

Original Article

Learning Environment and Science Self-Efficacy as Predictors of Junior High School Students' Scientific Literacy

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Abstract. Scientific literacy among Filipino junior high school students remains a concern, as reflected in their consistently low performance in international assessments. Given this context, this study aimed to determine the association of the learning environment and science self-efficacy with the scientific literacy of junior high school students. A quantitative, non-experimental correlational research design was employed. The respondents were 105 Grade 9 and Grade 10 students from a private junior high school in Davao City during the Academic Year 2025–2026, selected through simple random sampling. Data were collected using adapted and validated questionnaires measuring learning environment, science self-efficacy, and scientific literacy. Mean, Pearson product-moment correlation, and multiple regression analysis were used to analyze the data. Results revealed high levels of learning environment ($M = 4.09$), science self-efficacy ($M = 3.89$), and scientific literacy ($M = 4.10$). Using correlational analysis, the study found that the learning environment was strongly and positively associated with scientific literacy ($r = .64, p < .001$), while science self-efficacy also showed a significant positive association with scientific literacy ($r = .57, p < .001$). Multiple regression analysis indicated that the two variables jointly explained 45.5% of the variance in scientific literacy ($R^2 = .455, F(2, 102) = 42.65, p < .001$), with learning environment demonstrating a larger standardized regression coefficient ($\beta = .47$) than science self-efficacy ($\beta = .27$). Both variables significantly predicted scientific literacy, with the learning environment emerging as the stronger predictor. These findings are consistent with Constructivist Learning Theory, which emphasizes that knowledge develops through meaningful experiences and social interaction. The study contributes to the growing body of evidence supporting the role of learning environment and science self-efficacy in relation to scientific literacy among junior high school students.

Keywords: *Junior high school students; Learning environment; Philippines; Science self-efficacy; Scientific literacy.*

Science education plays a critical role in preparing students to understand and engage with the modern world, making scientific literacy an essential educational outcome. Scientific literacy refers to the ability to comprehend scientific concepts and apply them to real-life situations and decision-making (Aquino et al., 2025). In today's technology-driven society, scientific literacy is increasingly important for enabling individuals

to make evidence-based decisions, address societal issues, and participate responsibly in civic life (Hanson, 2022; Santhalia & Yuliati, 2021). Despite its importance, many students worldwide continue to struggle in science education, particularly in connecting scientific knowledge to practical, everyday contexts (Dabran et al., 2025).

In the Philippines, the challenge of developing scientific literacy remains significant. The 2022 Programme for International Student Assessment (PISA) results revealed that the Philippines ranked 79th out of 81 participating countries, with only 23% of students reaching at least Level 2 proficiency in science (OECD, 2023). This persistent crisis is associated with weak reading comprehension, limited educational resources, and insufficient teacher preparation, all of which hinder effective science learning and contribute to misinformation and reduced opportunities for students and communities (Pacala, 2022). Since individuals regularly encounter science-related issues such as climate change, health concerns, and biotechnology, strengthening scientific literacy is crucial for national development and informed citizenship (Kelp et al., 2023).

At the local level, similar concerns are evident in Davao City. A study conducted at Talandang National High School reported only moderate levels of scientific literacy among students, with greater difficulty in physical sciences compared to life sciences. Students also demonstrated recurring misconceptions regarding key scientific concepts, particularly in distinguishing scientific laws, theories, and hypotheses (Nuñala & Bete, 2024a; Jabello, 2021a). These findings highlight the need to examine factors that influence students' scientific literacy within the local educational context.

Among the factors identified in previous studies, the learning environment and science self-efficacy play vital roles in shaping students' science achievement and engagement. Research suggests that the learning environment strongly influences academic engagement, while effective study habits further enhance this relationship (Bulado et al., 2025). Likewise, science self-efficacy influences students' confidence, persistence, and willingness to engage in scientific tasks (Rallyta et al., 2025). Teacher support, classroom climate, and school administration have also been found to significantly affect students' scientific literacy (Palines & Cruz, 2021). However, despite existing studies on these variables, there remains a limited body of research examining how the learning environment and science self-efficacy jointly influence the scientific literacy of Grade 9 and Grade 10 students, particularly in Davao City (Jabello, 2021b; Nuñala & Bete, 2024b). Recent studies further emphasize a significant relationship between learning environment and self-efficacy, underscoring the importance of investigating their combined influence on scientific literacy (Pondang et al., 2025).

