, 2011). The level of inquiry has the advantage of providing meaningful direct learning experiences and can gradually improve cognitive outcomes, scientific attitudes, and student skills because learning is conducted systematically and comprehensively (Hosnan, 2014).

Conclusion

The results and discussion presented in this study demonstrate that learning through Levels of Inquiry (LoI) supported by live worksheets has a significant positive impact (p-value < 0.005) on students' science process skills. Notably, all indicators of science process skills showed improvement, reaching high and medium criteria. These findings suggest that the LoI learning model, in conjunction with live worksheets, can be a valuable tool in enhancing students' science process skills, particularly when applied to biological content.

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SS contributed to conceptualization of the research idea, designing research, writing article, editing and revision.; FSA

contributed to conducting research, analyze data, writing article; IRY contributed to editing and revision.

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Conflicts of Interest
The authors declare no conflict of interest

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