

The improvement of science process skills in prospective biology teacher students through the implementation of feedback

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Abstract

Science process skills (SPS) is a fundamental aspect in science education that enables prospective biology teachers to think critically, analyse data, and develop investigative skills. However, previous studies show that the mastery of SPS among prospective student teachers is still relatively low, so efforts are needed to improve it through appropriate learning strategies. This study seeks to improve the SPS of future Biology educators by integrating laboratory activities, especially focusing on providing feedback. This study used a quasi-experimental design, 84 students were divided into control and experimental groups for comparison. The results of data analysis revealed substantial improvements in students' SPS, especially in formulating titles, hypotheses, and inference through the implementation of feedback. Despite these improvements, there was variability in skill improvement among students. Results showed that the majority of students in the experimental group achieved a moderate level of improvement in SPS, while approximately 50% of students in the control group achieved the same level. However, it should be noted that 16.62% of students in the experimental group and 50% of students in the control group still showed low-level improvement. Future research is recommended to develop innovative learning methods, such as project-based learning and interactive technology, to optimally improve skills. Longitudinal analysis is also needed to understand the long-term impact. The findings confirm the importance of evaluating and strengthening teaching by integrating SPS in the curriculum as well as targeted teacher training. The implications include improving the quality of science education, graduate competitiveness and developing more competent science teachers.

Abstrak. Keterampilan Proses Sains (KPS) merupakan aspek fundamental dalam pendidikan sains yang memungkinkan mahasiswa calon guru biologi untuk berpikir kritis, menganalisis data, dan mengembangkan keterampilan investigatif. Namun, studi sebelumnya menunjukkan bahwa penguasaan KPS di kalangan mahasiswa calon guru masih tergolong rendah, sehingga diperlukan upaya peningkatan melalui strategi pembelajaran yang tepat. Studi ini berupaya meningkatkan KPS pendidik Biologi masa depan dengan mengintegrasikan kegiatan laboratorium, terutama berfokus pada pemberian umpan balik. Penelitian ini menggunakan desain kuasi-eksperimental, 84 siswa dibagi menjadi kelompok kontrol dan perlakuan untuk perbandingan. Hasil analisis data mengungkapkan peningkatan KPS siswa yang substansial, terutama dalam merumuskan judul, hipotesis, dan penarikan kesimpulan melalui implementasi umpan balik. Terlepas dari peningkatan ini, ada variabilitas dalam peningkatan keterampilan di antara siswa. Hasil menunjukkan bahwa mayoritas siswa dalam kelompok perlakuan mencapai peningkatan KPS tingkat sedang, sementara sekitar 50% siswa dalam kelompok kontrol mencapai tingkat yang sama. Namun, perlu dicatat bahwa 16,62% siswa dalam kelompok perlakuan dan 50% siswa dalam kelompok kontrol masih menunjukkan peningkatan tingkat rendah. Penelitian selanjutnya disarankan mengembangkan metode pembelajaran inovatif, seperti pembelajaran berbasis proyek dan teknologi interaktif, untuk meningkatkan keterampilan secara optimal. Analisis longitudinal juga diperlukan untuk memahami dampak jangka panjang. Temuan ini menegaskan pentingnya evaluasi dan penguatan pengajaran dengan mengintegrasikan KPS dalam kurikulum serta pelatihan guru yang terarah. Implikasinya mencakup peningkatan kualitas pendidikan sains, daya saing lulusan, dan pengembangan guru sains yang lebih kompeten.

A. Introduction

Understanding science has evolved from a mere collection of knowledge to a dynamic process that includes critical thinking, problem-solving, and scientific inquiry. Modern science education emphasizes the integration of four main elements: attitudes, processes, products, and applications (Hattie & Timperley, 2007; Wisniewski et al., 2020). This shift highlights the importance of developing scientific skills and an investigative mindset, so that students are encouraged to be active in scientific methods as well as master procedural knowledge. A holistic approach to science education not only provides factual understanding but also builds habits that support lifelong scientific inquiry (Andayani et al., 2022; Jufri, 2013; Yadav & Mishra, 2013). In addition, the use of technology in the learning process further strengthens the effectiveness of science education through more effective feedback (Chauhan, 2017; Wang et al., 2022). The SPS become a crucial key in this approach because SPS aid in developing scientific ideas and encourage students to become independent thinkers. These skills encompass the ability to observe, classify, measure, infer, predict, and communicate – all essential aspects in fostering a deeper understanding of the scientific process (Nefianthi et al., 2022). According to Panuluh (2022) found that the science process skills of students significantly improved after engaging in guided inquiry-based practicum activities.

