Formatif: Jurnal Ilmiah Pendidikan MIPA, March 2026, 16 (1), 171-186
https://doi.org/10.30998/chnesc77
p-ISSN: 2088-351X e-ISSN: 2502-5457
Accredited (S1) by Ministry of Higher Education, Science, and Technology No. 295/C/C3/KPT/2026
Available online at https://journal.lppmunindra.ac.id/index.php/Formatif/index

Science Process Skills Profile of Pre-Service Physics Teachers in an Inquiry-Based Laboratory Integrated with Local Context

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Abstract
Science process skills are essential competencies that need to be cultivated by pre-service physics teachers to support inquiry oriented science learning. However, in higher education, physics laboratory work is still predominantly conducted from a confirmation-oriented perspective and provides limited opportunities for students to engage in authentic scientific thinking. The study has the purpose to analyze the profile of science process skills on pre-service physics teacher through inquiry-based laboratory for local context integrated. In this quantitative descriptive study, 27 undergraduate students enrolled in Universitas PGRI Silampari's Physics Education Program studying Basic Physics I participated. Structured observation sheets on six indicators observing, classifying, forecasting, measuring, concluding, and communicating as well as a science process competency test were used to gather data. Data were analyzed descriptively through percentage analysis and categorical interpretation. The findings show the enhancement of students' science process skills which can be observed from the average score, increasing from 40.19 in the pretest to 80.93 in posttest. The paired-sample t-test showed a statistically significant difference between the pretest and posttest scores (Sig. = 0.000, $p < 0.05$) with a large effect size (Cohen's $d = 2.731$), indicating a substantial improvement in students' science process skills. The findings indicate that inquiry-based laboratory instruction integrated with local contextual elements facilitates the progressive development of pre-service teachers' science process skills across multiple instructional sessions. The current study makes a significant contribution to the development of context-based and inquiry-oriented laboratory instruction aimed at enhancing students' competencies in science teacher education programs.

Keywords: Local context; laboratory; science process skills; inquiry-based learning; pre-service teacher

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How to Cite: Tri Ariani, Maison, Sri Purwaningsih, & Bambang Hariyadi. (2026). Science Process Skills Profile of Pre-Service Physics Teachers in an Inquiry-Based Laboratory Integrated with Local Context. *Formatif : Jurnal Ilmiah Pendidikan MIPA*, *16*(1), 171-186. https://doi.org/10.30998/chnesc77

INTRODUCTION

A transformation in instructional practices is essential for advancing science education in the twenty-first century, shifting from an exclusive emphasis on conceptual mastery toward the development of higher-order thinking and scientific competencies. In physics education, learning is no longer just about passing along knowledge. Instead, it aims to train scientific thinking, problem-solving skills, and the ability to conduct systematic scientific investigations. This paradigm shift places science process skills (SPS) as an essential component in modern science learning (Azzahra et al., 2024; Mushani, 2021; Turiman et al., 2012). Science process skills are abilities that scientists use to build scientific knowledge. These skills include basic ones like observing, classifying, and measuring. Additionally, they cover integrated skills like developing hypotheses, determining variables, planning experiments, evaluating data, and presenting research findings (Ratnaningdyah et al., 2020; Sinta & Agustina, 2024; Turiman et al., 2012). In physics education, these skills serve as a bridge between theory and practice and as a foundation for the development of meaningful and sustainable conceptual understanding.

Mastering science process skills is more important for aspiring physics teachers than for science students in general. Aspiring educators must grasp the fundamental concepts of physics as

well as guide learners through the process of scientific inquiry. In the classroom, teachers with strong science process abilities may create a culture of scientific thinking, promote curiosity, and design process-oriented learning (Arslan, 2023; Li et al., 2024). The quality of physics education in schools is significantly affected by how well science process skills have been cultivated throughout the training of future teachers.

However, a range of studies consistently show that the scientific method abilities of prospective science teachers, including those specializing in physics education, remain underdeveloped and have not reached an optimal level. Several studies report that students tend to be more skilled in basic process skills but experience difficulties in integrated process skills such as formulating hypotheses, controlling variables, and drawing data-based conclusions (Hacieminoglu, 2022; Idris et al., 2022; Sukaria, 2025). This situation reflects a discrepancy between science education goals that prioritize mastery of scientific processes and the actual instructional practices implemented in real classroom settings. One of the main factors contributing to low science process skills is the dominance of verifiable laboratory practices in physics learning. Verifiable laboratories are generally designed to prove previously explained physics concepts or laws through step-by-step and highly structured procedures. In this context, students act more as executors of instructions than as novice researchers actively constructing knowledge (Ketonen et al., 2023; Lehesvuori et al., 2023)

Laboratories with a verification-based approach provide very limited space for students to ask questions, formulate hypotheses, or make decisions related to experimental procedures. Consequently, science process skills remain underdeveloped, as students are insufficiently engaged in authentic scientific thinking processes. Several studies indicate that although verification-based laboratories can aid conceptual understanding, this approach is less effective in developing scientific skills and higher-order thinking abilities (Holmes & Wieman, 2018; Ketonen et al., 2023; Papalazarou et al., 2024).

