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Profile of science process skills of elementary teacher education students in science learning at primary schools

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Abstract
Science process skills are essential for prospective educators today, especially in the subject of IPAS (Integrated Science and Social Studies). The purpose of this study is to describe the science process skills of PGSD (Primary School Teacher Education) students in science learning at elementary schools. This research employs a quantitative descriptive method. The data was obtained through the analysis of student practical assignments in the elementary school science education course involving 113 students in the 2024/2025 academic year. The results of the study show that students achieved an excellent category in the observing indicator (89%); a good category in the questioning and predicting indicators (85%), planning and conducting investigations (80%), and communicating results (80%). However, students were only in the fair category for the processing and analyzing information indicator (72%) and the evaluating and reflecting indicator (75%). This condition is attributed to students not being adequately trained in processing and analyzing information, as well as in evaluating and reflecting on observational results—skills that require critical thinking to connect learned concepts. These findings indicate the need to strengthen learning to train students' critical thinking skills in science education.

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1. Introduction

Science process skills (SPS) are a fundamental foundation in modern science education as they reflect how scientists acquire and develop knowledge (Wahyuni & Sukarmin, 2018). SPS encompasses basic skills such as observation, classification, and measurement, as well as integrated skills including formulating hypotheses, designing experiments, and interpreting data (Kurniasari et al., 2020). In the context of 21st-century learning, these skills play a crucial role

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in fostering students' critical thinking, problem-solving, and creativity (Saavedra & Opfer, 2012).

Along with curriculum developments, including the implementation of the *Merdeka Curriculum* in Indonesia, science process skills (SPS) have become a key indicator in inquiry- and science-based learning (Dewi & Isnaeni, 2022). However, various studies have shown that the mastery of SPS among students and pre-service teachers remains relatively low. This condition is attributed to the limited use of practice-based learning approaches, inadequate laboratory facilities, and insufficient teacher training in integrating SPS into classroom practice (Utami et al., 2020).

Although science process skills (SPS) are an essential competency for students in elementary teacher education programs, preparing them to become future primary school science teachers, numerous studies indicate that their achievement levels remain suboptimal. Pre-service teachers often struggle to apply scientific skills in practice, such as designing experiments, interpreting data, or connecting concepts to real-world phenomena. In fact, under the *Merdeka Curriculum*, teachers are expected to guide students to think scientifically and exploratively from an early age, which requires well-developed SPS competencies.

One contributing factor to this gap is the limited direct experience of pre-service teachers in laboratory activities and innquiry-based learning during their coursework (Sari et al., 2019). Learning at universities still tends to be theoretical and lecturer-centered, while practical work, collaboration, and field exploration are not yet sufficiently facilitated. As a result, students often develop a conceptual understanding of SPS but struggle to apply it in authentic classroom contexts. The low levels of scientific literacy and process skills among pre-service teachers are also associated with the limited use of process-skills–based modules or learning media in university courses. Students have had insufficient exposure to learning activities that integrate observation, prediction, experimentation, and scientific reflection—elements that should be integral to shaping their professional competence as future science teachers.

Given the challenges elementary teacher education students face in mastering science process skills (SPS), educators and researchers need to obtain a comprehensive picture of students' SPS profiles. Such profiles not only reflect the extent to which students understand and can apply SPS in learning contexts but also serve as a foundation for designing more targeted and effective educational practices.

Research that maps pre-service teachers' SPS abilities can provide valuable insights for higher education institutions, particularly elementary teacher education programs, in evaluating the effectiveness of the implemented curriculum and instructional approaches. Moreover, SPS profiles can serve as a reference in designing training programs and competency development initiatives for future science teachers, ensuring alignment with the demands of the *Merdeka Curriculum* and the requirements of 21st-century learning. A study by Rahayu et al. (2023) revealed significant variations in students' mastery of science process skills (SPS) across semesters and teaching practice experience. Furthermore, student-centered learning will positively impact science process skills (Kol & Yaman, 2022). Students still perform poorly in formulating hypotheses (Zannah et al., 2024). The science process skills of PGSD students are mostly in the moderate category (Handayani, 2020), and they still lack the application of the concepts Ningrum et al., 2022).