By emphasizing the development of SPS, science education can effectively instill not only knowledge but also the essential skills and mindset needed for students to engage in scientific inquiry, critical thinking, and problem-solving. This approach promotes active learning and empowers students to explore, question, and analyze the world around them, contributing to a more meaningful and enduring grasp of scientific principles (Yadav & Mishra, 2013). In line with the findings of Arrohman et al. (2021), the acquisition and refinement of certain skills are essential for students to effectively engage in scientific investigations or make discoveries. As a result, mastery of science process skills is deemed indispensable for every student. Recent studies also emphasize the importance of these skills. For example, a study by Al Azizah et al. (2023) found that mastery of science process skills significantly enhances students' ability to conduct experiments and analyze data. Similarly, Khotimah & Supratiyoko (2023) highlighted the role of critical thinking in scientific inquiry, while Wulandari & Sari (2024) demonstrated that active learning strategies improve students' proficiency in these essential skills. As a result, mastery of science process skills is deemed indispensable for every student.

Various studies show that the application of SPS has a significant impact on the quality of science learning. According to Aisah et al. (2024) science

process skills such as scientific procedures in science learning are able to deepen students' mastery of a concept. Science Process Skills are an important tool to help students develop a better understanding of science, both conceptually and practically (Shahali & Halim, 2010). In promoting SPS, it can be done through the application of appropriate learning models. According to Eliyana (2020) the development of SPS with good management, especially through a more interactive and participatory approach. Such as the application of guided inquiry models to temperature and heat materials, has been shown to improve the ability of; observation, classification, and conclusion of students significantly. Meanwhile, according to Al Azizah et al. (2023) found that Problem-Based Learning (PBL) is an effective approach in enhancing students' science process skills at the secondary education level. The implementation of SPS in science learning in Indonesia has helped students think logically, ask reasonable questions, and solve everyday problems, as well as foster creative thinking skills (Aditias & Kuswanto, 2024). Thus, the integration of SPS in the science learning process is essential to improve students' conceptual understanding and critical thinking skills.

The reality in science education, particularly in Biology teaching, reveals a gap between expectations and practice. Interviews with key high school teachers in Kendari City indicate that SPS are still inadequately applied in Biology lessons. This lack of implementation stems from insufficient teacher training, which is reflected in low student competency test results at local, national, and international levels. The 2021 National Assessment by the Ministry of Education, Culture, Research, and Technology of Indonesia reported that approximately 75% of students failed to meet the minimum numeracy competence, which is crucial for analyzing and interpreting scientific data.

In response to the National Assessment results, it is recommended that teachers focus on training numeracy skills in students. Similarly, at the international level, results from The Programme for International Student Assessment (PISA 2018) organized by the Organization for Economic Cooperation and Development (OECD) reveal that Indonesia's PISA scores are approximately 100 points lower than the OECD country average. In the field of science, the achieved score is 396 compared to the OECD average of 489 (OECD, 2019).

One of the challenges faced is the lack of emphasis on practical and process aspects in Biology science education. Teachers may be more inclined to focus on declarative knowledge or conceptual information without giving enough attention to the development of practical skills in students. A systematic literature review by Ilhami et al. (2023) highlighted that Problem-Based Learning (PBL) has a

significant impact on the development of science process skills, emphasizing the need for innovative instructional strategies in science education. This can create a gap between what is taught in the classroom and students' ability to apply these concepts in real-world contexts. The results of the study Sukarno et al. (2013), revealed that factors that affect low SPS can include lack of training for teachers, limited relevant teaching materials, and traditional learning. Schools that actively use laboratories show better SPS results, emphasizing the importance of experiment-based activities in science learning. So that to improve SPS, it is suggested that there is a need for teacher training, the development of specific teaching materials, and the application of laboratory-based learning models or exploration of the natural environment.

Thus, one solution to address this issue is to involve a learning approach that emphasizes practical, experimental, and observational aspects in Biology science education. Training teachers to integrate SPS into their curricula is also a crucial step. Teachers need adequate support and resources to enhance their skills in designing and managing lessons that promote SPS. Furthermore, there should be an evaluation and update of the biology science education curriculum to ensure that SPS is well-integrated into every learning topic. This may include reviewing textbooks, teaching materials, and evaluation methods to ensure that students not only understand biological concepts but also can apply them using science process skills. Involving teachers in professional development programs focusing on strengthening SPS can help improve the quality of education. Awareness of the importance of SPS in facing students' competency exams can drive a paradigm shift in Biology science education from a focus on knowledge alone to applied knowledge through science process skills. Thus, it is expected that student competency test results will improve with an increased focus on the development of SPS in Biology science education.