Inquiry-based learning is widely recognized as an approach that aligns more closely with the principles of contemporary science education and is frequently regarded as an alternative to traditional instructional methods. This approach emphasizes students' active involvement throughout all stages of scientific investigation, including problem identification, hypothesis formulation, experimental design and implementation, data analysis, as well as drawing conclusions and communicating findings (Antonio et al., 2022; Chen & Chen, 2025; Pedaste et al., 2015). In physics laboratories, the inquiry method offers students a chance to experience firsthand how scientists operate. Students discover not only "what" has been established in physics, but also "how" that knowledge has been created. Meta-analytic studies conducted Furtak et al., (2012) Lazonder & Harmsen (2016) demonstrate that inquiry-based learning is substantially more effective than conventional instructional approaches in enhancing science process skills and conceptual understanding, particularly when it is implemented in a systematic and well-structured manner. However, the effectiveness of inquiry-based learning is strongly influenced by the context in which the approach is applied.

One of the challenges in constructing scientific understanding arises from the disconnection of students from the subject matter due to the presentation of questions in highly abstract forms that lack relevance to their real-world experiences. Therefore, integrating local context (local context or local wisdom) into science learning is an important strategy for bridging scientific concepts with the realities of students' lives (Kostol & Remmen, 2022; Rasmawan, 2025; Sotero et al., 2020). One of the ways that local context in science education can be reflected is through natural phenomena, community traditions, local technology, or daily activities that are related to the concepts of physics. The incorporation of local context enables students to recognize that physics extends beyond a set of abstract formulas and constitutes an integral part of everyday life(Novaristiana et al., 2019; Skills, 2024; Taasoobshirazi & Carr, 2008).

In the education of science teachers, the incorporation of the local context additionally serves a valuable purpose on a strategic level, as it aids the student teachers to be socially and

culturally aware of the community they will be teaching. Teachers who are accustomed to using local context in learning tend to be better able to design learning that is relevant to the lives of students and supports inclusive science learning (Aikenhead & Elliott, 2010; Prasad et al., 2025). Therefore, the incorporation of local context influences not only the cognitive aspects but also the development of teachers' professional identities. Several studies report that local context-based science learning can improve students' science process skills, scientific attitudes, and conceptual understanding (Barrun & Cajurao, 2025; Rapsanjani et al., 2025) . However, most of these studies still focus on measuring general learning outcomes or on school students, while studies that specifically map the profile of science process skills of prospective physics teachers in a local context-integrated inquiry-based laboratory learning are still relatively limited. Furthermore, science process abilities in many studies are often treated as a single variable or merely an additional indicator, rather than the main focus of analysis. In fact, each science process skill indicator has different characteristics and levels of complexity. Without the detailed profile mapping, it is difficult to identify the skills that have already been well-developed and the ones that still need learning intervention.

Examining the profile of scientific process skills is highly significant in physics teacher education, as it offers empirical insight into students' preparedness to apply inquiry-based science learning in their future teaching practice. This data can serve as a starting point for curriculum development, enhancing laboratory design, and creating more focused and sustainable ways of learning. In addition, examining the profile of science process skills is closely aligned with the demands of 21st-century skill development, which emphasizes the cultivation of critical thinking, problem-solving abilities, and scientific literacy. Science process skills are essential to science literacy because they refer to the capability of using scientific knowledge to comprehend phenomena, make decisions based on evidence, and engage in a science and technology-oriented society (Agustya et al., 2023; Istyadji, 2023). From this explanation, it can be inferred that there is a pressing need for research that focuses on analyzing the science process skills profile of prospective physics teachers when local contextual components are incorporated into inquiry-based laboratory learning. This study is anticipated to bridge the gaps in the existing literature and, at the same time, give some empirical basis for the development of physics laboratory learning that is more contextual, investigative, and focused on strengthening scientific skills. Accordingly, this article seeks to examine and provide an in-depth analysis of the science process skills profile of prospective physics teachers engaged in inquiry-based laboratory learning that incorporates local contextual elements. The study concentrates on the attainment of each science process skill indicator as a foundation for identifying and understanding patterns in the development of students' scientific competencies. The findings of this study are expected to serve as a reference for physics education lecturers, curriculum designers, and science education researchers in developing laboratory learning experiences that support the preparation of prospective physics teachers who are competent, reflective, and responsive to the demands of 21st-century science education.

Science process skills (SPS) are essential competencies in science learning that enable students to conduct scientific investigations through activities such as observing, classifying, predicting, measuring, concluding, and communicating. These skills develop through active engagement in scientific inquiry, particularly in laboratory learning environments where students interact directly with scientific phenomena. Inquiry-based laboratory learning is therefore widely recognized as an effective approach for fostering SPS because it encourages students to formulate questions, design investigations, and interpret experimental results.