Therefore, it is important to conduct systematic research to identify patterns, weaknesses, and potential areas for developing these skills at an early stage. In this way, research findings on students' SPS profiles will not only serve a descriptive purpose but can also provide a valuable

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reference for academic decision-making and the formulation of data-driven instructional strategies. Research on mapping students' science process skills has been conducted, but none has used practicum reports as the primary source of data collection, which are the main source of data for this study. Science process skills in student practical activities (Bautista et al., 2021; DEMİR KAÇAN et al., 2020), through learning models (Irwanto, 2023), and preparation of learning plans (Bilgisi et al., 2012).

Based on the issues raised and supported by findings on students' science process skills, research is needed to map PGSD students' process skills. The researcher took a sample of 113 PGSD FKIP UIR students in the 2024/2025 academic year. Therefore, it is crucial to conduct mapping and develop instructional models that can integrate SPS across various science education contexts. Therefore, this study aims to map students' science process skills through practicum activities employing an inquiry-based approach. The skills to be mapped include the ability to observe, question and predict, plan and conduct investigations, process and analyze data and information, evaluate and reflect, and communicate findings.

2. Literature review

Science Process Skills (SPS) constitute a set of fundamental abilities that serve as the foundation for learners to comprehend scientific concepts as they systematically engage in research activities. SPS encompasses the abilities to observe, measure, classify, formulate hypotheses, design experiments, process and analyze data, draw conclusions, and communicate research findings. In higher education, particularly among students in elementary teacher education (PGSD) and science education programs, mastery of SPS is essential not only to support academic competence but also to equip students with the critical, reflective, and applicable thinking skills required to effectively teach science at the elementary school level (Elliyani et al., 2024).

Science process skills reflect the scientific ways of thinking and acting that form the foundation for understanding scientific concepts (Rustaman, 2005). Science process skills are abilities used to acquire, develop, and apply scientific knowledge through activities such as observing, classifying, interpreting data, and conducting experiments. In line with this, Carin & Sund (1989) explain that science process skills encompass intellectual, manual, and social abilities employed in investigative activities to discover and construct scientific concepts. SPS not only serve as a means of acquiring knowledge but also as a tool for fostering higher-order thinking, creativity, and analytical reasoning (Darmaji et al., 2024). Through learning that emphasizes scientific processes, students are expected to independently discover scientific concepts and understand how scientific knowledge is produced.

Science process skills are generally categorized into two levels: basic (simple) and integrated (complex)(Padilla, 1990). Basic skills include fundamental abilities such as observation and classification, which tend to develop earlier than integrated skills because they are more concrete and easier to practice among elementary school students (Farida et al., 2021). Integrated science process skills, on the other hand, involve higher-level abilities such as identifying variables, formulating hypotheses, defining variables operationally, designing experiments, organizing data tables, constructing graphs, and interpreting observational results (Padilla, 1990).

The profile of students' science process skills (SPS) tends to vary across different aspects. Students are relatively proficient in basic skills such as observing, measuring, and classifying,

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yet they still face difficulties in higher-level skills such as formulating hypotheses, independently designing experiments, and critically analyzing data (Huliadi, 2021). This condition indicates that higher-order scientific thinking skills still require special attention in higher education.

The research findings indicate that pre-service teachers' science process skills (SPS) still need improvement, particularly in integrated science process skills. This condition is consistent with the findings of Darmaji et al. (2024), who reported that pre-service teachers possess a moderate level of SPS, especially in designing and interpreting experiments. The ability to observe emerged as the most prominent aspect, as this activity is frequently practiced in lecture sessions that include demonstrations and simple observational phenomena. However, the ability to infer and predict remains low, as students are not yet accustomed to connecting their observations to relevant scientific concepts. This aligns with the findings of Farida et al. (2021), who found that students tend to focus on the outcomes of their observations without developing deeper scientific reasoning.