This study aligns with United Nations Sustainable Development Goal 4 (Quality Education), which emphasizes inclusive and equitable quality education and the promotion of lifelong learning opportunities for all (United Nations, 2024). Specifically, this research examines how the learning environment and science self-efficacy influence the scientific literacy of Grade 9 and Grade 10 students in Davao City. Science self-efficacy is particularly important because it serves as a strong predictor of academic achievement, career aspirations, and persistence in science-related fields (Burns et al., 2020a). By examining these interconnected factors, this study aims to contribute to the development of evidence-based strategies that address local educational needs while supporting broader global efforts to strengthen science education (Robinson et al., 2022). Furthermore, fostering supportive learning environments and strengthening students' confidence in science can promote not only academic success but also lifelong scientific literacy among Filipino learners (Kurbanoğlu et al., 2023).

This study is anchored in Constructivist Learning Theory, introduced by Jean Piaget and Lev Vygotsky. Constructivist Learning Theory explains that students actively construct knowledge through experience, interaction, and guided learning. Piaget's cognitive constructivism emphasizes individual knowledge construction through developmental processes, while Vygotsky's social constructivism highlights the importance of social interaction, cultural context, and the Zone of Proximal Development in learning. In science education, constructivist learning environments encourage active participation, collaboration, and inquiry-based experiences that enhance understanding and application of scientific concepts. Such environments also strengthen science self-efficacy by providing mastery experiences, peer support, and guided practice (Bandura, 1997; Britner & Pajares, 2006). Moreover, constructivist approaches foster critical thinking, evidence-based reasoning, and the application of scientific knowledge to real-world issues, thereby promoting scientific literacy (National Research Council [NRC], 2012; Kumi-Manu, 2021). Thus, this theory provides the foundation for explaining how an enriched learning environment can enhance science self-efficacy and ultimately support the development of scientifically literate students.

The main objective of this study was to determine the combined influence of the learning environment and science self-efficacy on the scientific literacy of Junior High School Students. Specifically, it sought to answer the following objectives:

- a) To assess the level of the learning environment in terms of: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity.
- b) To assess the level of science self-efficacy in terms of: biology self-efficacy, chemistry self-efficacy, physics self-efficacy, and laboratory self-efficacy.
- c) To ascertain the level of scientific literacy in terms of: nature of science knowledge, science-technology knowledge, science content knowledge, and technology usage knowledge.
- d) To determine the significant relationship between the learning environment and the scientific literacy of Junior High School Students.
- e) To determine the significant relationship between science self-efficacy and scientific literacy of Junior High School Students.
- f) To determine the combined influence of the learning environment and science self-efficacy on the scientific literacy of Junior High School Students.

Methodology

Research Design

This study employed a quantitative, non-experimental correlational research design to examine the relationships among the learning environment, science self-efficacy, and scientific literacy of Junior High School students. This design was appropriate for examining statistical associations among variables without manipulating any conditions (Creswell & Creswell, 2022). A quantitative approach was selected because it enabled the collection of numerical data through structured survey instruments and the application of statistical techniques to examine the relationships among the study variables (Bhandari, 2023). The objectives of the study required measuring the levels of the learning environment, science self-efficacy, and scientific literacy using mean scores, testing the relationships among the variables using correlation analysis, and determining the predictive value of the predictor variables through multiple regression analysis.

In this study, the learning environment and science self-efficacy served as the predictor variables, while scientific literacy served as the outcome variable. The study adopted a non-experimental, cross-sectional design in which data were collected from individual Junior High School students at a single point in time without manipulating the study variables, an approach that is appropriate when variables cannot be ethically or practically manipulated in educational settings (Saunders et al., 2021). Consequently, temporal precedence could not be established, and the findings describe statistical associations rather than causal relationships. In addition, the respondents were naturally clustered within existing class sections, which may have resulted in non-independent observations. Potential confounding variables, such as prior academic achievement, socioeconomic status, and gender, were not statistically controlled. These limitations should be considered when interpreting the findings.

Research Locale

The study was conducted in a private secondary school in Davao City during the School Year 2025–2026. The school implements the K–12 Basic Education Curriculum and offers Junior High School education, including Grade 9 and Grade 10, across six class sections. The study was conducted under the school's regular instructional setting. Data were collected through standardized self-administered questionnaires that measured the respondents' perceptions of the learning environment, science self-efficacy, and scientific literacy rather than through direct observation of classroom instruction or peer interactions.

The school was selected through purposive sampling based on the following inclusion criteria: (1) implementation of the K–12 Basic Education Curriculum; (2) availability of Grade 9 and Grade 10 students; (3) willingness of the school administration to participate in the study; and (4) accessibility for data collection. Prior to the conduct of the study, approval to administer the research was obtained from the school administration in accordance with the institution's research policies.

Generalization of the findings is limited to the population from which the sample was drawn, specifically the participating private secondary school. Generalization to all Junior High School students in Davao City or the Philippines is beyond the scope of this study. Future studies employing probability sampling from a broader population are recommended to enhance the generalizability of the findings.