However, laboratory learning often lacks contextual relevance to students' real-life experiences, which may limit meaningful engagement in the inquiry process. Integrating local contextual elements into inquiry-based laboratory activities has the potential to make scientific investigations more meaningful while supporting the development of SPS. Despite the growing interest in contextualized science learning, empirical studies that describe the profile of SPS among

prospective physics teachers within inquiry-based laboratories integrated with local contexts remain limited. Therefore, this study aims to analyze the profile of science process skills of prospective physics teachers engaged in inquiry-based laboratory learning integrated with local contextual elements.

To clarify the relationship between inquiry-based laboratory learning, local contextual integration, and the development of science process skills, this study proposes a physics laboratory instructional design framework. The framework integrates local cultural contexts with the ADDIE instructional design model to guide the development and implementation of inquiry-based laboratory activities. Through this framework, physics laboratory learning is designed to connect scientific investigation with meaningful local phenomena, thereby supporting the development of students' science process skills. The overall structure of the framework is presented in Figure 1.

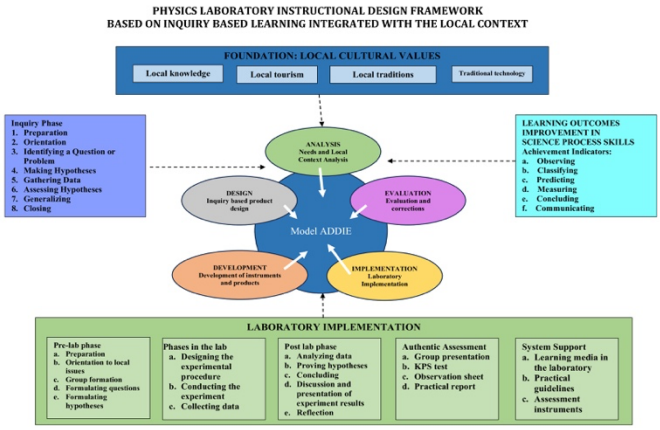


Figure 1. Framework Instructional Design for Basic Physics Laboratories

The framework is built upon local cultural values, including local knowledge, tourism, traditions, and traditional technologies, which serve as contextual foundations for laboratory learning. The instructional design process follows the ADDIE model, consisting of analysis, design, development, implementation, and evaluation. During implementation, laboratory activities are organized into pre-lab, in-lab, and post-lab phases based on the inquiry learning process. These activities are supported by authentic assessment and instructional resources such as laboratory media, practicum guidelines, and assessment instruments. Through this integrated process, the framework aims to facilitate the development of students' science process skills, including observing, classifying, predicting, measuring, concluding, and communicating.

METHODS

Study Design

This study employed a quasi-experimental design using a one-group pretest-posttest model to examine changes in students' science process skills after participating in inquiry-based laboratory learning integrated with local contextual elements. In this design, participants were assessed before and after the implementation of the instructional treatment to observe the development of science process skills. Although the primary objective of this research was to describe the profile and development pattern of students' science process skills, the use of pretest and posttest data enabled a statistical comparison of students' performance before and after the learning intervention. This research design is in line with the characteristics of a profile study, which emphasizes the description of the actual conditions of students' abilities after participating in a specific learning design (Zamecnik et al., 2022).

Research Subjects

The research subjects consisted of 27 undergraduate students from the Physics Education Study Program at Universitas PGRI Silampari who were enrolled in the Basic Physics I course during their first semester. All participants were involved in a series of laboratory practicum sessions designed using an inquiry-based laboratory approach integrated with the local context of Lubuklinggau. The participants were selected using a total sampling technique, considering the relatively small number of students in one class and the fact that all students experienced the same instructional design. The laboratory learning activities emphasized hands-on inquiry processes in which students actively engaged in observing contextual phenomena, formulating problems, proposing hypotheses, collecting and analyzing data, and drawing conclusions. Several local contexts from Lubuklinggau were integrated into the practicum activities to support meaningful learning. For example, traditional measuring tools such as *cupak* were used in the measurement practicum, the motion of trains passing through the Lubuklinggau railway line was used to illustrate straight motion concepts, and the traditional activity of *nggegai duku* (harvesting duku fruit) was used to contextualize vertical motion. Other contexts included drawing water from wells using pulleys (particle dynamics), the traditional practice of *numbak ikan* in fishing (momentum and impulse), and the preparation of *kue maksuba*, a traditional local cake, to explain temperature and heat concepts. Through the integration of these local contexts, students were encouraged to relate abstract physics concepts to real-life situations familiar in their surrounding environment while developing their science process skills through inquiry-based laboratory activities.