The development of SPS in learning must start from college, especially at the Teacher Education and Training Institution, to prepare prospective Biology teachers who have conceptual knowledge and practical skills. Because SPS is an absolute requirement for students to develop their knowledge to find understanding in Biology lecture activities (Khairunnisa et al., 2019). However, based on the results of the study, the mastery of SPS among prospective students of Biology teachers at Halu Oleo University is still relatively the same in all batches and is equivalent to high school students in Kendari City. This shows that learning in college today, especially in practical courses, has not been able to significantly improve SPS. Although laboratory exercises are widely recognized as a beneficial method for augmenting science process skills (Artayasa et al., 2023; Elfrida et al., 2021; Puspitaningrum & Nuraeni,

2024), conventional methods may not be satisfactory for advancing integrated process skills. Thus, serious efforts are still needed to control SPS in each student.

In response to the low SPS issue, the researchers feel the need to improve practical activities and reports that directly focus on practicing each component of SPS. This will be achieved by emphasizing feedback aspects to improve the SPS of student teachers participating in the animal ecology practicum. This process is intended to address the weaknesses of student teachers who are still unaware of practicing each component of SPS, even though their practicum activities meet scientific work standards.

Based on the review of previous research on the influence of laboratory activities on student SPS, no information was found regarding the effect of feedback provision on improving student SPS. This study is crucial to answer the research questions: (1) To what extent do students who receive feedback (experimental group) and students who do not receive feedback (control group) achieve SPS? (2) To what extent is there a significant difference in the achievement of SPS between students who receive feedback (experimental group) and students who do not receive feedback (control group)?

B. Material and method

This study employs a quasi-experimental design, specifically "The Matching-Only Pretest-Posttest Control Group Design," to compare the effectiveness of feedback in enhancing SPS among prospective biology teachers. A true experimental design was not feasible due to the constraints of random assignment in an educational setting. Instead, a quasi-experimental approach was chosen to ensure ethical considerations and practical implementation, allowing researchers to compare naturally formed class groups while maintaining control over key variables. This design provides a valid alternative for measuring intervention effects in real classroom settings where full randomization is impractical. Competency evaluations will be conducted before and after the intervention for both groups. The control group will receive conventional treatment without any intervention, while the experimental group will receive an intervention or treatment with guidance during the practicum activities, including feedback provision. The research design is crafted to examine the extent of SPS achievement among prospective teacher students who receive feedback (experimental group) compared to those who do not receive feedback (control group). Additionally, the study aims to assess the significant difference in SPS achievement between the experimental and control groups. The data collected will undergo thorough analysis employing suitable statistical techniques to ascertain and compare the distinctions between the two groups.

This experimental approach allows the researcher to identify the effects of the intervention in more detail, utilizing the control group as a baseline for comparison. By incorporating pretest and posttest stages, this study aims to provide more accurate information about the impact of the intervention on the SPS achievement of prospective teacher students. The subsequent statistical analysis will help measure the effectiveness of the intervention and determine whether the differences between the two groups are statistically significant.

In this research, a total of 84 students enrolled in the Animal Ecology practicum course were selected as study participants using a purposive sampling technique. This method was chosen to ensure that

participants met specific criteria, namely being prospective Biology teacher students who were enrolled in the same course and had similar prior knowledge levels. The students were then divided into two groups: Class A (experimental group) and Class B (control group), with each group consisting of 42 students. The grouping was done using matching techniques, where students were paired based on their pretest scores to ensure comparability between the groups. Both groups participated in the same practicum activities, covering identical subject matter, number of activities, and structured reports based on SPS. However, only the experimental group received two rounds of feedback on their practical reports, while the control group did not receive any feedback.

Table 1 Distribution of SPS test items by indicator

SPS indicator	Question type	Question numbers
Formulating an Experiment Title	2 Multiple-choice	1, 2
	1 Short-answer	16
Identifying Variables	3 Multiple-choice	3, 4, 5
	1 Short-answer	17
Defining Operational Variables	2 Multiple-choice	6, 7
	1 Short-answer	18
Formulating Hypotheses	2 Multiple-choice	8, 9
	1 Short-answer	19
Tabulating Data	2 Multiple-choice	10, 11
	1 Short-answer	20
Data Analysis	2 Multiple-choice	12, 13
Drawing Conclusions	2 Multiple-choice	14, 15

Data were collected using a SPS test instrument consisting of 20 questions, including 15 multiple-choice items and five short-answer items. These questions were specifically designed to assess various SPS indicators. Table 1 presents the distribution of questions and their alignment with each SPS indicator.