In response to these issues, it is essential to enhance students' science process skills (SPS). The development of SPS can be facilitated by implementing instructional designs that emphasize science process skills, such as inquiry-based and problem-based learning. This aligns with recent studies showing that instructional designs emphasizing hands-on practice and inquiry-based learning (IBL) significantly improve students' science process skills. The integration of process skills within the inquiry approach can enhance both learning outcomes and students' scientific competencies (Kassaye, 2025). Similarly, experiential learning models have been proven effective in developing students' abilities to observe, conduct experiments, and process data, as they enable learning through authentic experiences (Nurita, 2024).

Cooperative learning strategy and problem-based learning have also been identified as effective in fostering the development of science process skills (SPS), as they promote active student engagement in scientific problem-solving (Gizaw, 2023). A common challenge in implementing science process skills (SPS) lies in the limited availability of laboratory facilities and the readiness of instructors to design learning activities that genuinely integrate SPS (Putri et al., 2022). Other factors, such as learning motivation, scientific attitude, and prior laboratory experience, also influence students' achievement in science process skills (SPS) (Ningrum, 2022).

Measuring the profile of science process skills (SPS) cannot rely solely on written tests. Performance-based instruments, such as the Performance-Based Lab Assessment Technique (PBLAT), have been developed to directly assess students' practical skills while conducting experiments (Chabalengula & Mumba, 2023). These instruments are regarded as more valid for assessing manipulative skills and scientific reasoning than conventional tests. A comprehensive profile of science process skills (SPS) therefore, requires a combination of assessment techniques, including laboratory observation, data analysis tests, research reports, and reflective interviews (Elliyani et al., 2024).

Mapping students' science process skills (SPS) is essential, as there is an urgent need to design instruction that more explicitly integrates SPS and to develop valid and reliable assessment instruments for comprehensive profiling. The results of such mapping can serve as a basis for decision-making to improve the quality of science education in higher education, particularly in teacher education programs that play a strategic role in preparing prospective elementary school science educators.

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3. Method

The method employed in this study was a quantitative descriptive research design, aimed at portraying the profile of science process skills (SPS) among elementary teacher education students in primary school science learning. The subjects of this study were 113 students enrolled in the Elementary School Teacher Education program at Universitas Islam Riau during the 2024/2025 academic year. The selection of participants included all students taught by the researcher to comprehensively map the overall profile of students' science process skills (SPS).

This method was chosen because the research only captures the existing conditions without providing specific treatments to the subjects (Creswell, 2012). Data were collected by assessing practicum reports. Student laboratory reports were evaluated using an expert-validated rubric, and reliability was calculated. Four experts were involved in this study, consisting of four theoretical experts (lecturers with more than 10 years of teaching experience). The study emphasizes the importance of using a heterogeneous panel of experts (Arzahan, 2021), and several studies have reported that experts with fewer than 10 years of experience can produce satisfactory validation (Parsazadeh & Cheng, 2025; Blegur et al., 2024; Ziebart et al., 2022). The content design was validated by four theory experts (lecturers with more than 10 years of teaching experience) (see Table 1), who assessed it using a four-point rating scale.

The validation results were assessed using the Aiken formula (Acosta-Banda et al., 2021), with the Aiken parameter set at 0.75 or higher. Meanwhile, to test agreement among experts, intraclass correlation coefficients (ICC) were used, following the norm (Koo & Li, 2016), with a 95% confidence interval>0.50. Item revision was not used in this study, so items that did not meet the test parameters were eliminated. The scoring guidelines were compiled using low, medium, high, and very high criteria.

Table 1. Tim validator

No.	Validator	Gender	Age (Years)	Affiliation
1.	Dr. Validator 1., S.Pd, M.Pd.	Female	41	Islamic University of Riau
2.	Dr. Validator 2., S.Pd, M.Pd.	Female	48	Islamic University of Riau
3.	Dr. Validator 4, S.Pd, M.Or	Male	39	University of Riau
4.	Dr. Validator 4, S.Pd, M.Pd	Female	43	Islamic University of Riau

The assessment of students' laboratory reports was conducted using an evaluation rubric previously validated by experts. The rubric for assessing students' science process skills (SPS) in laboratory reports is presented as follows:

Table 2. Assessment rubric

No	SPS indicator	Description	Score 4	Score 3	Score 2	Score 1
1	Observing	The ability to observe phenomena or objects systematically using the five senses and tools.	Observe very carefully, record complete, objective, and relevant data.	Observe and record most of the important data.	Observations were made, but the data were incomplete or irrelevant.	Observations are unsystematic, and data do not correspond to the phenomenon.

