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Equalizing Scientific Literacy of Prospective Elementary Teacher through Science Process Skill (SPS)-based Science Matriculation

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Abstract. The role of elementary teachers in science education is crucial in developing students' scientific literacy. Teachers are also expected to be scientifically literate. However, existing studies indicates the scientific literacy of prospective elementary teachers is still classified moderate as a gap found among them. This research was aimed to obtain a comprehensive overview of Science Process Skill (SPS)-based science matriculation implemented to equalize scientific literacy of prospective elementary teachers. The method used was a mix method with a convergent parallel design where both quantitative and qualitative data are collected simultaneously, analyzed separately, and interpreted as integrated results. The research subjects were 24 first semester students of PGSD study program taken through purposive sampling. The Wilcoxon test showed a Z-value of 269.0 with an Asymp. Sig. (2-tailed) < 0.001, indicating a significant difference between pretest and post-test scores. The average post-test score increased by 16.9 points after completing the matriculation. Further analysis of N-gain score was conducted to evaluate the effectiveness of matriculation. The results of the t-test showed a significant difference with a comparison value of 0.70 ($t(23) = -10.3$, $p < 0.001$), indicating that the effectiveness of science matriculation can be still improved to meet the better result.

Keywords: prospective elementary teacher, science matriculation, Science Process Skill (SPS), scientific literacy

INTRODUCTION

In 2015, the World Economic Forum already identified sixteen skills that individuals need to develop in this 21st century' global challenges. One of those skills is scientific literacy (World Economic Forum, 2015). It is a competency that enable individuals to make informed decisions and to deal with problems in daily life through their own scientific knowledge (Foster, 2011; Kähler, 2020; Norris, 2014; OECD, 2018). In general, it is defined as an ability to use scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and construct conclusions based on existing facts (Jamilah, 2023). Those abilities are pretty needed to be developed unless individuals find it hard to survive in this era.

As part of the national education goals (Husna, 2022; Mulyani et al., 2025), scientific literacy has an important role in the development of science education in Indonesia. Childhood, especially at the elementary education level, is a potential period for the development of students' scientific concepts and skills (National Science Teachers Association, 2009). Several countries, like US, England, and also Indonesia, have made science learning an essential part of their curriculum at the elementary education level (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022; Vieira & Tenreiro-Vieira, 2016). It means that

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science learning is highly considered as one of competencies students have to involve in their class. The Indonesia government already stated how science learning should be implemented by school. Two kind of elements such as cognitive profile and process skill are obligately consisted in learning process (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022).

Therefore, the role of elementary teachers in science education is very crucial for developing students' scientific literacy at that level. Teachers are expected to have a good understanding of science concepts and adequate scientific literacy (Chin, 2005; Osborne, 2007). However, based on various existing studies, the scientific literacy of prospective elementary teachers is still classified as moderate. Only a small number of students come from a science major at the secondary level, while the majority come from non-science majors (Mulyani et al., 2025). This phenomenon shows a gap in scientific literacy of prospective elementary teachers and it implies the needs of learning strategies that can overcome this gap.

Science Process Skill (SPS)-based science matriculation can be one of approach can be taken to address that gap. This matriculation aims to equalize scientific literacy among prospective elementary teacher before they attend lectures in the first semester. According to Direktorat Pembinaan SMA in 2014, matriculation program is a package of activities to avoid the gap existence and to help students fulfilling any lack of learning content, substance, understanding, or experiences due to the curriculum difference in their previous study (Direktorat Pembinaan SMA, 2014).Similar to that aim, in matriculation, students will be served some courses to equip their basic competencies in some field (Fikri et al., 2025). The general purpose of matriculation program is equalizing student competencies in a field to help them in upcoming program that might be hard and different. Various studies show that matriculation can be effective in improving students' understanding in certain fields, such as physics and mathematics, with nearly 80% of students achieving the same level of understanding after participating in the program (Noviantari, 2022; Sopacua, 2024). It also supports students' future career as they had fulfilled all stages of main courses at that level without gap existence (Fikri et al., 2025).