Laboratory Learning Design

The laboratory learning implemented in this study is grounded in the principles of inquiry-based laboratories, where students assume an active and central role in the scientific investigation process. The laboratory design follows a sequence of structured inquiry stages, including understanding contextual problems, formulating research questions, developing hypotheses, designing and conducting experiments, analyzing data, evaluating hypotheses, and constructing conceptual understanding. The integration of local context was carried out by presenting phenomena and practices from the Lubuklinggau community as the starting point for inquiry activities. For example, traditional measuring tools such as *cupak* were used to introduce measurement concepts, the motion of trains passing through the Lubuklinggau railway line was used to illustrate straight motion, and the traditional activity of *nggegai duku* (harvesting duku fruit) was used to contextualize vertical motion. In addition, the local practice of preparing *kue maksuba*, a traditional Lubuklinggau cake, was used to explore temperature and heat concepts. Through these contextual examples, students were encouraged to investigate physics concepts through experimental inquiry while connecting scientific principles with real-life situations familiar to their environment. This approach was intended to increase the relevance of learning and to promote students' cognitive and procedural engagement during laboratory activities.

Research Instruments

The instruments employed in this study consisted of written test items and an observation sheet designed to assess students' science process skills (SPS). The use of these two instruments aimed to obtain a comprehensive understanding of students' SPS from both cognitive and performance perspectives during laboratory activities. The written test was used to evaluate students' understanding and application of scientific procedures through contextual questions that required the analysis of physical phenomena, formulation of predictions, explanation of measurement procedures, and drawing of conclusions based on data. Each item represented specific indicators of science process skills to reflect students' ability to process scientific information systematically.

Meanwhile, the observation sheet was used to directly assess students' science process skills during inquiry based laboratory activities. The observation instrument was structured using specific indicators and a rating scale to capture the level of skill performance. The assessed SPS indicators included observing, classifying, predicting, measuring, drawing conclusions, and communicating (Hardiansyah et al., 2022; Wazni & Fatmawati, 2022 Darmaji et al., 2019; Ozkan & Topsakal, 2021; Wazni & Fatmawati, 2022).

All instruments were reviewed by experts and subjected to content validation to ensure their relevance to the research objectives and clarity of measurement indicators. Instrument reliability was tested using Cronbach's Alpha, which yielded a coefficient of 0.911, indicating excellent internal consistency. This result confirms that the instruments were highly reliable for measuring students' science process skills. By combining test and observational instruments, this study provides a more comprehensive and authentic profile of students' science process skills within inquiry-based laboratory learning integrated with local contextual elements.

Data Analysis Techniques

The data were examined using descriptive quantitative techniques to portray the science process skills profiles of prospective physics teachers participating in inquiry-based laboratory learning that incorporates local contextual elements. This approach was adopted in light of the study's primary aim to provide a detailed mapping of students' mastery across each science process skill indicator, rather than to examine differences or relationships among variables (Jannah, 2024; Wola et al., 2023). The data collected from observation sheets and written tests were analyzed through multiple systematic steps. The raw scores for each science process skill indicator were first converted into percentages using the formula:

$$\text{Percentage} = \frac{\text{score obtained}}{\text{maximum score}} \text{ x } 100\% \quad (1) \text{ (Riduwan, 2015)}$$

The resulting percentages were subsequently used to classify the level of students' science process skills. The categorization criteria were adjusted to the science education assessment standards, which classify skills into the categories of very low, low, moderate, high, and very high. The criteria for grouping science process skill categories are presented in Table 1 below.

Table 1. Criteria for grouping science process skills categories

Score Range (%)	Science Process Skills Categories
81	Very High
61-80	High
41-60	Moderate
21-40	Low
≤ 20	Very Low

Source: (Jannah, 2024)

These categories were applied to support clearer interpretation of the findings and to offer a more informative depiction of students' strengths and limitations across each science process skill indicator. In addition, a detailed analysis was carried out for every indicator, encompassing observing, classifying, predicting, measuring, drawing conclusions, and communicating skills. Examining each indicator makes it possible to determine which science process skills have developed most strongly and which ones still require further improvement within the framework of inquiry-based laboratory learning. In addition, the overall average score for science process skills is also calculated to describe the comprehensive general profile of students. Besides descriptive analysis, this research also implements inferential statistical analysis to provide a more convincing interpretation of the differences in science process skill achievement from the pretest to the posttest. Before performing the difference analysis, the pretest and posttest data were first

examined for normality using the Shapiro-Wilk test, considering that the sample size was below 50. When the data were normally distributed, a paired-sample t-test was applied to compare the pretest and posttest results.

