

Analysis of New Students' Science Process Skills Readiness and Its Impact on Basic Physics 1 Learning Outcomes

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Submitted: 22-01-2026

Accepted: 20-02-2026

Published: 03-03-2026

Abstract

Physics courses require mastery of Science Process Skills (SPS) as a foundation for developing conceptual understanding and scientific thinking skills. However, problems often exhibit heterogeneous practical skills due to differences in previous learning experiences. Therefore, this study aims to analyze the relationship between SPS and student learning outcomes in Basic Physics courses. This study used a quantitative approach with a correlational research design. A total sampling technique was used, involving 20 first-year students as participants. SPS data were collected through a science process skills test, while learning outcomes were obtained from final course grades. The results showed a significant positive relationship between SPS and learning outcomes, with a correlation coefficient of 0.431 ($p = 0.029$), indicating a fairly strong correlation. This indicates considerable variation in students' SPS levels, while academic grades tend to be relatively homogeneous. There is an imbalance between students' practical competencies and their cognitive achievements. In conclusion, SPS is significantly related to student learning outcomes in Basic Physics. Differences in SPS encourage the need for standardization of laboratory-based learning to improve the quality and equality of physics learning outcomes.

Keywords: Science Process Skills, Learning Outcomes, Basic Physics

Abstrak

Mata kuliah Fisika membutuhkan penguasaan Keterampilan Proses Sains (SPS) sebagai dasar untuk mengembangkan pemahaman konseptual dan keterampilan berpikir ilmiah. Namun, permasalahan sering menunjukkan keterampilan praktis yang heterogen karena perbedaan pengalaman belajar sebelumnya. Oleh karena itu, penelitian ini bertujuan untuk menganalisis hubungan antara SPS dan hasil belajar mahasiswa pada mata kuliah Fisika Dasar. Penelitian ini menggunakan pendekatan kuantitatif dengan desain penelitian korelasional. Teknik pengambilan sampel total digunakan, melibatkan 20 mahasiswa tahun pertama sebagai partisipan. Data SPS dikumpulkan melalui tes keterampilan proses sains, sedangkan hasil belajar diperoleh dari nilai akhir mata kuliah. Hasil menunjukkan hubungan positif yang signifikan antara SPS dan hasil belajar, dengan koefisien korelasi 0,431 ($p = 0,029$), menunjukkan korelasi yang cukup kuat. Hal ini menunjukkan variasi yang cukup besar dalam tingkat SPS mahasiswa, sementara nilai akademik cenderung relatif homogen. Adanya ketidakseimbangan antara kompetensi praktis mahasiswa dan prestasi kognitif mereka. Kesimpulannya, SPS berhubungan signifikan dengan hasil belajar mahasiswa dalam Fisika Dasar. Perbedaan SPS mendorong perlunya standarisasi pembelajaran berbasis laboratorium untuk meningkatkan kualitas dan kesetaraan hasil pembelajaran fisika.

Kata kunci: Keterampilan Proses Sains, Hasil Belajar, Fisika Dasar

Introduction

Education is a planned effort to create a learning environment that encourages students to actively develop their potential[1]. Physics education aims to hone students' reasoning skills so that they are able to apply physics concepts and principles in explaining natural phenomena around them[2]. Students, as future educators, must be equipped with a systematic scientific framework of thinking so that they are able to face the challenges of education in the modern era. One of the main instruments that determines success in understanding science as a whole is Science Process Skills (SPS). SPS serves as a bridge for students to build knowledge independently through a series of scientific activities such as observing, classifying, measuring, and predicting physical phenomena[3]. Difficulties in solving physics problems often lie in transformation, namely the difficulty in converting problem information into the appropriate operational form or mathematical formula[4]. The use of SPS means that the process of learning physics will not only focus on memorizing formulas without a deep understanding of their essence[5].