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No	SPS indicator	Description	Score 4	Score 3	Score 2	Score 1
2	Questioning and Predicting	The ability to formulate scientific questions and make predictions based on observations.	Sharp, relevant, and logical questions; predictions supported by strong scientific reasoning.	The question is quite relevant; the prediction is logical, but the reasoning is not strong enough.	The question is unclear; the prediction is general/not strongly substantiated.	Unable to ask meaningful questions or make meaningful predictions.
3	Planning and Conducting an Investigation	The ability to design and carry out experiments to answer scientific questions.	Comprehensive plan, systematic steps, controlled variables; implementation in accordance with scientific procedures.	The plan is quite good; there are minor shortcomings in variable control/work steps.	The plan is unclear, and implementation is inconsistent with scientific procedures.	Unable to design or carry out investigations correctly.
4	Processing and Analyzing Data	The ability to organise, interpret, and analyse an investigation	Data is processed accurately; analysis is thorough and logical; conclusions are consistent with the data.	The data has been processed well; the analysis is quite thorough; the conclusions are still logical.	Data partially processed; superficial analysis; conclusions not entirely accurate.	Data was not processed correctly; analysis/conclusions were unfounded.
5	Evaluating and Reflecting	The ability to assess the process and results of investigations and identify weaknesses or alternatives for improvement.	Critical evaluation, deep reflection, and realistic suggestions for improvement.	Evaluated quite well; reflections demonstrate understanding of the process.	Superficial evaluation; reflection on only some aspects.	Not conducting evaluations/reflections.

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No	SPS indicator	Description	Score 4	Score 3	Score 2	Score 1
6	Communicating Results	The ability to present research findings orally/in scientific writing.	Presenting results in clear, logical, systematic, and engaging scientific language.	The results are presented clearly and systematically, with few shortcomings.	The presentation is not systematic or entirely scientific.	Unable to communicate results effectively.

The average score for each indicator component was calculated using the following formula:

NP=R/SM×100%

NP = Percentage score obtained

R = Total score achieved by students for each indicator

SM = Maximum possible score

The percentage criteria for science process skills are categorized as follows, adapted from Ngalim (Romadhoni & Wilujeng, Dr. Insih, 2017):

Table 3. Data interpretation

Percentage	Category
86-100	Very good
76-85	Good
60-75	Fair
55-59	Poor
≤ 54	Very poor

4. Results

For the instruments to be valid in truly measuring what they are intended to measure and reliable in estimating the level of error in the measurement, so that they align with the research objectives. Researchers used two validity tests, namely content validity and construct validity. According to, an instrument must first have content validity before it can have construct validity.

In this study, the Aiken-V threshold was set at 0.75, based on the Aiken table. Using a scale of 1-4, the validators gave a maximum score of 4 and a minimum score of 2, with an average validator score of 3.60 on the statement items (see Table 4).

Table 4. Validator assessment results (content analysis)

Item	Validator	M ± SD	Aiken-V	Decision	Item	Validator	M ± SD
1	4	3	4	4	3.29 ± 0.49	0,88	Valid
2	3	4	4	4	3.57 ± 0.53	0,88	Valid
3	3	4	3	4	3.71 ± 0.49	0,75	Valid
4	4	4	4	4	3.86 ± 0.38	1,00	Valid
5	4	4	4	4	4.00 ± 0.00	1,00	Valid
6	4	3	4	4	3.43 ± 0.53	0,88	Valid

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1 Of the six items validated by the expert panel, the highest Aiken value of 1.00 was found in items 5 and 6. Conversely, the lowest Aiken value was 0.75 for item 3, and, based on the Aiken table, the comparative value was 0.75. Since the Aiken value of 0.67 < 0.75, all items met the content validity standard and were declared valid. After testing content validity, the next step is to test inter-rater reliability using Intraclass Correlation Coefficients (ICC) (Hardiansyah & Zalindro, 2025).