SPS-based science matriculation focuses on developing basic Science Process Skill (SPS) including observing, classifying, predicting, hypothesizing, measuring, and interpreting data and experimental results. Those SPS activities in class actually enhance the development of students' thinking skills. It is an ability needed by individual to construct, process, acquire, build, and apply scientific concepts and theories (Ahmad et al., 2019). It is

ability needed to proceed some scientific actions to build a scientific concept and thought (D. Darmaji et al., 2018). It is also a provision to the scientific method that is beneficial in acquiring new knowledge and working for its development (Asrial et al., 2019). Science Process Skill is also helping individuals to construct information and knowledge, to think about problem and phenomena, and to solve some related problems (Zasmita & Kaniawati I, 2015). A research revealed that scientific literacy including the comprehension of science concept of someone who has high category of science process skills were better than others who have low category of science process skills.

According to those factors, Science Process Skill are fundamental and essential in the process of equalizing scientific literacy for prospective elementary school teachers (Derilo, 2019; Mulyani et al., 2025; Prayitno et al., 2017). It is categorized into two level such as basic science process skills and integration science process skills (Darmaji et al., 2018). In SPS-based matriculation, those levels should be implemented to optimize student' scientific literacy development. Previous studies about matriculation program in universities had been published, such as in physic education (Sopacua, 2024), mathematic education (Afrida et al., 2019; Noviantari, 2022), english education (Afrida et al., 2019), arabic education (Afaria, 2020), doctoral degree (Nguyen et al., 2022), engineering (Ohland et al., 2014), medical (Heck et al., 2017) and pharmacy (Awuonda et al., 2021). Among those researches, either topic of science matriculation for prospective elementary teacher or SPS-based science matriculation were not found. Meaning that either the urgency how elementary teacher should have good scientific literacy or how SPS-matriculation could help students in enhancing their scientific literacy has not been identified. These imply that a research about the implementation of SPS-based science matriculation for prospective elementary teachers could be potentially conducted to improve students' scientific literacy, as well as provide a positive response to more effective science learning. Based on this background, this research aims to provide a comprehensive overview of scientific literacy of prospective elementary teachers after the implementation of SPS-based science matriculation.

METHODOLOGY

This research used a mixed method with convergent parallel design, which is a combination of quantitative and qualitative approaches. It is aimed to obtain a comprehensive picture and to show a deeper understanding of the phenomenon (Cohen et al., 2018; Creswell & Creswell, 2017). The quantitative approach is used to measure changes in scientific literacy, while the qualitative approach is used to understand the implementation of SPS-based

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science matriculation. In this convergent parallel design, quantitative and qualitative data were carried out simultaneously but analyzed separately. The results of both data were then integrated to obtain a more in-depth interpretation (Cohen et al., 2018; Creswell & Creswell, 2017).

This research was conducted at Elementary Teacher Education (PGSD) Study Program, Universitas Perjuangan Tasikmalaya. The subject of this research was 24 students called as prospective elementary teachers enrolled in their first semester. The subjects were selected using purposive sampling, considering that the selected students had diverse backgrounds previously. The research procedure included several stages designed to obtain quantitative and qualitative data in a structured and systematic manner. The procedures to be carried out were as follows: (1) research preparation, (2) quantitative data collection, (3) qualitative data collection, (4) data analysis (quantitative and qualitative) and (5) integration of data results.

Research Preparation

Researcher decided many points in research preparation such as matriculation concept design, sources and media used, and research instruments. SPS-based science matriculation held during five days and seven chapter of basic science material such as nature of science, measurement, life system, living thing characteristics, classification of materials, observation and microscope, and force and motion. A SPS-based science module was made and distributed to research subject to support their activities in this matriculation. It actually underwent the content validity by the experts.

Other instruments constructed such as pretest posttest question and question list of student interview. For the pretest and posttest instruments, they underwent a validity and reliability analysis prior to implementation. Item validity was examined using Pearson's product-moment correlation by correlating each item score with the total score. The analysis showed that all test items had correlation values ranging from 0.32 to 0.71, indicating that all items were valid. Instrument reliability was determined using Cronbach's Alpha. The pretest obtained an Alpha coefficient of 0.76, while the posttest reached 0.81.

Based on those results, both instruments were suitable for assessing students' scientific literacy. The activities in SPS-based science matriculation were aligned to the concept of two stage of Science Process Skill (SPS) which are basic SPS and integrated SPS. It actually included some process like observing, classifying, predicting and hypothesizing, inferring and

investigating, constructing table and graph, describing relationship between variables, processing and analyzing data, and designing experiments (D. A. Darmaji et al., 2019).

Quantitative Data Collection

This research used one group pretest posttest design to gain quantitative data collection. Thirty five numbers of pretest and posttest questions were constructed based on content aspect of scientific literacy generated by PISA (Programme for International Student Assessment). The question focusing on biology and physic aspects. The result of pretest and posttest then descriptively analyzed by SPSS.