Modern physics education emphasizes that mastery of theory alone is not enough; students are required to have scientific process skills (SPS)[6]. SPS is a set of intellectual, social, and physical skills that originate from basic abilities that, in principle, already exist within students[7]. SPS are divided into two types, namely basic SPS and integrated SPS[8]. SPS function as the driving force behind the discovery and development of concepts as well as the growth of attitudes and values[9]. According to Funk (1985) in Budiarti (2025), SPS indicators include observing, classifying, predicting, measuring, concluding, and communicating[10]. With SPS, students do not just memorize formulas, but understand how knowledge is obtained. The integration of cognitive and psychomotor aspects through continuous SPS exercises is believed to increase students' readiness to absorb complex lecture material, such as in the Basic Physics 1 course[11]. The importance of SPS is also in line with the need for students to have good scientific literacy in order to be able to interpret experimental data accurately[12]. Therefore, the effectiveness of the learning process is often measured by the extent to which students are able to apply these scientific methods in real situations in the laboratory[13].

Learning outcomes are the main indicator of the achievement of learning objectives, reflecting behavioral changes after undergoing the educational process. Referring to Bloom's classification, learning outcomes cover three main domains: cognitive (thinking skills ranging from memory to creativity), affective (attitudes and values), and psychomotor (physical skills and coordination)[14]. These three domains form the foundation for the development of scientific literacy, where students are not only required to master theory but also have the ability to identify questions, draw conclusions based on scientific evidence, and understand natural phenomena comprehensively[15]. These learning outcomes are influenced by internal factors such as intelligence and motivation, as well as external factors such as the institutional environment[16]. Learning motivation is an internal and external drive that provides enthusiasm and direction in learning activities to achieve certain goals[17]. In the basic

physics 1 course, optimal learning outcomes demonstrate mastery of the basics of mechanics and thermodynamics, which form the foundation for advanced courses.

Several previous studies have examined the relationship between science process skills and learning outcomes in physics education. Research has shown a significant relationship between mastery of process skills and the academic achievement of physics students[18], while a literature review confirmed that the implementation of SPS plays an important role in improving the quality of physics learning at various levels of education[3]. In addition, activity-based learning models such as Project Based Learning (PjBL) have also been proven to increase students' interest and learning outcomes[19]. However, most of these studies are still general in nature and have not specifically examined the conditions of new students who are in the transition phase from school to college learning, which is characterized by high heterogeneity in practical skills. Previous studies also tend to focus on improving average learning outcomes, but have not yet examined the disparities in SPS mastery among students and their implications for academic achievement. Therefore, studies that specifically investigate the relationship between SPS and learning outcomes in new students with diverse backgrounds are still very much needed.

This study was conducted to fill the empirical gap regarding the relationship between science process skills and learning outcomes among new students majoring in Physics Education at UIN Ar-Raniry, who have very heterogeneous initial abilities. Unlike previous studies, which generally examined the student population in general and emphasized average learning outcomes, this study specifically highlighted the variation and inequality in SPS mastery in the early stages of lectures and its implications for academic achievement in Basic Physics 1 courses. Thus, this study not only examines the relationship between SPS and learning outcomes but also reveals how differences in the level of science process skills among new students can potentially affect the quality of learning. These findings are expected to provide an empirical basis for the design of more adaptive and equitable learning and practicum strategies from the beginning of the lecture.

Method

a. Research Design

This study uses a quantitative approach with a correlational research design that aims to determine the relationship between variable X and variable Y.

b. Population and Sample

The population in this study consisted of all 20 students enrolled in the 2024 Physics Education program at UIN Ar-Raniry Banda Aceh. The results of this study cannot be generalized to a wider population because the sampling was conducted using total sampling technique[20]. This means that the sample is only representative of the subject group studied under certain environmental conditions and characteristics in the Physics Education study program at UIN Ar-Raniry Banda Aceh.

c. Research Instruments

The instruments used in this study consisted of:

1. Science Process Skills Test

The science process skills test was used to measure practical abilities in scientific methods and consisted of 30 multiple-choice questions. The SPS indicators measured in this instrument are presented in Table 1.

Table 1. SPS Test Instrument Grid

SPS Indicator	Question Item	Number
Observe	12, 24	2
Classify	1, 5, 10, 13, 17, 20, 25, 28	8
Predict	2, 6, 11, 14, 18, 21, 26, 29	8
Measure	3, 7, 15	3
Conclude	4, 8, 16, 22, 27, 30	6
communicate	9, 19, 23	3
Number		30