Using ICC analysis, all items were then assessed for the level of agreement among the expert panel in their evaluations. The ICC analysis yielded an average measure value of 0.550 (Sig. = 0.009), which is classified as moderate (>0.50) according to the normative values of Koo & Li (2016). Thus, the items were included in the trial (construct validity).

After the scale underwent content validity testing and inter-rater reliability testing by a panel of experts, it was then tested (construct validity) on 113 elementary education students. Construct validity was conducted to see the extent of the relationship between scores. Correlation tests were used to test construct validity.

To determine cross-validity and total score correlation by comparing the total correlation value with the r-table value. If a construct exceeds the r-table value, then the construct is considered valid. The six questionnaire items that were considered valid at the previous level were tested for construct validity. Table 5 shows that the 6 statement items are valid because the r-count values are greater than the r-table values (see Table 5).

1 Table 5. Descriptive analysis and Pearson correlation

Item	M±SD	Pearson	r-table	Decision
1	3.28 ± 1.10	0.60	0.183	Valid
2	3.64 ± 1.15	0.67	0.183	Valid
3	2.88 ± 1.17	0.66	0.183	Valid
4	2.98 ± 1.08	0.77	0.183	Valid
5	2.75 ± 1.14	0.79	0.183	Valid
6	2.96 ± 1.10	0.65	0.183	Valid

The item-total correlation analysis in Table 5 shows that the calculated r values range from 0.60 to 0.82, which are greater than the table r value of 0.183. It can be concluded that all items are valid, and the next step is to conduct a Cronbach's Alpha reliability test to assess the internal consistency of the items by examining their relationships. Based on the Cronbach's Alpha reliability test, a value of 0.922 was obtained (see Table 6). A Cronbach's Alpha result >0.90 indicates that the instrument meets the reliability criteria and is therefore acceptable.

1 Table 6. Reliabilitas Cronbach's alpha

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of items
0.922	0.923	6

The reliability test, using Cronbach's alpha, yielded a very significant value of 0.922, indicating that the PMAS-CFP Questionnaire instrument has a very high level of reliability. The next stage of construct validity is to use Confirmatory Factor Analysis (CFA). However, before performing CFA analysis, the data must meet the Kaiser-Meyer-Olkin (KMO) requirements (see Table 7).

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Table 7. Kaiser–Meyer–Olkin dan Bartlett

Kaiser-Mayer-Olkin measure of Sampling		0.895
Bartlett's Test of Sphericity	Approx. Chi-Square	835.391
	df	78
	Sig.	0.000

The KMO results show a value of 0.896, which is> 0.50; therefore, factor analysis using CFA can be performed. KMO can evaluate the correlation between variables, making it relevant for factor analysis and for assessing sample adequacy. Next, the CFA PMAS-CFP Questionnaire analysis was conducted using Jamovi software version 2.6.44. The results of the CFA construct validity analysis are shown in Table 8.

Table 8. Confirmatory factor analysis (CFA)

Indicator	Estimasi	SE	Z	P	Decision
Observing	0.685	0.1080	6.35	<.001	Valid
Questioning and Predicting	0.808	0.1106	7.31	<.001	Valid
Planning and Conducting an Investigation	0.719	0.1094	6.57	<.001	Valid
Processing and Analyzing Data	0.946	0.0969	9.76	<.001	Valid
Evaluating and Reflecting	0.935	0.0911	10.26	<.001	Valid
Communicating Results	0.667	0.0973	6.85	<.001	Valid

The CFA test results show factor loadings for the concentration disruption indicator of 0.685-0.808, for the somatic anxiety indicator of 0.667-0.946, and for the worry indicator of 0.808-0.909. Based on the sample size, the comparative value was 0.50, indicating that all three indicators had factor loadings greater than 0.50. Thus, all items were declared valid through CFA.

