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Analysis of Integrated Science Process Skills in Elementary School

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Abstract: This study aims to analyze the ISPS owned by 4th-grade students at one of the Public Elementary Schools in Cilegon City, in the subject of IPAS on the five senses material. This study used a quantitative descriptive method whose sample consisted of 5 male students and 9 female students. The instrument used was a written test in the form of an essay consisting of 5 questions to measure students' science process skills. The results of the study showed that students' SPS was still low, as evidenced by the average test score of 51, which means the results of this study still indicate low abilities in ISPS. This study identified that integrated science process skills in grade 4 students are still low. These findings provide insight to teachers to design science learning activities that can actively involve students in learning activities. Thus, it is necessary to implement a learning model based on inquiry so that students can be actively involved in learning making learning more meaningful.

Keywords: Elementary school students; Scientific concepts; Science process skill

Introduction

Scientific process skills form the foundation for students' science learning. Science instruction that integrates scientific process skills does not merely teach students to memorize concepts, but also helps them develop critical thinking skills and understand how processes work—just as scientists do (Dwianto et al., 2017). Science process skills in learning can reflect students' abilities in applying scientific methods systematically to discover and understand natural phenomena carried out through observation, experimentation, and critical and creative data analysis activities (Husna et al., 2022). Learning that tends to be theoretical and focused on memorization is likely to lead to misconceptions among students. Therefore, in the science learning process, teachers can integrate science process skills through experimental activities by actively involving students to enhance their thinking skills (Widyaningsih et al., 2020).

In elementary education, this skill serves as the primary foundation for students to deeply understand scientific concepts and apply them to their daily routines. The Independent Curriculum emphasizes the importance of learning that stimulates curiosity, critical thinking, and problem-solving skills through hands-on, exploratory, and context-relevant learning experiences (Kemendikbud, 2022). Students with strong scientific reasoning skills have strong argumentation skills because they are able to express opinions supported by data, evidence, and scientific justification (Darmaji et al., 2022).

Learning that takes place in schools still tends to be teacher-centered using lecture techniques, resulting in a lack of opportunities for students to try learning through direct practice (Ismunayah et al., 2025). This results in students' SPS development not reaching its maximum potential, especially in integrated science process skills elements, such as formulating hypotheses, recognizing variables, and analyzing data. Students' basic science process skills are still in the low category because learning is still focused on products (Astuti et al., 2025). Thus, this situation reflects the continuing gap between curriculum expectations and classroom teaching practices.

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Based on the results of the 2022 PISA (Philosophy of International Student Assessment), Indonesian students' scientific literacy remains relatively low compared to the average for OECD countries. Indonesia achieved an average score of 383 points, a 13-point decrease from 2018, the lowest score since 2009, and still far below the OECD average of 476 points.

Only about 34% of Indonesian students reach level 2 or higher, meaning most students are unable to understand or apply basic scientific concepts, such as identifying variables, analyzing data, and drawing conclusions from simple experiments. Furthermore, almost no students reach Level 5 or 6, indicating that advanced scientific thinking skills, such as designing experiments, evaluating evidence, and applying scientific concepts in new contexts, remain very limited.

Overall, these findings indicate that Indonesian students' mastery of science process skills is still at a basic level and does not yet reflect the scientific competencies needed to face the challenges of the 21st century (Organisation for Economic Co-operation and Development, 2023).

Several previous studies have presented data that the majority of elementary school students already possess adequate basic science process skills, but are not yet proficient in integrated science process skills and face challenges in their implementation. Research from Darmayanti et al. (2022) stated that the basic science process skills of sixth-grade students were quite good, but their implementation needed to be further improved to achieve optimal results. Meanwhile, a study conducted by Dani et al. (2024) stated that one of the factors influencing students' science process skills is the teacher's delivery of the material, so teachers need to improve their understanding in preparing learning so that students' science process skills can improve. Questions that are designed to assess student learning outcomes in science still focus primarily on the ability to recall concepts rather than on the ability to engage in the scientific process, resulting in an incomplete assessment of science process skills in the classroom (Annisa et al., 2017).

In line with this, Idris et al. (2022) also stated that many factors can influence students' science process skills, including a lack of practical activities that allow students to be directly involved, so, they can develop their SPS. Process skills in science learning need to be developed through direct experiences for students as meaningful learning experiences so that students can better appreciate the processes or activities being carried out (Bahri et al., 2022). According to research conducted by Gültekin et al. (2022) science process skills can be improved even without special interventions; however, learning that integrates science process skills has been shown to be more effective in improving students' science process skills compared to classes that do not receive special interventions.