Instrument feasibility testing includes validity and reliability testing. Content validity was assessed by three experts using Aiken's V formula with a criterion of $V > 0.80$. Next, item validity was analyzed by comparing r_{count} against r_{table} (0,396) pada taraf signifikan 5%. at a significance level of 5%. The reliability of the instrument was determined using the KR-20 formula. The results of the instrument testing showed that the instrument had content validity of 0.83 and reliability of 0.751, so it was declared feasible for data collection. The following is the KR-20 formula used:

$$r_t = \left[\frac{k}{k-1} \right] \left[\frac{v_t - \sum pq}{v_t} \right] \dots \dots \dots (1)$$

Tabel 2. Guilford Scale

Alpha Coefficient (α)	Reliability Level
0,81-1,00	Very high
0,61-0,80	High
0,41-0,60	Moderate
0,21-0,40	Low
0,00-0,20	Very low

2. Learning Outcome Documentation

The learning outcome data in this study is secondary data obtained through documentation techniques. The learning outcome data consists of scores covering all aspects of assessment during one semester.

d. Data Analysis Techniques

Data analysis is carried out in several stages to ensure the accuracy of the research results

1. Instrument Score Processing

SPS test data is calculated with a score of 1 for correct answers and 0 for incorrect answers. The final result is converted to a scale of 0-100 using the formula:

$$score = \frac{score\ obtained}{maximum\ score} \times 100 \quad (2)$$

2. Descriptive Statistics

Descriptive statistical analysis is used to provide an overview of the data, including calculations of the mean, median, mode, standard deviation, and minimum and maximum values of the SPS variable and learning outcomes.

3. Prerequisite Analysis Test

Before conducting a hypothesis test, a prerequisite analysis test in the form of a normality test is carried out to determine the type of statistics to be used. Considering that the sample size in this study was 20 students ($N < 50$), the normality test was carried out using the Shapiro-Wilk technique.

4. Hypothesis test (non-parametric correlation)

Hypothesis testing was conducted to determine the significance of the relationship between science process skills (SPS) and physics learning outcomes. Because the data were not normally distributed, the analysis was conducted using Spearman's rho nonparametric correlation statistics with a one-tailed test at a significance level of $\alpha = 0.05$. The Spearman's rho formula used was:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)} \quad (3)$$

Table 3. Hypothesis Decision Criteria

Significance value	Decision	Statistical meaning
Sig. < 0.05	H_0 rejected, H_1 accepted	There is a significant relationship between variables X and Y.
Sig. > 0.05	H_0 accepted, H_1 rejected	There is no significant relationship between variables X and Y..

Table 4. Interpretation of Correlation Coefficients[21]

Coefficient interval	Level of relationship
0,00-0,199	Very low
0,20-0,399	Low
0,40-0,599	Fairly strong
0,60-0,799	Strong
0,80-1,000	Very strong

Results

a. Descriptive Statistics

Descriptive statistical analysis was conducted to provide an overview of the data distribution for both research variables. Based on the data processing results, the following statistical summary was obtained:

Table 5. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
SPS Score (X)	20	13.3	96.7	73.330	22.5891
Learning Outcome Score (Y)	20	65.03	87.50	77.2505	6.28358
Valid N (listwise)	20				

Based on Table 5, there are contrasting characteristics in the range of values of both variables. The SPS variable has a very wide range of 83.40 (from a maximum value of 96.70 and a minimum value of 13.30). This shows that the practical skills of the 2024 students are very uneven. There is a group of students who are already highly proficient in scientific procedures, but there are others who still face significant challenges in basic laboratory skills. In contrast, the learning outcome variable has a much narrower range of 22.47 (from a minimum of 65.03 to a maximum of 87.50). This indicates that although their process skills are very diverse, students' academic achievements in theory in class tend to be similar and at a fairly good level with an average of 77.25.

b. Normality Test

Before conducting the correlation test, a normality test was performed using the Shapiro-Wilk method, given the relatively small sample size (N=20).

Table 6. Tests of Normality

	Shapiro-Wilk			
	Statistic	Df	Sig.	Description
SPS Score (X)	.767	20	<.001	Abnormal
Learning Outcome Score (Y)	.946	20	.309	Normal

The test results show that the SPS value data has a significance value of 0.001 ($\rho < 0.05$), which means that the data is not normally distributed. On the other hand, the learning outcome data has a significance value of 0.309 ($\rho < 0.05$), which means that the data is normally distributed. Because one of the variables does not meet the assumption of normality, the analysis of the relationship between variables was performed using Spearman's rho correlation test.

c. Hypothesis Testing

Based on Spearman's rho correlation test conducted to determine the strength of the linear relationship, the following results were obtained:

Tabel 7. Correlations

		Learning Outcome	
		SPS value (X)	Score (Y)
Spearman's rho	SPS value (X)	Correlation Coefficient	1.000
		Sig. (1-tailed)	.431*
		N	.029
Learning Outcome Score (Y)		Correlation Coefficient	20
		Sig. (1-tailed)	.431*
		N	.029
			1.000
			.
			20
			20

*. Correlation is significant at the 0.05 level (1-tailed).