The indicators of SPS measured in this study encompass seven main components. Formulating an Experiment Title evaluates students' ability to formulate experiment titles that are relevant to the problems being investigated. Identifying Variables involves recognizing independent, dependent, and controlled variables within an experiment, while Defining Operational Variables focuses on the ability to define variables operationally to ensure clear and accurate measurements. Formulating Hypotheses assesses students' capability to construct hypotheses that align with the research problem and objectives. Furthermore, Tabulating Data measures students' skills in organizing experimental data into tables, while Data Analysis concentrates on their ability to analyze collected data. Lastly, Drawing Conclusions examines students' capacity to draw conclusions based on the analysis of the data. These indicators are designed to provide a comprehensive understanding of students' scientific process skills in the context of science learning.

These questions were administered both before and after the intervention. Prior to its implementation, the instrument underwent a validation process involving experts in science education to ensure its content validity, construct validity, and reliability. The validation process included a review by three subject matter experts who assessed the alignment of the questions with the targeted SPS indicators, the clarity of language, and the appropriateness of difficulty levels.

The results of the validation process indicated that the instrument achieved a Content Validity Index (CVI) of 0.87, categorized as highly valid. Furthermore, reliability testing using Cronbach's Alpha yielded a score of 0.81, signifying high internal consistency. This validated instrument was then used to collect data from prospective teacher students in both the control and experimental groups.

The data were analyzed using the Mann-Whitney U test with a significance level of $\alpha = 0.005$. The Mann-Whitney U test is a non-parametric statistical method used to compare differences between two independent groups when data do not meet the assumption of normality (Nachar, 2008). This test was chosen because it is particularly suitable for small sample sizes and ordinal data, making it an appropriate alternative to the independent t-test in cases where normality assumptions are violated.

(Sheskin, 2003). In this study, the test was applied to compare the pre- and post-intervention SPS scores between the control and experimental groups, ensuring that differences in students' SPS were statistically evaluated without assuming a normal distribution of the data.

The utilization of this statistical test aimed to ascertain whether notable differences existed between the control and experimental groups concerning the SPS of prospective teacher students throughout the Animal Ecology practicum, both before and after the intervention. Meanwhile, the effectiveness of the feedback implementation for enhancing the SPS of prospective teacher students was analyzed using the N-gain Score test with the criteria proposed by Hake (1998). The N-Gain Score quantifies the relative improvement of students' SPS from pretest to posttest and categorizes learning gains as high (>0.70), moderate ($0.30 - 0.70$), or low (≤ 0.30). All statistical analyses were conducted using IBM SPSS v.26.

Before the intervention, a pretest was conducted and analyzed using the non-parametric Wilcoxon test with a significance level of 0.05. This testing aimed to ensure whether there was a significant difference in pretest SPS values between the experimental and control groups. The result of the significance analysis for pretest SPS values showed that the Sig. (2-tailed) value was 0.934, which is greater than α (0.05). This means that there is no significant difference between the pretest SPS values of the experimental and control groups. This finding reinforces that the SPS of prospective teacher students in both classes did not differ significantly.

C. Results and discussion

Mean and standard deviation of N-gain for each component of SPS

The mean, standard deviation, and N-gain score for each component of SPS in the experimental and control groups are presented in Figure 1.