The next step is to conduct further reliability testing on all declared valid items. revealed that to determine whether an instrument is error-free, reliability testing needs to be conducted. The advanced reliability test in this study used Composite Reliability (CR). CR shows minimal differences between CFA and exploratory structural equation models, with multilevel extensions that address observed versus latent composite scores. The CR results are shown in Table 9.

Table 9. Composite reliability

Composite Reliability	N of Items	Decision
0.965	6	Reliable

The CR analysis yielded a value of 0.965 (> 0.70), indicating excellent construct reliability, and the PMAS-CFP Questionnaire met the composite reliability standard. The final stage in this study was the convergent validity test using Average Variance Extracted (AVE). AVE aims to test construct validity in the structural equation modelling approach (see Table 10).

Table 10. Average variance extracted

Average Variance Extracted	N of Items	Decision
0.681	6	Valid

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The analysis results show an AVE value of 0.681. An AVE value > 0.50 indicates that the convergent validity standard has been met. Thus, it can be stated that the 6 items of the PMAS-CFP Questionnaire instrument are valid and reliable and therefore suitable for use.

to describe the science process skills of prospective elementary school teachers based on six leading indicators: observation, questioning and predicting, planning and conducting investigations, processing and analyzing data, evaluating and reflecting, and communicating results. The data were obtained from practicum reports conducted by PGSD FKIP UIR students. The results showed that PGSD students' achievement in science process skills varied across indicators (see Table 11).

Table 11. Results of science process skills of pgsd fkip uir students for the 2024/2025 academic year

No	Indicator	4	3	2	1	Total	Persentase
1	Observing	97	16	0	0	404	89%
2	Questioning and Predicting	77	12	15	9	386	85%
3	Planning and Conducting an Investigation	76	11	5	19	366	80%
4	Processing and Analyzing Data	19	74	11	7	327	72%
5	Evaluating and Reflecting	24	70	14	4	338	75%
6	Communicating Results	74	11	10	18	366	80%

Based on the data, the observation indicator showed the highest percentage, indicating that students demonstrated strong abilities to use their senses and gather relevant facts during the learning process. This finding is consistent with Asyhari & Hartati's (2021) research, which found that observation skills are relatively easy for students to master because they are directly related to concrete activities in science learning.

The indicators of questioning and predicting abilities also show a high level of achievement. This shows that students can ask critical questions and make assumptions about scientific phenomena that have not yet occurred. This ability is essential because it supports the higher-order thinking skills needed in science learning. The ability to predict and ask questions plays an important role in fostering students' curiosity and critical thinking skills (Putri et al., 2020).

Meanwhile, indicators of investigation planning and implementation, as well as presentation of results, were categorized as good. This achievement shows that students are competent in designing investigation procedures and presenting scientific reports clearly. It also shows that students can integrate conceptual understanding with procedural skills. Suastra & Ristiati (2019) also emphasize that inquiry-based learning can improve students' science process skills, particularly in the planning of experiments.

Data processing and analysis indicators were categorized as reasonably good. These results indicate that students still have difficulty processing information, explaining experimental results, and drawing conclusions based on data. Similar challenges were also observed in the evaluation and reflection indicators, which were also categorized as reasonably good. This shows that some students have not yet fully developed the ability to connect the concepts they have learned to new situations or real-life contexts.

The overall research data show that students' science process skills (SPS) fall into the categories of excellent, good, and adequate. Students demonstrate strengths in observation and prediction; however, improvement is still needed in data analysis and reflection. These findings highlight the need for innovative learning strategies that place greater emphasis on

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analytical and evaluative activities, such as inquiry- or problem-based learning. As a result, prospective teachers will not only be able to observe but also develop proficiency in interpreting data and relating it to broader scientific concepts. A clearer picture of these results is shown in the bar chart below.