The observational data were processed by computing the mean score for each indicator across all practicum sessions. The pattern of science process skill development from one session to the next was analyzed to see the consistency of student performance during the implementation of learning. The observation analysis results were also confirmed with the test results as a form of data triangulation to corroborate the research findings. To enhance the interpretation of the findings, the quantitative data were presented through graphical representations illustrating the percentage distribution of each science process skill indicator. These visuals are intended to make emerging patterns more apparent and to assist readers in more easily comprehending the profile of students' science process skills. Through the application of these analytical approaches, the study is expected to provide an accurate and comprehensive depiction of the science process skills of prospective physics teachers engaged in inquiry based laboratory learning integrated with local contextual elements. In addition to significance testing, effect size analysis was conducted to determine the magnitude of the improvement in students' science process skills. Cohen's d was used to calculate the effect size of the difference between pretest and posttest scores. Effect size interpretation followed Cohen's criteria, where values around 0.2 indicate small effects, 0.5 moderate effects, and 0.8 or higher large effects.

RESULTS & DISCUSSION

Results

This section presents the results obtained from the analysis of prospective physics teachers' science process skills, derived from written assessments (pretest and posttest) and observational data collected during inquiry-based practicum activities integrated with local contextual elements. The findings are displayed in quantitative and visual forms to illustrate patterns of improvement in science process skills, viewed from pre- and post-learning outcomes as well as from the progression of student performance across each practicum session. The findings of this research are reported to demonstrate the shifts in science process skills among prospective physics teachers following their involvement in inquiry-based practicum activities that incorporate local contextual elements. The interpretation of science process skill achievement refers to the category criteria presented in Table 1. Based on the findings from the assessment of science process skills, the students' achievement in the initial measurement showed that most students were in the low to moderate category. Following the completion of the laboratory activity sequence, the distribution of students' science process skills moved toward higher levels. In the final assessment, most students fell into the high and very high categories.

Figure 1 below shows a comparison of the average scores for students' science process skills between the pretest and posttest.

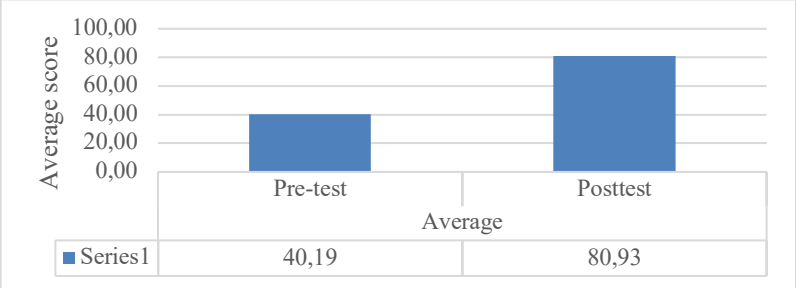


Figure 1. Graph comparing pretest and posttest scores

The analysis of the mean scores presented in the graph indicates a clear difference between the initial and final assessments of students' science process skills. The average score at the conclusion of the evaluation is higher than that of the initial test, demonstrating an improvement in students' science process skills throughout the laboratory activities. Specifically, the graph shows that the mean score increased substantially, rising from 40.19 in the pretest to 80.93 in the posttest. The relatively low average pretest score indicates that, before participating in context-integrated inquiry-based practical learning, students' science process skills were still in the low to moderate category. This indicates that students were not yet accustomed to applying scientific skills such as systematic observation, data classification, phenomenon prediction, accurate measurement, experimental conclusion drawing, and scientific communication of findings. While the posttest average score goes up to 80.93. It indicates that through a series of hands-on activities, students have made huge progress in acquiring science process skills. Students' science process skills have now reached a higher level, which means that the laboratory design created is indeed capable of providing the students with a more significant experience of the scientific process through their active involvement. Before performing the mean difference analysis, the pretest and posttest data were examined for normality using the Shapiro-Wilk test. The results of this normality assessment are shown in Table 2.

Table 2. Results of the Shapiro Wilk Normality Test for Pretest and Posttest Scores

Data	N	Test	Sig. (p)	Decision
Pretest	27	Shapiro Wilk	0.179	Normal distribution
Posttest	27	Shapiro Wilk	0.096	Normal distribution

The pretest and posttest significance values are both higher than 0.05, as indicated in Table 2, indicating that the data are normally distributed. Thus, the mean scores of science process skills before and after the intervention were compared using a paired-sample t-test. Table 3 displays the results of this analysis.

Table 3. Results of the Paired Sample t-test

		Mean	Std. Deviation	Std.Error Mean	95% Confidence internal of the difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	before the treatment – after the treatment	-40.741	14.917	2.871	-46.642	-34.840	-14.192	26	.000

A statistically significant difference between the pretest and posttest scores is indicated by the paired-sample t-test findings, which demonstrate a significance level of $p < 0.05$ (Table 3). The mean difference's negative value indicates that students' science process skills improved after participating in the practicum activities, as seen by the posttest scores surpassing the pretest scores.

Table 4. Paired Sample Effect Sizes

			Standardizer[a]	Points Estimate	95% Confidence Interval Lower.	Upper
Pair 1	before the treatment – after the treatment	Cohen's d	14.917	-2.731	-3.554	-1.896
		Hedges' correction	15.136	-2.2692	-3.503	-1.869

After the paired sample t-test analysis, the effect size calculation using Cohen's d showed a large effect size, indicating a substantial improvement in students' science process skills after participating in inquiry-based laboratory learning integrated with local contextual elements. Furthermore, effect size analysis using Cohen's d revealed a value of 2.7, indicating a large effect size. This result suggests that the improvement observed between the pretest and posttest scores represents a substantial change in students' science process skills following the implementation of the inquiry-based laboratory learning integrated with local contextual elements.