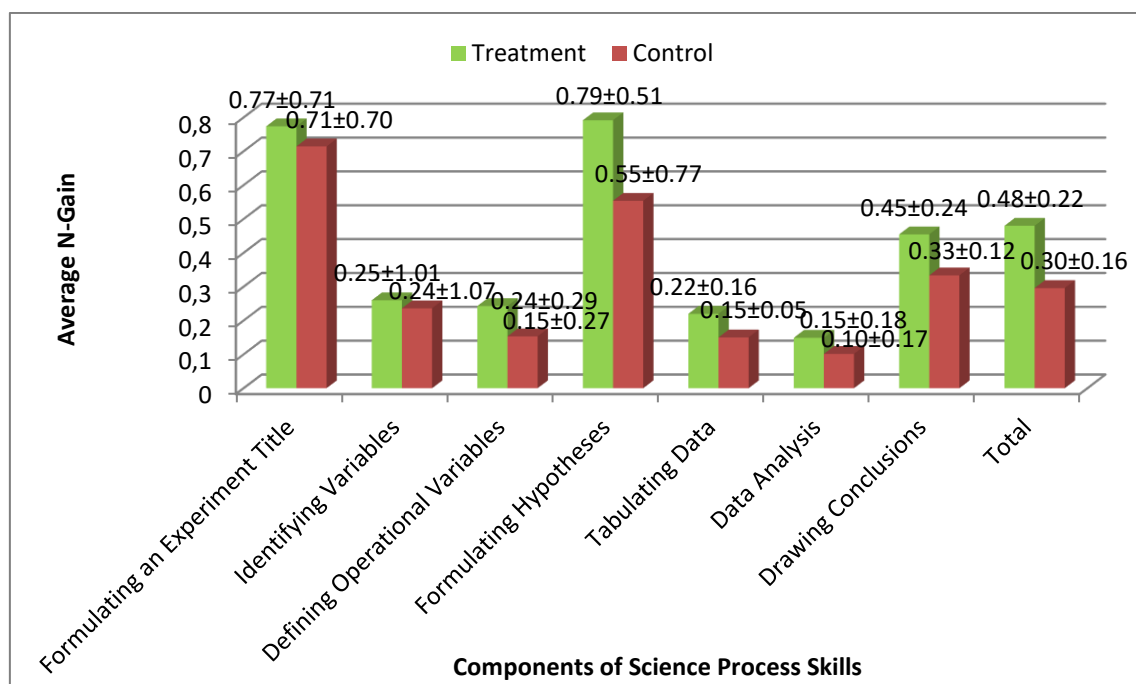


Figure 1 Mean, standard deviation, and N-gain score for each component of SPS

The examination of Figure 1 reveals a noticeable trend where the mean N-gain for each SPS component is generally higher in the experimental group as opposed to the control group. This result indicates a positive influence of feedback provision on the improvement of SPS among prospective teacher students participating in the animal ecology practicum. However, the observation of standard deviation values indicates relatively high variability, suggesting that the improvement in SPS is not uniform and is more focused on certain students.

In this context, it is important to note that the impact of feedback provision is not entirely uniform

among all practicum participants. Some students have experienced a significant improvement in SPS, while others have shown a lower level of improvement. Research suggests that individual differences, such as learning styles (Kolb, 2015), prior knowledge (Hattie, 2012), and cognitive engagement (Wisniewski et al., 2020), play a crucial role in shaping students' responses to feedback. Students with high self-regulation skills tend to benefit more from feedback, as they can effectively reflect on and apply corrections, whereas those with lower metacognitive awareness may struggle to use feedback constructively (Nicol & Macfarlane-Dick, 2006).

Therefore, variations in learning outcomes can be attributed to a combination of student-specific factors, instructional approaches, and the nature of feedback provided.

In this context, it is important to note that the impact of feedback provision is not entirely uniform among all practicum participants. Some students have experienced a significant improvement in SPS, while others have shown a lower level of improvement.

Specific factors such as learning styles, initial understanding levels, or individual needs can influence students' responses to feedback.

N-gain score for each component of SPS

The comparison of the percentage results of N-gain scores for each component of the treatment, both in the experimental and control groups, can be presented in Figure 2.