Qualitative Data Collection

Qualitative data collection was done after the SPS-based science matriculation is officially done. Qualitative data was taken by interview to matriculants and asking about what actually they did during matriculation, how their feelings, benefit they take, and the whole responds to this matriculation.

Data Analysis and Integration of Data Results

Data were analyzed using both quantitative and qualitative approaches in accordance with the convergent parallel design. Quantitative data obtained from pretest posttest score processed using descriptive and inferential statistics through the SPSS software. Descriptive analysis included the calculation of means, standard deviations, and percentages, while inferential analysis was conducted using Wilcoxon tests to determine significant differences and relationships among variables. Qualitative data, on the other hand, were analyzed using thematic analysis. The interview transcripts were read several times to gain a deep understanding of students' experiences. Open coding was applied to identify meaningful result, which were then grouped into categories and resulted in thematic summary continuing to interpretation as a final result.

RESULTS AND DISCUSSION

The results of this research reveal how the SPS-based science matriculation program was implemented and how it contributed to enhance prospective elementary teacher scientific literacy. Table 1 show the descriptive statistic result of pretest and posttest score using SPSS software to find out the means, standard deviation, and maximum and minimum score.

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Table 1. Descriptive Statistic Result of Pretest and Posttest Score

	Minimum score	Maximum score	Mean	Standard Deviation
Pretest	17,10	88,60	37,62	15,18
Posttest	31,40	88,60	54,53	13,66

The descriptive statistical results in Table 1 show an improvement in student performance after participating in SPS-based science matriculation program. The mean score increased from 37.62 in the pretest to 54.53 in the posttest, indicating a notable enhancement in their scientific literacy. The minimum score also rose from 17.10 to 31.40, assuming that students with initially low performance benefited from this SPS-based science matriculation. The standard deviation decreased slightly from 15.18 to 13.66, indicating that the variation in their scores became more consistent after the matriculation. These findings demonstrate that the SPS-based science matriculation program not only improved student average performance of scientific literacy but also contributed to reduce learning disparities among them. Table 2 show the result of normality test of pretest-posttest score.

Table 2. Normality Test Result of Pretest and Posttest Score

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
Pretest	.140	24	.200	.866	24	.004
Posttest	.174	24	.059	.921	24	.060

Based on Table 2, the Shapiro–Wilk test results show that the pretest data have a significance value of 0.004, which is lower than 0.05, indicating that the pretest data are not normally distributed. Meanwhile, the posttest data have a significance value of 0.060, which is higher than 0.05, indicating that the posttest data are normally distributed. This Shapiro–Wilk test is then generally considered more reliable for small samples because the sample were just 24 ($n < 50$). Therefore, this result was used as the main reference for determining the normality of this data. The non-parametric test called Wilcoxon Signed-Rank Test is finally conducted to compare this pretest and posttest results. Table 3 show the result of Wilcoxon Signed-Rank Test.

Table 3. Result of Wilcoxon Signed-Rank Test

Total N	24
Test Statistic	269.000
Standard Error	32.799
Standardized Test Statistic	3.994

Asymptotic Sig. (2-sided test)	<.001

This Wilcoxon Signed-Rank Test at the end was conducted to determine the significant difference between the pretest and posttest score as the data did not fully meet the assumption of normality (Harris & Hardin, 2013). Based on Table 3, a Z value of 3.994 with an Asymptotic Significance (2-tailed) of < .001, indicating a statistically significant difference between the pretest and posttest scores. This result suggests that the scientific literacy of prospective elementary teacher significantly improved after participating in the SPS-based science matriculation. Table 4 show the result of N-gain analysis conducted to summarize the effectivity of this SPS-based science matriculation.

Table 4. Descriptive Statistic Result of N-Gain

	Minimum	Maximum	Mean	Std. Deviation
Pretest	-8.60	42.90		
Posttest	-.25	0.79	.2467	.21552

The results of the N-Gain analysis presented in Table 4 show an average gain score of 0.25 with a standard deviation of 0.21, indicating a low-to-moderate level of the SPS-based science matriculation effectiveness. The minimum and maximum N-Gain values ranged from -0.25 to 0.79, suggesting that while most students experienced notable progress, a few demonstrated limited or negative gains. This was assumed possibly due to differences in prior knowledge or engagement levels while having matriculation. According to Hake' classification, an N-Gain value below 0.3 falls into the low improvement category, while values between 0.3 and 0.7 are considered moderate (Hake, 1998). Therefore, the mean N-Gain of 0.25 indicates that the SPS-based science matriculation program provided measurable but modest improvements in their scientific literacy.