Additionally, Figure 2 compares the percentage of pretest and posttest results for six science process skill indicators: observing, classifying, predicting, measuring, concluding, and communicating to give a preliminary picture of how students' science process skills have changed for each indicator. Through inquiry-based laboratory learning that is incorporated with the local context, this graph shows how students' skills have grown over time.

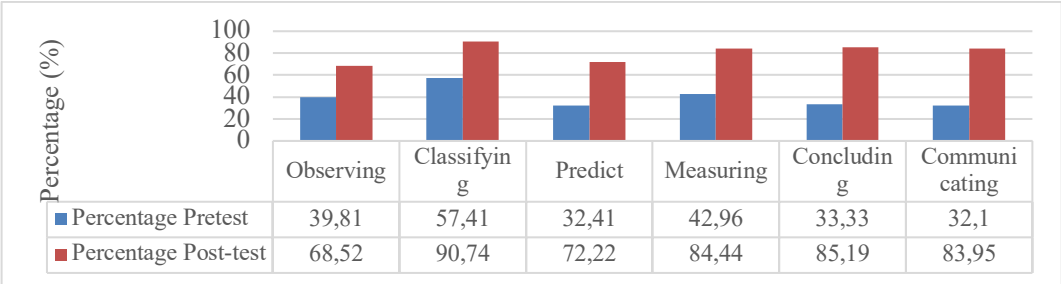
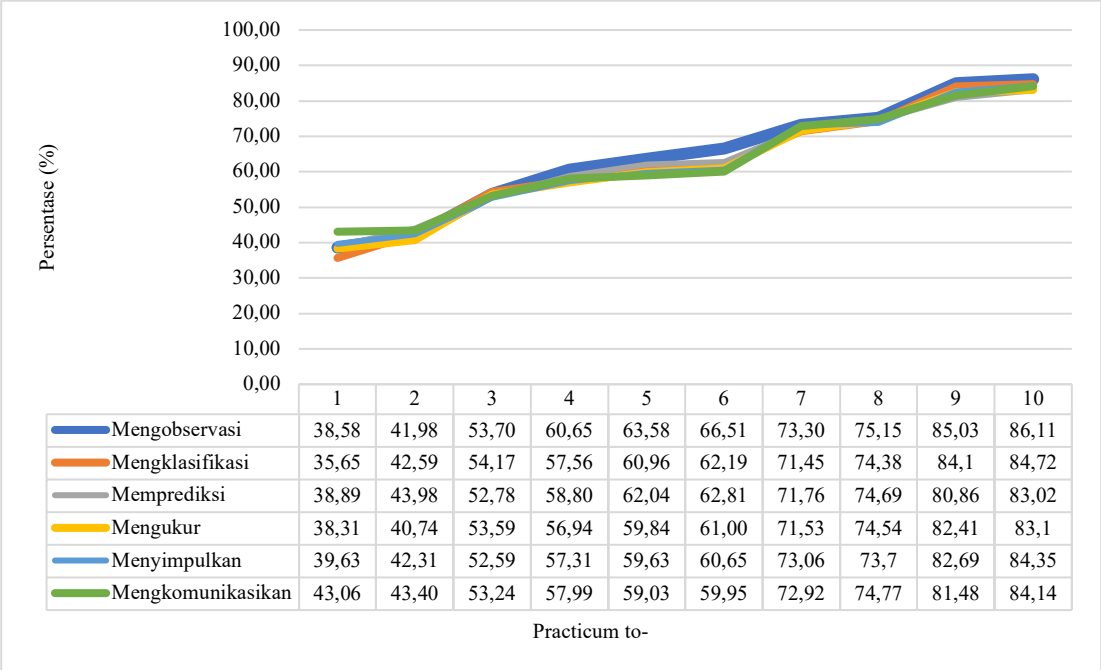


Figure 3. Comparison of pretest and posttest percentages for each indicator of science process skills

The findings from the science process skills assessment of prospective physics teachers indicate a uniform improvement across all indicators following the application of inquiry based laboratory learning integrated with local contextual elements. The assessment covered six aspects, namely observing, classifying, predicting, measuring, drawing conclusions, and communicating. Based on the pretest data, the students' science process skills were in the low to moderate category. The classification indicator showed the highest percentage at the initial stage (57.41%), while the communication and prediction indicators were at the lowest percentages (32.10% and 32.41%, respectively). These results show that students were relatively more familiar with simple data grouping tasks before the intervention, but still struggled with more sophisticated process skills involving scientific reasoning and expression. After the implementation of the inquiry based laboratory design integrated with local wisdom, all indicators showed a significant increase in the posttest stage. The highest achievement percentage was shown by the classification indicator (90.74%), followed by concluding (85.19%), measuring (84.44%), and communicating (83.95%). During this time, observing and predicting indicators also saw significant growth, at 68.52% and 72.22%, respectively.