Science process skills are concepts that are relevant to students' daily lives, so that students can design a concept, investigate a problem, determine an alternative solution, and conclude a problem (Romadhona & Suyanto, 2020). Science process skills are divided into two main groups, namely basic skills and integrated skills. Basic skills include abilities such as observing, interpreting, measuring, communicating, classifying, and predicting. Meanwhile, integrated skills include the ability to control variables, create operational definitions, formulate hypotheses, interpret data, and carry out experiments systematically (Sutisnawati et al., 2025).

Many previous studies have discussed basic science process skills at the elementary school level state that the basic process skills of fourth-grade students are already in the high category, but still require improvement in integrated science process skills. Research discussing integrated science process skills in elementary schools, especially for fourth-grade students, is still limited. Science instruction in schools still tends to focus on memorizing theories, and students are not actively engaged during lessons, so only a few students are able to actively participate in the learning process (Parmiti et al., 2021).

Integrated SPS analysis at the elementary school level, particularly on the five senses subject, is rarely explored intensively. Yet, the five senses theme offers a significant opportunity to hone SPS because it is closely linked to students' direct experiences through observation and light experiments. Therefore, this study aims to analyze the integrated science process skills of fourth-grade elementary school students in the topic of the five senses (sense of taste). This analysis aims to present data on students' integrated science process skills, whether they are adequate or still need improvement.

Method

Time and Place of the Research

This study was conducted on October 3, 2025, at a public elementary school in the city of Cilegon City.

Research Design

The research design flow chart can be seen in the figure 1. Based on Figure 1, it can be stated that the research began with 1) theoretical knowledge, 2) primary observation, 3) preparing the research instrument, 4) collect data field by using the written instrument. then 5) analyze data that has been collected, 6) describe the current state to classified students' science process skills ability. The last step is 6) writing the problem findings and suggestions.

This research uses a descriptive quantitative research methodology. Descriptive research is a type of quantitative research that involves making careful

descriptions of educational phenomena (Loeb et al., 2017). The measurement used in this study uses a test instrument on the subject of science, material on the five senses of IPAS in grade 4. The subjects of this study consisted of 14 fourth-grade students from a public elementary school in Cilegon City. The sample selection was based on non-probability sampling. Non-probability sampling involves selecting individuals because they possess certain characteristics or because they are conveniently available to the researcher (Creswell & Creswell, 2018).

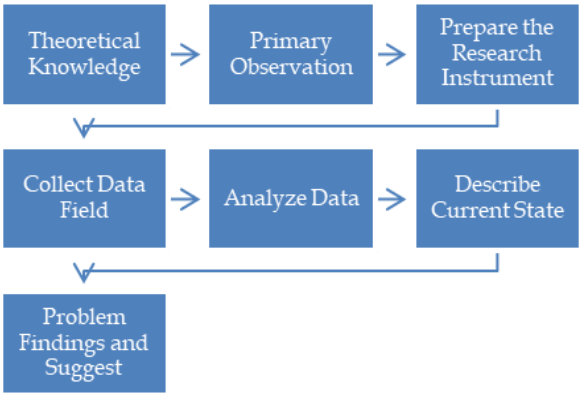

Figure 1. Stages of the research method

The sampling technique used was purposive sampling, in which participants are selected based on specific criteria such as comparable initial abilities (Etikan, 2017). The independent variable in this study was instruction based on scientific process skills (SPS) activities, while the dependent variables were students' scientific process skills and critical thinking abilities. In processing the research data, the researcher uses statistical data obtained using the SPSS application to determine the mean, median, standard deviation, variance, and range through descriptive statistics.

Research Procedure

The research procedure was conducted in several stages. The first stage was the preparation phase, which involved developing and validating research instruments, as well as preparing instructional materials. The second stage was collecting data. At this stage, the researcher conducted the SPS test with fourth-grade students to collect data that represents their proficiency in science process skills. The data were collected in a typical classroom environment without any experimental intervention, consistent with the features of descriptive research (Mishra et al., 2019).

The third stage was the data processing and interpretation phase, during which the collected data were arranged, tabulated, and examined using descriptive statistics methods. The findings were subsequently analyzed to offer a detailed account of students' science process skills through various indicators. This process guarantees that the results truly reflect the real state of the participants (Siedlecki, 2020).

Data Analysis

The data were analyzed using descriptive statistics to summarize and present the main characteristics of the dataset, including mean, percentage, minimum and maximum scores, and standard deviation (Mishra et al., 2019). The analysis was conducted for each integrated SPS indicator, such as controlling variable, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models, in order to provide a more detailed description of students' competencies. The results were presented in the form of tables to illustrate the distribution of students' science process skills.