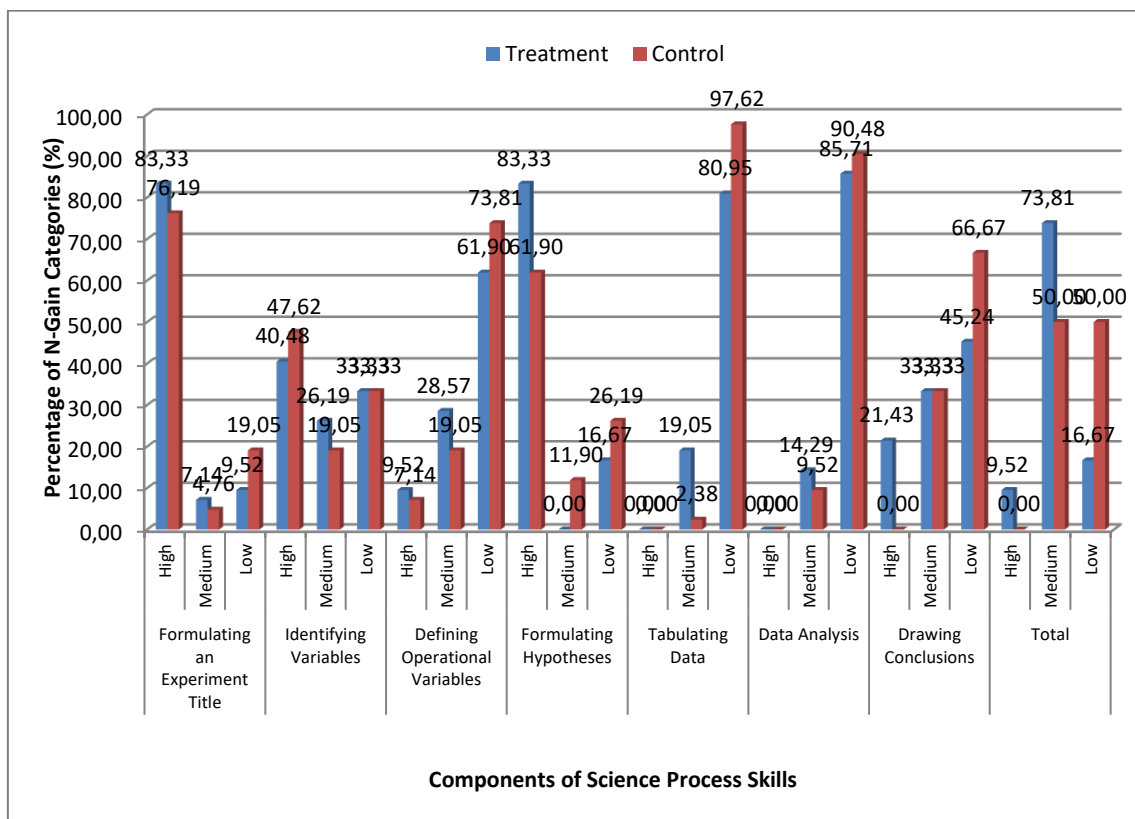


Figure 2 Percentage categories of N-gain for each component of SPS based on Hake (1998)

Based on the N-gain category criteria according to Hake (1998), the percentage of total SPS N-gain in the high and moderate categories is higher in the experimental (with treatment) group compared to the control group (see Figure 2). However, the percentage of high N-gain is only 9.52%, primarily observed in the formulating an experiment title and formulating a hypothesis component. The majority of students in the experimental group (73.81%) achieved moderate N-gain, particularly in identifying variables, defining operational variables, and drawing conclusions, while in the control group, only 50% reached the same category. In the experimental group, 16.62% of students remained in the low N-gain category, primarily in tabulating data and data analysis, whereas 50% of students in the control group showed low improvement across almost all SPS components.

Breaking down each component of SPS, the results show that high and moderate N-gain categories are more dominant in the experimental group, while the low N-gain category is relatively

higher in the control group. Exceptions are observed in specific SPS components, such as tabulating data and analyzing data, where there is no achievement of high N-gain in the experimental and control groups.

The SPS components that have achieved high N-gain (more than 80%) are formulating a title and formulating a hypothesis. However, a challenge that still needs attention lies in SPS components like tabulating and analyzing data, where no students have achieved high N-gain. A similar situation also occurs in SPS components such as identifying variables, defining variables operationally, and drawing conclusions, where the N-gain categories only range from 21.43% to 40.48%.

N-gain score of effectiveness in the experimental and control group

The comparison of the average N-gain scores in both research groups can be seen in Table 2. Following the N-gain criteria established by Hake (1998), the average N-gain outcomes indicate that the

enhancement in SPS within the experimental class (47.98%) is categorized as less effective, whereas in the control class (29.58%), it is deemed ineffective. These findings indicate that the feedback provided during practical activities has not fully achieved the

expected level of effectiveness. Nevertheless, descriptive statistical analysis reveals differences in effectiveness between the class receiving feedback intervention and the class without such intervention in enhancing students' prospective teachers' SPS.

Table 2 N-gain score test results

N-gain percent	Group	Statistic	Std. error
	Experimental group	Mean	47.9860
	Control group	Mean	29.5837
			2.52383

Table 3 Mann-Whitney test results

Test statistics ^a	
	Science process skills learning outcomes
Mann-Whitney U	401.000
Wilcoxon W	1304.000
Z	-4.303
Asymp. Sig. (2-tailed)	.000
a. Grouping variable: Class	

To determine the significance of the effectiveness difference between the two research classes, a Two Independent Samples Tests was conducted. Table 3 displays the outcomes of the Mann-Whitney test. The test results indicate that the Asymp. Sig. (2-tailed) value is 0.000, which is less than 0.05. It can be stated that there is a significant difference in the effectiveness of feedback provision on the SPS of prospective teacher students in each experimental group. This suggests that the intervention, specifically in the form of feedback, exerts a positive influence on enhancing the SPS of prospective teacher students engaged in practical activities related to animal ecology.