This rise implies that inquiry-based laboratory learning gives students enough opportunities to be deeply engaged in the entire cycle of the scientific process, including observing phenomena and systematically presenting results. Incorporating local issues serves as a mental stimulant that facilitates students' comprehension of physics concepts through the phenomena around their day-to-day life, thus making the scientific thinking process more significant. From an educational point of view, these findings strongly support the perspective that students' science process skills may not be developed to the maximum through just verifiable practicum, but also that they should be engaged in learning activities that challenge them to design, interpret, and communicate data in real-life situations, on their own. Furthermore, to reinforce the test results and provide a more comprehensive picture of the development of science process skills (SPS) during the learning process**,** Figure 4 presents the results of observations of students' science process skills in ten practicum sessions. This graph demonstrates the dynamics of the gradual improvement in students' skills from the initial practicum to the final practicum, illustrating the consistency of the impact of the instructional design applied.



	1	2	3	4	5	6	7	8	9	10
Mengobservasi	38,58	41,98	53,70	60,65	63,58	66,51	73,30	75,15	85,03	86,11
Mengklasifikasi	35,65	42,59	54,17	57,56	60,96	62,19	71,45	74,38	84,1	84,72
Memprediksi	38,89	43,98	52,78	58,80	62,04	62,81	71,76	74,69	80,86	83,02
Mengukur	38,31	40,74	53,59	56,94	59,84	61,00	71,53	74,54	82,41	83,1
Menyimpulkan	39,63	42,31	52,59	57,31	59,63	60,65	73,06	73,7	82,69	84,35
Mengkomunikasikan	43,06	43,40	53,24	57,99	59,03	59,95	72,92	74,77	81,48	84,14

Figure 4. Graph of the increase in science process skills in each practicum

In addition to tests, students' science process skills were also analyzed through observation sheets during ten practicum sessions. The observation results indicated a gradual and consistent upward trend in all science process skill indicators from the first to the tenth practicum. In the early phase of the practicum (practicums 1–3), the percentage of science process skills was still in the low to moderate category. This showed clearly in the practical skills of communicating and concluding, which call for reflection and argumentation. However, as students gained more experience in following the inquiry stages, there was a steady increase in each indicator.

Entering the 6th to 10th practicums, all indicators showed high achievement. The indicators measuring and classifying developed faster than the other indicators, while the indicators communicating and concluding showed a more gradual but consistent improvement. This is an indicator that science process skills have a hierarchy, and it is through continued practice within a learning environment that these skills are developed. The consistency of improvement in the observation data is an indicator that supports the test results, proving that not only did the instructional design have an effect on the cognitive domain of the students, it also influenced actual

student performance during the process of the practicum. This proves that it is possible to influence scientific thinking through inquiry-based learning.

Discussion

The findings indicate that pre-service physics teachers' science process skills generally improved following engagement in inquiry-based laboratory learning integrated with the local environment. The pretest and posttest results, along with the observation data that documented the growth of students' skills during 10 practicum sessions, demonstrate this rise. The conclusion that there was a substantial difference between the first and final scores is further supported by the findings of statistical tests. The pretest and posttest results, as well as the observational data on the students' skill progress across 10 practice sessions, likewise demonstrated this improvement. Figure 1 shows that from the pretest to the posttest, every science process skill indicator increased significantly as a percentage. While the indicators of watching and forecasting also demonstrated a considerable increase, the indicators of classifying, measuring, concluding, and communicating showed the largest growth. These findings imply that inquiry-based laboratory instruction can improve students' integrated process skills, integrating higher-order thinking abilities as well as their fundamental science process skills.

A deeper examination of the indicator-based results reveals that the improvement of science process abilities in prospective physics teachers does not occur uniformly but follows a hierarchical and cumulative pattern. Basic process skills, such as observing and classifying, tended to develop earlier and more rapidly, while integrated skills, particularly predicting, concluding, and communicating, required longer exposure and repeated inquiry cycles to reach a high level of mastery. This finding supports the theoretical perspective that science process skills are structured progressively, where higher-level skills depend on the stability of foundational skills acquired through sustained practice.

The relatively high posttest achievement in classifying and measuring skills suggests that inquiry-based laboratory activities provide strong scaffolding for procedural engagement. Throughout the practicum sessions, students were consistently required to organize experimental data, identify variables, and perform measurements independently. These repeated actions appear to strengthen students' procedural fluency and accuracy. However, the more gradual improvement observed in predicting and communicating skills indicates that these competencies involve more complex cognitive processes, including abstraction, inference, and scientific argumentation. Such skills require not only hands-on experience but also structured reflection and opportunities for discussion.