Although the effectiveness of SPS-based science matriculation was categorized as low, qualitative findings revealed that prospective elementary teacher gained greater motivation, new passion and confidence in learning science, new experience in doing experiment, and conceptual clarity of science and its phenomenon after completing the matriculation. Table 5 shows the interpretation of interview result of Matriculants after they accomplished SPS-based science matriculation.

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Table 5. Interpretation of Interview Result of Matriculants toward Implementation of SPS-based Science Matriculation

No	Category	Thematic Summary	Interpretation Result
1.	Readiness in attending science course	Different backgrounds in previous level of education made students a bit unready to attend science course	Students mostly came from different school and they learn deeply non-science major and rarely learning science. Students were not ready yet to fully attend science course with this background.
2.	Passion in learning science	Different backgrounds in previous level of education made students have no passion in science learning	Students did not learn science for a long time and they also were not convidence enough in attending science class. By having matriculation, students found their interest in science learning.
3.	Implementation of SPS-based science matriculation	Content of matriculation	1. Students thought that the content material delivered in matriculation was enough for them. 2. Students got difficulties in learning physic than biology.
		Learning method in matriculation	Students thought that learning method applied in matriculation was quite varios such as experiment, discussion, presentation, direct observation, lecturing, and etc.
		Lecturer attending matriculation	Students thought that the lecturer who deliver the material was good enough in facilitating them in learning
		The duration of matriculation	1. Students thought that five days of matriculation was very enough for them to rebuild science understanding through matriculation 2. Students felt that the time allocation for one session was not enough, especially when they had to accpmplish their worksheet
		Learning material and media in matriculation	Students felt enjoyed with learning material and media used in matriculation as they could ease them in learning process

No	Category	Thematic Summary	Interpretation Result
		Assessment in matriculation	Students thought that some questions could not be well-answered as they got difficulties in analyzing the questions, especially physic
		Module effectivity in some aspects	Students thought that the module should be improved in some aspects such as picture legibility, picture contrast, and procedure of activities
4.	Benefit and impact of SPS-based science matriculation	Students' reconnecting to science concept	Students felt that they were reconnected to some science concept they already knew in this matriculation
		Motivation in learning science	Students felt this matriculation could motivate them to learn science
		Strengthening science concept	Students felt this matriculation could strengthen their science concept and understanding
5.	SPS-based science matriculation' difficulties	Science concept delivered is too much	Some students thought that the concept delivered in this matriculation was too much and they got difficulties
		Time allocation is quite minimum	While the science concept delivered was too much, but students didn't have much time to accomplish, for example when they had to fulfill the worksheet.

The findings from the interviews provide valuable insights into the implementation of SPS-based science matriculation and its role in equalizing the scientific literacy of prospective elementary teachers. Overall, the participants perceived this matriculation as beneficial in helping them reconnect to science learning, rebuild their confidence, and strengthen their conceptual understanding, although several challenges were also identified. The significant result observed in the Wilcoxon test aligned with the qualitative findings obtained from those student interviews. The changes in post-test as the increment in scientific literacy indicates that this matriculation had an effect in equalizing scientific literacy gap among them as there was better result after matriculation. This result was similar to the statement that participants in medical matriculation perform better than participants who were not covered (Schneid et al., 2022). Looking at many components worked in this SPS-based matriculation such as learning experiences with various method and media, kinds of experiment students did, lecture capabilities in delivering material, it was confirmed by the interview result that those aspects

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giving indirect impacts to their scientific literacy after matriculation. In another research result about matriculation in any field, it is stated that most matriculants stated that supporting components like infrastructure, lecturers, kind of material or content was actually giving huge supports for students to adapt into new academic life at the faculty (Lepertery et al., 2023).

Based on the interview result, students said that they were lucky enough to be in SPS-based science matriculation as it could reconnect and rebuild their perspective of science concept, strengthened their conceptual understanding, and built motivation to learn science more deeply. They also realized that their passions were started to rise after having matriculation. Through performing experimental activities, employing appropriate tools, and systematically following the procedures, the students acquired valuable experiential learning that stimulated their interest in advancing their understanding in science. Besides, they also had more preparation to be ready in experience the first year of study, recognize how the process be conducted, adapt the new style of learning method in university and so on. These results were also in accordance with another research result that stated many students should be aware of the matriculation as the beginning preparation to help them during the first year as so many knowledge provided regarding the subject they study later (Lepertery et al., 2023).