The research findings underscore the importance of feedback in enhancing the quality of learning, aligning with previous studies by Hattie (2012) that consistently support such findings. Feedback, as described by Hattie, operates at three levels: task, process, and self-regulation. Each level plays a critical role in supporting students' learning processes, particularly in interpreting data and drawing conclusions-core components of SPS. In this study, basically feedback is incorporated into the intervention to guide students in analyzing data and forming evidence-based conclusions. Feedback during these stages aligns with the Data Analysis and Drawing Conclusions indicators, helping students critically evaluate their findings, identify trends, and connect results to their research objectives. Hattie (2012) findings further support the notion that effective feedback enhances student motivation, clarifies learning goals, and fosters metacognitive skills, which are essential for mastering SPS.

However, the results obtained in this study were less effective in the experimental class, raising questions about the feedback strategies used. Recent studies also highlight the crucial role of effective

feedback design in the learning context, for example (Black & Wiliam, 2009). Therefore, a thorough review of the feedback strategies applied in animal ecology practical activities is necessary to enhance their effectiveness.

The evaluation of the differences between Class A (experimental) and Class B (control) provides further insights into the potential for overall practical activity development. These findings indicate a need for improvements in the design and implementation of practical activities. Recommendations can be made regarding changes in feedback strategies or adjustments to practical activity content. Altering feedback strategies or adapting practical activity content becomes crucial for enhancing the effectiveness of learning and improving the SPS of prospective teacher students. Hence, concrete steps and careful planning are required to optimize the effectiveness of feedback in enhancing the SPS of prospective teacher students.

In efforts to improve learning effectiveness, practical activity organizers need to reconsider feedback strategies and reevaluate the design and content of practical activities. According to Hattie & Timperley (2007), optimizing feedback effectiveness requires special attention to the context and characteristics of learning. Therefore, concrete steps and follow-up plans need to be formulated to ensure that the development of SPS in prospective teacher students achieves optimal results. For instance, providing varied feedback focused on specific aspects of SPS may be more effective than general feedback. Additionally, leveraging digital media technology as an effective feedback tool can be considered. According to Andayani et al. (2022), the use of appropriate media is a factor that can influence these skills. Results from Arrohman et al. (2021), suggest that using video demonstration media during

practical activities can strengthen basic and integrated science process skills in students.

Recent studies, such as that conducted by Wu (2023), explore the impact of technology on providing feedback in education. Findings from this research indicate that the use of digital technology in delivering feedback to students can enhance learning effectiveness, particularly in the development of SPS. Digital tools enable timely, specific, and targeted feedback that directly supports students in mastering SPS indicators, such as Data Analysis, Interpreting Data, and Drawing Conclusions. For instance, during Data Analysis, digital platforms can provide real-time feedback on how students process, organize, and visualize experimental data, enhancing their critical thinking skills. Similarly, in the Drawing Conclusions stage, digital simulations and visualization tools help students identify patterns and relationships in their findings, fostering evidence-based reasoning.

The integration of digital feedback tools also aligns with findings from Chauhan (2017) and Wang et al. (2022), which emphasize the positive impact of technology on critical thinking and problem-solving in learning. These tools not only improve learning effectiveness but also offer innovative methods to engage students in practical activities. Leveraging digital technology in feedback delivery during practical activities can significantly enhance students' ability to apply SPS in scientific investigations, making it an essential strategy for optimizing science education.

Research by Wisniewski et al. (2020) emphasizes the importance of providing constructive feedback to support learner development. Feedback is most effective when it is timely, specific, actionable, and individualized. As a two-way communication process, feedback not only provides valuable insights into students' strengths and areas for improvement but also encourages dialogue that fosters deeper understanding and reflection. Timely and constructive feedback reinforces learning by allowing students to immediately apply corrections or adjustments, while specific and actionable feedback gives clear guidance on what needs to be improved and how. Moreover, feedback that is tailored to individual learning styles and needs helps students feel supported in their unique learning journey.