The correlation coefficient (ρ) value of 0.431 indicates a positive relationship between Science Process Skills and Physics Learning Outcomes. Based on the criteria for the strength of the relationship, this value is in the fairly strong category. The significance test shows a Sig. (1-tailed) value of 0.029, which is smaller than the significance level $\alpha = 0,05$. Thus, H_1 is accepted. The results of Spearman's rho correlation test showed a correlation coefficient of 0.431 with a significance of 0.029, proving a positive and significant relationship between Science Process Skills (SPS) and learning outcomes. This finding is in line with the that science literacy, which includes the process dimension, has a linear correlation with students' academic achievement in physics[12]. This reinforces the idea that students who are accustomed to the scientific method will find it easier to construct their understanding of concepts.

Although the correlation strength in this study is in the fairly strong category, when compared to the study which signed a difference in the strength of the relationship that may be influenced by media intervention. The use of media aids such as PhET Colorado can strengthen the correlation between SPS and learning outcomes[22]. In the context of research at UIN Ar-Raniry, the low correlation coefficient (0.431) compared to several other studies is thought to be influenced by the heterogeneity of students' initial abilities. The very wide range of student SPS scores (83.40) indicates extreme technical skill disparities at the beginning of the lecture.

This phenomenon of inequality found that students' mastery of SPS was often uneven, especially in the aspects of data interpretation and scientific communication[18]. Students who have difficulties with basic procedures, as observed in this research sample, tend to have difficulty achieving high academic grades. This is because physics is a science that requires empirical validation; the inability to take precise measurements will result in incorrect data, which will lead to conceptual errors. Furthermore, students' difficulties in solving physics problems often stem from weak process skills in the problem identification and data collection stages[4]. Therefore, the relationship found in this study confirms that SPS is not just an additional skill, but a crucial predictor of learning outcomes. As researched proved to strengthen this relationship, learning strategies such as Project Based Learning are needed to intensively train students' SPS so that the gap in technical abilities between proficient and challenged students can be minimized from the first semester[19].

This relationship is also states that technical skills are not merely memorization of procedures but a process of internalizing concepts[23]. The disparity (heterogeneity) found in this study, where the SPS standard deviation reached 22.59, validates the findings att the primary to secondary education levels, SPS training is often uneven. As a result, when they become new students, a laboratory culture shock occurs, causing the correlation between skills and learning outcomes to not reach the maximum (very strong) level[24].

This fairly strong correlation of 0.431 provides empirical evidence that success in learning physics is highly dependent on students' readiness for observation and measurement processes. Therefore, the low correlation compared to other studies due to heterogeneity factors is not a weakness of the research, but rather a basis for applying learning strategies such as Inquiry or Project Based Learning. By focusing on SPS

familiarization from the early semesters, institutions can ensure that students have sufficient intellectual tools to construct physics knowledge independently and accurately.

Conclusion

Based on the results of the study, it can be concluded that there is a positive and significant relationship between Science Process Skills (SPS) and the learning outcomes of Physics Education students at UIN Ar-Raniry, with a correlation strength of 0.431, which is classified as fairly strong. This finding confirms that SPS is a crucial variable for academic achievement, where readiness in observation and measurement is the main foundation for students in constructing an understanding of abstract physics concepts. However, the correlation coefficient, which has not reached the very strong category, is influenced by the high heterogeneity or imbalance in students' technical skills at the beginning of the lecture, which is marked by a very wide range of SPS scores. Institutions and lecturers are advised to apply innovative learning models such as Project Based Learning or intensive Inquiry from the first semester to minimize these technical ability gaps. Additionally, the use of interactive simulation media and standardization of laboratory procedures through matriculation activities are highly recommended to strengthen students' cognitive abilities and ensure empirical validity in every physics learning process.

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