Table 1. Indicators of Integrated Science Process Skills (Sutisnawati et al., 2025)

Integrated Science Process Skills	Indicator
Controlling variable	Being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable.
Defining operationally	Stating how to measure a variable in an experiment.
Formulating hypotheses	Stating the expected outcome of an experiment.
Interpreting data	Organizing data and drawing conclusions from it.
Experimenting	Being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a "fair" experiment, conducting the experiment, and interpreting the results of the experiment.
Formulating models	Creating a mental or physical model of a process or event.

The instrument used in collecting this data was a test instrument consisting of 5 descriptive questions covering 6 aspects of integrated science process skills indicators.

Result and Discussion

Based on the results of the instrument testing conducted, the following results were obtained. I used SPSS to test the results of the students' scores.

Table 2. Analysis of Descriptive Statistics Results of Students' ISPS Indicators

	N	Min	Max	Mean	Std Deviation
Controlling Variable	14	1.00	4.00	2.7143	1.20439
Defining operationally	14	.00	4.00	2,3571	1.39268
Hypotheses	14	.00	4.00	2,5000	1.65250
Interpreting data	14	.00	3.00	1.7143	.82542
Formulating models	14	.00	4.00	1.7143	1.06904
Experimenting	14	.00	3.00	1.4286	.93761
Valid N (listwise)	14				

Categories for classifying high, medium, and low ability students are obtained as follows (Azwar, 2019):

$$\text{Interval length} = \frac{Maximum\ score - minimum\ score}{Number\ of\ categories} \quad (1)$$

Thus, the category limits for each interval are obtained as follows:

Table 3. Score Classification

Score	Category
0.00 – 1.33	Low
1.34 – 2.66	Medium
2.67 – 4.00	High

Based on the results of descriptive analysis of 14 respondents, an overview of students' science process skills in five integrated science process skills (SPS) indicators was obtained: The results of the descriptive analysis showed that students' science process skills (SPS) were in the medium to low category, with the highest average value in the controlling variable indicator (2.71) and the lowest in experimenting (1.43). This condition illustrates that students' ability to control variables has developed quite well, but the ability to design and carry out experiments is still limited. Controlling variables is one of the core skills in integrated science process skills (ISPS), namely the ability to recognize and regulate independent, dependent, and control variables so that the experiments carried out are fair and produce valid data. Students who are able to identify and control variables correctly will more easily understand the cause-and-effect relationships between the factors being tested, so that science learning becomes more meaningful.

Furthermore, the defining operational indicator obtained an average score of 2.36, which is in the moderate category. The ability to define variables operationally indicates the extent to which students can transform theoretical concepts into observable or measurable forms. According to Kurniawati (2021), operational definitions is to define what they do or what they observe, also to serve bridge the gap between abstract concepts and empirical measurements, for example, defining plant growth as the increase in stem height (cm) over seven days. However, a common difficulty students face in this area is the tendency to define variables qualitatively without including clear quantitative measurements. Therefore, teachers need to guide students in understanding the importance of operational definitions so that observation results can be objectively tested and compared. Another way that teachers can imply in learning process is by creating a meaningful learning experiences by connecting science concepts with social issues (Wisdayana et al., 2025).

The aspect of formulating hypotheses achieved an average score of 2.50, which is also considered moderate. This skill reflects students' ability to propose tentative assumptions about the relationships between variables to be tested. A good hypothesis must be logical, theory-based, and empirically testable. The ability to form hypotheses is an essential characteristic of scientific thinking because it helps students understand cause-and-effect patterns before conducting experiments (García-Carmona, 2025). However, field research shows that some students still struggle to formulate focused and measurable hypotheses.

Meanwhile, the data interpretation indicator showed an average score of 1.71. The ability to interpret data requires students to analyze observations, identify patterns, and draw conclusions based on empirical evidence. The low results in this aspect may be due to limited experience in processing experimental data and the minimal use of visual aids such as graphs and tables. Based on the study by Liu et al. (2022) the experimental approach was effective in training students to understand and apply the scientific process. Therefore, teachers need to improve a science learning process by designing a learning process that actively engage students direct experiences.

The formulating models indicator also fell into the moderate category (average 1.71). The ability to construct scientific models requires students to construct conceptual representations (e.g., graphs, diagrams, or equations) that illustrate observed scientific phenomena. This ability has not developed optimally because students often focus on the procedural steps of experiments and are not yet accustomed to conceptually visualizing relationships between variables.

The experimenting aspect was the indicator with the lowest average (1.43). This skill includes the ability to design, carry out, and evaluate scientific experiments. According to Kurniawati (2021), experimentation is the most complex skill in the hierarchy of science process skills because it combines various aspects such as hypotheses, variable control, and data interpretation. The results of this study indicate that students still need

intensive guidance in conducting independent experiments, especially in ensuring consistent procedures and careful data collection. The experiments have a significant effect on increasing students' critical thinking ability by providing real experience that can influence critical thinking skills (Bintoro et al., 2022).