Effective feedback plays a vital role in boosting students' confidence, self-awareness, and enthusiasm for learning. It creates a sense of progress by acknowledging accomplishments while offering a clear pathway for growth. In the context of animal ecology practical activities, re-evaluating the role of lecturers in delivering feedback is essential. This involves not only providing detailed and constructive feedback on practical tasks, such as data analysis and hypothesis formulation, but also understanding the diverse needs of students. By incorporating flexible approaches that align with students' individual

learning styles and leveraging digital tools to enhance feedback delivery, lecturers can significantly improve the effectiveness of learning and help students master SPS.

Integrating the findings from this research provides a foundation for the development of more effective and contextual animal ecology practical activities, specifically by focusing on the indicators of SPS and their unique characteristics. The indicators assessed in this study include Formulating an Experiment Title, Identifying Variables, Defining Operational Variables, Formulating Hypotheses, Tabulating Data, Data Analysis, and Drawing Conclusions. Each indicator represents a distinct skill essential for scientific inquiry and practical learning.

The findings of this study reveal that feedback plays an important role in improving certain SPS indicators, specifically in formulating titles, establishing hypotheses, and drawing conclusions. Through detailed guidance and repeated feedback cycles can help students perfect their analytical and reasoning skills. However, the study also highlights areas that need improvement, such as; identification of variables, definition of operational variables, and processing and analyzing data. In this study, prospective teacher students often struggle with accuracy and clarity. This specificity differentiates these studies by providing unique insights into which SPS indicators benefit the most from tailored interventions. Nonetheless, the effective implementation of feedback should still be a further concern. The use of technology in the form of digital tools can be used to create a more effective feedback process to support low SPS indicators.

The uniqueness of this study lies in its focus on the activities of animal ecology practices, which provides real-world context for applying SPS. By combining feedback strategies with specific SPS indicators, this study offers a nuanced approach to improve the skills of prospective student teachers. The study highlights the interaction between feedback and skills development, emphasizing that effective interventions must address the challenges and strengths of each SPS indicator.

Integrating SPS into education is essential for fostering scientific literacy and equipping students with critical inquiry-based competencies. SPS are generally categorized into basic skills such as observing, classifying, predicting, and measuring and integrated skills including hypothesizing, experimenting, controlling variables, and interpreting data. Each indicator possesses distinct characteristics that contribute uniquely to student development. For instance, observing involves accurately noting phenomena, while hypothesizing entails formulating testable explanations based on observations (Anjugam & Chellamani, 2024). Recent studies emphasize the importance of tailoring practical activities to specific SPS indicators to enhance their

effectiveness. Inquiry-based learning approaches have been shown to significantly improve students' SPS by engaging them in hands-on, investigative processes that mirror authentic scientific inquiry (Gizaw & Sota, 2023).

Effective feedback is pivotal in supporting SPS development, particularly during stages like data analysis and drawing conclusions. Feedback that is timely, specific, and actionable enables students to refine their inquiry processes and deepen their understanding. The integration of digital technologies into feedback delivery has further enhanced this process. Digital tools, such as simulations and interactive platforms, provide immediate and personalized feedback, facilitating a more responsive and engaging learning environment (Senisum et al., 2022). Moreover, the use of technology, such as interactive simulations or video demonstrations, can bridge the gap between theoretical knowledge and practical application. These tools enable students to visualize complex scientific concepts and engage in virtual experiments, thereby enhancing their SPS and understanding of real-world scientific applications (Biswal & Behera, 2023).

In conclusion, aligning practical activities with the unique characteristics of each SPS indicator, incorporating innovative feedback strategies, and leveraging digital technologies are crucial steps in enhancing the effectiveness of science education. These strategies not only improve students' SPS but also prepare them to apply these skills in diverse scientific contexts.

D. Conclusion

This study aimed to improve the SPS of prospective biology teacher students through the implementation of feedback strategies during animal ecology practical activities. The findings demonstrate that feedback significantly contributes to enhancing students' SPS, particularly in the indicators of formulating experiment titles, formulating hypotheses, and drawing conclusions. The experimental group, which received feedback, showed a higher average N-gain (47.98%) compared to the control group (29.58%), indicating the positive impact of feedback on SPS development. However, the results also revealed that certain SPS indicators, such as identifying variables, defining operational variables, and data analysis, require further attention as their improvement was relatively low in both groups. These findings highlight the need for more targeted feedback strategies that address these specific skills to achieve comprehensive SPS development. In conclusion, the implementation of feedback in practical activities has proven effective in supporting the development of SPS among prospective biology teacher students. Future studies should focus on refining feedback mechanisms and exploring the integration of digital tools to enhance the quality and reach of feedback. Additionally, long-

term studies are recommended to assess the sustained impact of these strategies on SPS development.

E. Acknowledgement

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