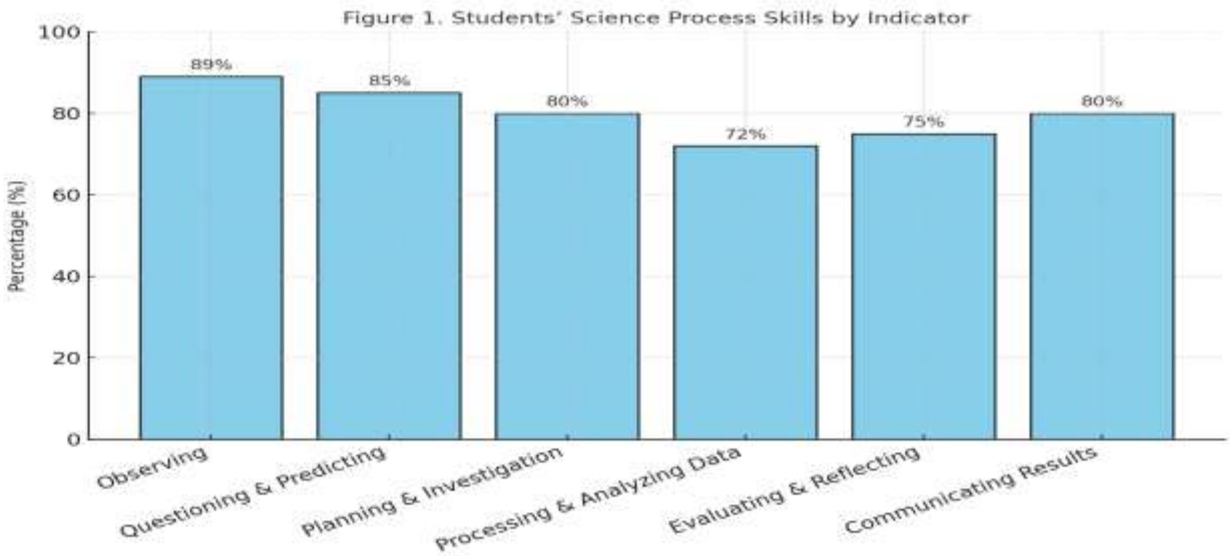

Figure 1. Students science process skills by indicator

5. Discussion

The results of this study indicate that PGSD FKIP UIR students in the 2024/2025 academic year remain weak in data processing and analysis, as well as in evaluation and reflection indicators. This is because students are not yet accustomed to processing and analyzing information based on the experimental data they collect. The compilation of practicum data is still limited to data description, without any analysis, evaluation, or reflection based on the data obtained. Therefore, for the analysis, evaluation, and reflection stages, further practice and familiarity are needed in preparing practicum reports through practicum/investigation activities. This study is consistent with previous research highlighting the importance of improving pre-service teachers' science process skills. For example, Maulida et al. (2019) reported that inquiry-based learning effectively improves students' ability to analyze data. Similarly, Fauziah & Suyatna (2019) found that project-based learning models strengthen students' reflective abilities, as they are directly involved in solving real-world problems. Therefore, innovation in science learning design in higher education is necessary so that prospective elementary school teachers are not only proficient in observation but also able to analyze data and reflect on scientific concepts in greater depth.

Research (Suryani et al., 2019) reveals that direct experience in conducting investigations improves students' science process skills, especially in planning. Similarly, scientific communication skills are an important part of science literacy that prospective teachers need to master. (Putri et al., 2020) emphasise that the ability to deliver scientific reports orally and in writing is an essential skill in building students' understanding in the classroom. These findings have important implications for the development of prospective primary school teachers' competencies, especially in addressing the challenges of 21st-century science learning.

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Furthermore, practical activities not only focus on work stages but also on how students process and analyze data, and on evaluating and reflecting on the results. Therefore, it is necessary to emphasise these indicators, such as in practical activities that focus not only on work steps but also on how students process and analyse data, and on evaluating and reflecting on the results of the practical activities. Furthermore, classroom learning activities can be improved by providing strategies that emphasise indicators of processing and analysing data, as well as evaluating and reflecting, such as problem-based and inquiry-based learning. This should be followed by learning or practical assessments that emphasise the indicators of processing and analysing data, as well as evaluating and reflecting. Research by Nurjanah et al. (2022) also found that prospective teacher students often have difficulty interpreting experimental data, especially when faced with simple statistical calculations. Therefore, learning strategies are needed that provide more opportunities for students to practise data analysis skills, for example, through inquiry- or problem-based learning.