The implementation of the SPS-based science matriculation was generally good for students, particularly in terms of the learning content, method, and facilitation by the lecturers. Students mentioned that the variety of learning methods helped them better engagement with the material and develop science process skills such as observing, hypothesizing, constructing table and graph, analyzing data, and communicating the results through many activities designed. Yet, looking at the descriptive result of N-Gain that summarized the effectivity of SPS-based science matriculation, several challenges were identified. First, students' readiness to attend science courses actually affect to the effectivity of matriculation. Many students came from non-science majors during their previous studies, made diverse educational background in class, resulting in a lack of foundational scientific knowledge and confidence. This finding indicates the low-to-moderate effectivity of this matriculation affected by this aspect. It was actually aligned with the statement that academic readiness significantly affects the success of higher-level learning, particularly in scientific fields (Hanushek & Woessmann, 2020).

Second, regarding to students' passion and motivation in learning science, this SPS-based science matriculation appeared to reignite their interest. Initially, most students lacked enthusiasm for science learning because they had not studied science for a long time. This

indicated that students had low motivation and confidence in learning science and affect to their performance in scientific literacy. As other research result expressed, learning science and technology by participating active and hand-on experiment could stimulate individual confidence, interest, and desire toward science (Docherty-Skippen et al., 2020).

Third, some students reported challenges in understanding physics content compared to biology. They were involved in hands-on activity where they had to manage themselves not only in operating tools but also in calculating number in short and limited time. Besides, they were also to be active in analyzing and interpreting data, which probably a new thing yet turn into a cognitive load for them. The short duration of the matriculation was also identified as both sufficient for review but insufficient for deep exploration, especially when completing worksheets or laboratory tasks.

Forth, in terms of learning materials and media, students appreciated the modules and visual aids, which they found helpful in clarifying science concepts. Nonetheless, they suggested several improvements, such as enhancing picture contrast and revising procedural instructions for better legibility and usability. Those aspects actually help them a lot when they have to learn independently by the existence of module. As stated by other research that a module has some benefits in learning process such as help teachers explain material more easily to understand, overcome the limitations of time, space and students' five sensory abilities, provide interesting learning materials and guides for students and train students' independent attitudes in learning (Yuniharto et al., 2024). Therefore, in this research, when a module is lack of legibility and usability, it might an aspect that affect the result of scientific literacy and the effectivity of matriculation.

In summary, the SPS-based science matriculation program actually functioned as an effort to equalize prospective elementary teacher' scientific literacy by fostering readiness, motivation, and science conceptual reinforcement among students from diverse educational backgrounds. These findings reinforce other implementation of this kind of preparatory programs which consider to adjust duration, material complexity, and module effectivity. Besides, structured and contextualized approach used in SPS-based science matriculation could be ensured to more equitable and comprehensive learning experiences. The integration of these findings suggests that the SPS-based science matriculation program successfully initiated a positive learning trajectory, but continuous support and scaffolding are essential to sustain and strengthen prospective elementary teacher' scientific literacy.

CONCLUSION

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This study explored the implementation of SPS-based science matriculation for prospective elementary teacher focusing on how this program can equalize the scientific literacy among them. The quantitative results revealed a significant increase in posttest scores compared to their pretest scores, as confirmed by the Wilcoxon Signed-Rank Test ($Z = 3.994$, $p < .001$). The mean N-Gain score of 0.25 indicated a low-to-moderate level of improvement, suggesting that further reinforcement may still be needed to achieve higher levels of effectivity.

The qualitative findings complemented these results, showing that prospective elementary teacher experienced increased readiness, motivation, confidence, and engagement throughout the SPS-based science matriculation process but of course with some difficulties they got during the time. Overall, the SPS-based science matriculation program served as a preparational activities to equalize the scientific literacy of prospective elementary teacher before entering the formal coursework. Study program might be able to consider this SPS-based matriculation as a standard component of pre-course preparation, particularly for incoming students with varied academic backgrounds. The results imply that such programs should be sustained and possibly extended with follow-up enrichment activities, ongoing formative feedback, and continuous support and scaffolding, to ensure deeper and more consistent learning gains in scientific literacy. Future research could explore the long-term impact of SPS-based science matriculation into the broader curriculum to support continuous professional growth and scientific literacy development among prospective elementary teachers.

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