Theoretically, these results are in line with the view that the best development of science process abilities occurs when students are actively involved in all stages of scientific inquiry, from problem formulation to communication of results (Ekici, 2020; Riga et al., 2017; Syahgiah et al., 2023). Inquiry-based learning mainly focuses on allowing students to construct knowledge themselves through their direct experience, instead of just getting knowledge through experimentation and verification. Researches by (Arslan, 2023; Guler & Sahin, 2019; İrwanto et al., 2019) reveal that inquiry-based laboratories have a great impact on students' science process skills and scientific reasoning development, whereas traditional laboratory methods have very little effect. Classification and measurement indicators show a very high posttest percentage. This can be explained because inquiry activities in the *in-lab* phase consistently require students to group data, determine variables, and take measurements independently. According to(Hofstein & Lunetta, 2004), science process skills develop most effectively when students are given direct responsibility for collecting and processing experimental data. This finding is also reinforced by research on the "(Hofstein & Lunetta, 2004) , which confirms that laboratory designs that emphasize exploration and scientific decision-making encourage a deeper mastery of experimental skills.

Moreover, summarizing and communication indicators have likewise revealed statistically significant improvement. This means that students, apart from collecting data, are also capable of interpreting and presenting experimental results logically. Through integrated inquiry learning in the local context, real situations are offered to students; thus, it is easier for them to experimentally relate data to real phenomena in their environment. This method agrees with the results of, which assert that contextual learning can enhance the quality of students' scientific reasoning and argumentation skills.

From the first to the tenth practicum, students' science process skills gradually improved, as evidenced by the observation data displayed in Figure 2. Students' abilities remained in the moderate range during the first practicum, particularly in the communication and prediction indicators. Nonetheless, during the practicum sessions, the indicators all showed a stable upward trend. This pattern suggests that science process skills are not acquired immediately but rather developed through repeated practice and ongoing reflection. These results are consistent with studies (Valls Bautista et al., 2021) that shows inquiry based labs need some adjustment period but have a long-lasting impact on students' scientific skill development. Likewise, (Walsh et al., 2022) argue that laboratory work offering room for reflection and discussion after the experiment greatly enhances the level of conceptual understanding and science process skills.

Furthermore, incorporating local contexts in instructional design is also essential in increasing students' engagement. When local events are used as the context of physics problems, it gives the students a more significant and appropriate educational experience. This agrees with the findings of the study conducted by (Nadhifatul A'yun et al., 2020), who assert that the use of local context in science learning can increase the degree of motivation among students, their enthusiastic involvement, and their conceptual understanding. Moreover, this episode becomes a very valuable asset for prospective physics teachers to develop their context-based pedagogical competencies in the future. Overall, the results of this study reinforce the argument that inquiry-based laboratory learning design integrated with the local context is an effective approach to systematically and sustainably build the science process skills of prospective physics teachers. This approach is not only relevant to the demands of 21st-century science learning but also aligns with the professional development needs of teachers who are able to relate physics concepts to the surrounding social and cultural realities.

Despite these promising findings, several limitations should be acknowledged. First, the study involved a relatively small sample consisting of 27 students from a single cohort in one university, which may limit the generalizability of the results to broader educational contexts. Second, this research employed a descriptive research design without a control group, meaning that the study does not claim a causal relationship between the instructional design and the observed improvements in science process skills. Third, the integration of local context was implemented within a specific cultural and geographical setting, namely Lubuklinggau, which may produce different outcomes if applied in other regions with different local characteristics. Future studies are therefore recommended to involve larger participant groups, apply comparative experimental designs, and explore the integration of local context in different educational settings. Such investigations would provide a deeper understanding of the effectiveness and scalability of inquiry-based laboratory learning integrated with local contextual elements.

CONCLUSION

This study provides an overview that inquiry oriented physics laboratory learning that incorporates local contextual elements correlates with an increase in the scientific process skills of prospective physics teacher students during a series of practicum activities. According to a report on test and observation analysis results, student performance improved over time in all

science process skill indicators, including the capacity for observation, classification, prediction, measurement, conclusion, and communication. The progress made explains that practicum activities which focus on student active participation in the phases of scientific inquiry at the same time using local contexts relevant to learning experiences can be a great tool for meaningful and contextual learning.

These results suggest that an alternative to enhance scientific process abilities in the practicum training of aspiring physics teachers is inquiry based laboratory learning combined with local contexts. Further research is recommended to involve a broader subject and diverse local contexts, as well as using a stronger research design to strengthen the generalization of findings. Besides, there is still room for more research on how this method relates to other higher, level thinkingskills like problem solving and science literacy in order to provide more concrete data in inquiry based physics learning.

ACKNOWLEDGEMENT

The author expresses gratitude to PPAPT Kemendiktisaintek for providing the 2025 Doctoral Program Completion Scholarship and for supporting the publication costs of this article.

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