Overall, the findings of this study show that the science process skills of PGSD FKIP UIR students in the 2024/2025 academic year are not yet evenly distributed across all indicators. This indicates an imbalance between basic science process skills and integrated science process skills. According to the framework proposed by Chiappetta and Koball (2015), skills such as observation, classification, and prediction are categorized as basic skills, whereas data analysis, evaluation, and scientific communication are considered integrated skills that require higher-order thinking. The relatively low achievement in integrated skills poses a challenge that needs to be addressed through curriculum improvement and the implementation of more effective learning strategies in elementary teacher education programs.

This study is consistent with previous research highlighting the importance of enhancing pre-service teachers' science process skills. For instance, Maulida et al. (019) reported that inquiry-based learning effectively improved students' ability to analyze data. Similarly, Fauziah & Suyatna (2019) found that project-based learning models strengthened students' reflective skills by directly engaging them in solving real-world problems. Therefore, innovation in the design of science learning in higher education is necessary so that pre-service elementary teachers are not only proficient in observation but also capable of analyzing data and reflecting more deeply on scientific concepts.

Inquiry-based approaches, project-based learning, discovery learning, and STEM have been proven effective in enhancing students' science process skills (SPS) (Rahmawati et al., 2023). In addition, the use of digital media and virtual laboratories has also demonstrated potential in fostering SPS development flexibly and independently (Fadillah et al., 2021). Recent studies have also shown that lesson study–based training, process skill modules, and ethnoscience-based practicum play a significant role in enhancing pre-service teachers' pedagogical readines(Rohim & Wulandari, 2021).

6. Conclusion and implications

This study shows that the science process skills of PGSD FKIP UIR students in the 2024/2025 academic year are in the pretty good to excellent category, with varying levels of achievement across all indicators. The highest score was obtained on the observation indicator (89%), followed by questioning and predicting (85%), while planning and conducting investigations and communicating results each reached 80%. Conversely, the lowest scores were found in the data processing and analysis indicator (72%) and the evaluation and reflection indicator (75%).

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To improve the abilities of PGSD FKIP UIR students in the 2024/2025 academic year in terms of data processing and analysis, as well as evaluation and reflection, it is necessary to conduct learning that emphasizes these aspects in practical work or classroom learning activities using inquiry-based learning (PBL), PBL, and PJBL. This can be achieved by changing the weighting of assessments, placing greater emphasis on indicators related to data processing and analysis, as well as evaluation and reflection. Thus, students' competencies are not limited to observation skills, but also develop into higher-order thinking skills needed to teach science in elementary schools.

This study has limitations: it was conducted only on PGSD FKIP UIR students in the 2024/2025 academic year, and the data were obtained from student practicum reports. For this reason, similar studies can expand the research sample and take other data sources to describe students' science process skills. This study also opens the door to more in-depth investigation into the factors that influence lower student performance in data analysis and reflective skills. In-depth studies through interviews and observations are also needed. Future researchers may explore the influence of specific teaching strategies, the role of digital technology in laboratory practice, or the relationship between science process skills and students' science literacy achievement. Such studies could provide more targeted recommendations for improving the science process skills profile of prospective elementary school teachers.

Credit authorship contribution statement
First Author: Conceptualization, Methodology, Formal analysis, Data curation, Resources, Investigation.
Second Authors: Project Administration, Visualization, Investigation.
Last Author: Funding acquisition, Formal analysis, Review&Editing.

Declaration of competing interest
3 The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data Availability Statement
The data that support the findings of this study are available from the corresponding author upon reasonable request. Because the data include human participant information, they are not publicly available to protect participant privacy.

Ethical Declaration
This study was conducted in accordance with established research ethics principles and in compliance with the Declaration of Helsinki. Ethical approval was obtained from the relevant institutional ethics committee prior to the commencement of the study. All participants provided informed consent before participating in the research.

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Declaration of AI statement

Portions of this manuscript were edited using ChatGPT (OpenAI) to improve grammar, clarity, and language quality. All content was carefully reviewed, revised, and validated by the authors. The authors take full responsibility for the final content of the manuscript.

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