Overall, these results demonstrate that students' mastery of integrated science process skills still needs to be strengthened through inquiry- and experiment-based learning models. Therefore, teachers need to facilitate students' direct experience of the scientific process, from identifying problems and formulating hypotheses to testing and interpreting results. Based on the previous study by Budiarti et al. (2022) shows that student interest and science process skills have a significant correlation with the effect on success, increase learning outcomes, and affect student achievement. These efforts are expected to improve students' scientific thinking and foster scientific attitudes such as thoroughness, critical thinking, and objectivity. The classification of student scores is obtained as follows:

Table 4. SPS Scores of Grade 4 Students

Student Name	Score
JAS	54
AN	17
MHT	60
FM	25
RAP	50
AR	50
SW	31
MR	46
ZA	63
AR	81
OUCH	71
AN	33
MARS	48
YN	85
Average	51

Table 5. Classification of Student Scores

Score	Category
0-59	Low
60-79	Medium
80-100	High

Based on the graph above, 9 students scored in the low category, 3 students in the low category, and 2 students in the high category. The average score was 51, which is in the low category. Therefore, it can be said that students' science process skills are in the low category.

Next, student scores are analyzed based on each indicator of students' integrated science process skills, as shown in Table 6.

Table 6. Average Student Scores on Each Indicator

Indicator	Mark	Category
Controlling Variable	63	Medium
Defining operationally	59	Low
Hypotheses	63	Medium
Interpreting data	36	Low
Formulating models	43	Low
Experimenting	43	Low

Based on these results, the integrated science process skills of grade 4 students are still in the low category, which can be caused by various factors, including teachers needing to prepare learning optimally, which includes planning, strategies, and mastery of SPS by teachers so that students can better understand SPS (Gizaw & Sota, 2023). Another way that can be applied to increase student SPS is that Courses could be designed to progress from basic science process skills, such as observing, measuring, communicating, classifying, and predicting, to more complex tasks such as defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models (Ignacio & Yabut, 2025).

The causes of low student SPS can be caused by several factors, namely in line with Hariandi et al. (2023) this is influenced by several factors, such as a low science background, lack of laboratory facilities, dependence on textbooks, and limited science-process-oriented learning. Another factor that could contribute to students' low levels of integrated science process skills is the low level of basic science process skills that students should already possess. This is in line with Farida et al. (2023) each school studied does not yet have a science laboratory, which is one of the reasons for the low science process skills. Meanwhile, Basic SPS is a prerequisite for Integrated SPS. It is obvious from the findings that the relevance of basic SPSs for the development of integrated SPSs is undeniable. Focusing on the development of the basic science process would enhance the development of integrated SPSs which are essential to become competent in future science programs (Kamarudin et al., 2022).

So, this is something that must be improved in future learning, SPS is the initial foundation of scientific literacy that students must have because this will have an impact on science learning achievement (Dolapcioglu & Subası, 2022). Efforts to prepare students to face the challenges of the 21st century and can improve critical and creative thinking skills, in line with what was expressed (Maraisane et al., 2024), namely developing science process skills is essential for societal progress, highlighting the necessity of introducing these skills early in learners' education. Apart from that, Science Process Skills (SPS) are very useful in designing and constructing scientific facts in natural sciences at the school level and scientific activities that involve a variety of methods, including such activities as observing phenomena, questioning, scrutinizing, examining

books, and other sources of information to find out about the phenomenon (Kurniawati, 2021).

Science process skills have an important role in increasing students' understanding through direct experience to develop scientific thinking skills and contribute to the advancement of science and technology (Uriyah et al., 2023). Teachers can improve students' scientific process skills, and teachers can implement discovery-based learning. In line with that Ederon (2024), in their research, stated that the use of inquiry-based learning material successfully fosters the development of integrated science process abilities. Discovery-based learning is one of the instructional models that can effectively improve students' skills because students can be directly involved in the investigative process (Prayitno et al., 2017).

Conclusion

The results of this study indicate that fourth-grade elementary school students' integrated science process skills still need to be improved, particularly in the indicators of operationally defining variables and conducting experiments. To improve students' integrated science process skills, discovery-based learning is needed, prioritizing students' direct experiences to make learning more meaningful.

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Conceptualization, M. and D.H.; methodology, M. and D.H.; validation, D.H., A.S., and E.S.; formal analysis M.; investigation, M.; resources, M, D.H., A.S., and E.S.; data curation, A.S.; writing—original draft preparation, M.; writing—review and editing, M. D.H., A.S., and E.S.; visualization, M.; All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

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