Research Participants

The respondents of this study were Grade 9 and Grade 10 students enrolled in the Junior High School department of the selected private secondary school during the School Year 2025–2026. The target population consisted of 155 students distributed across six class sections, comprising 55 female and 100 male students. Thirty (30) students were selected to participate in the pilot testing of the research instruments and were excluded from the actual data collection. The final sample consisted of 105 students who participated in the main study, representing 67.7% of the target population. For a population of 155, a sample of 105 yields a margin of error of approximately $\pm 5.5\%$ at the 95% confidence level under simple random sampling, assuming maximum variability. This is acceptable for descriptive purposes. However, for regression analysis with 11 predictors, the sample is slightly below the recommended size for adequate power.

Grade 9 and Grade 10 students were selected because the Philippine K–12 Science Curriculum provides more specialized learning experiences in Biology, Chemistry, Physics, and Earth and Space Science at these grade levels. As students develop deeper scientific knowledge and inquiry skills across these disciplines, the assessment of their learning environment, science self-efficacy, and scientific literacy becomes particularly relevant. Simple random sampling was employed to select the respondents for the main study. A complete list of all Grade 9 and Grade 10 students was obtained from the school administration and served as the sampling frame. Each student was assigned a unique identification number, after which the required number of respondents was selected using a random selection procedure, giving every eligible student an equal chance of being included in the study. The distribution of the selected respondents was reviewed to ensure that both Grade 9 and Grade 10 students were represented in the sample.

The inclusion criteria required participants to be officially enrolled in Grade 9 or Grade 10 during the School Year 2025–2026, able to comprehend the language used in the research instruments, and willing to participate in the study with written parental or guardian consent and student assent. Students who participated in the pilot testing of the research instruments were excluded from the actual data collection to prevent response bias. Students with documented cognitive conditions that prevented independent completion of the questionnaire and those who were absent during the scheduled data collection were likewise excluded.

Research Instruments

This study utilized a three-part survey questionnaire as the primary instrument for data collection. The questionnaire was adapted from the studies *The Evolution of the Field of Learning Environments* (Fraser, 2023), *General Chemistry and Self-Efficacy* (Smist, 1993), and *Development of an Attitude Scale Towards Science Literacy for Secondary School Pupils* (Çelik & Doğru, 2024). The adapted questionnaire was paraphrased and revised to ensure that the items were appropriate for the context and objectives of the study. Prior to data collection, the adapted questionnaire underwent content validation by a panel of three (3) expert validators, all of whom were Science Education faculty members with doctoral degrees, with one validator specializing in educational research and instrument validation. The validators evaluated the instrument using a five-point Likert validation scale, where 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Fair, and 1 = Poor. The validation focused on the clarity, organization of items, suitability, adequacy, attainment of purpose, objectivity, and appropriateness of the rating scale to ensure that the questionnaire items aligned with the objectives of the study.

The overall validation score was computed by first obtaining the mean rating of each validator across all evaluation criteria. The three validators' mean scores were then summed and divided by three to obtain the overall mean validation score. The instrument obtained an overall mean score of 4.10, which was interpreted as Very Good, indicating that the questionnaire was valid and suitable for data collection. Based on the validators' comments and recommendations, minor revisions were made to improve the wording, clarity, grammar, and contextual appropriateness of several questionnaire items before the final administration of the instrument.

The survey questionnaire was administered through face-to-face data collection using a simple random sampling technique. It consisted of three sections that measured the respondents' learning environment, science self-

efficacy, and scientific literacy. The first independent variable, learning environment, comprised seven indicators: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity.

The learning environment variable was operationalized as seven correlated but distinct dimensions; therefore, reliability analysis was reported at the subscale level. The student cohesiveness indicator obtained a Cronbach's alpha of 0.89, indicating good internal consistency, while teacher support obtained a Cronbach's alpha of 0.90, reflecting excellent reliability. Moreover, involvement yielded a Cronbach's alpha of 0.87, indicating good internal consistency, whereas investigation recorded a Cronbach's alpha of 0.79, suggesting acceptable reliability. In addition, task orientation obtained a Cronbach's alpha of 0.81, and cooperation obtained 0.83, both indicating good internal consistency. Finally, equity achieved the highest Cronbach's alpha of 0.93, reflecting excellent reliability. According to Bobbitt (2021), Cronbach's alpha values of 0.70 and above are generally considered acceptable indicators of internal consistency reliability, with higher values reflecting stronger reliability. These results indicate that each dimension of the learning environment scale demonstrated acceptable to excellent internal consistency, supporting the reliability of the instrument in measuring the different aspects of students' learning environment.

Furthermore, the second independent variable, science self-efficacy, encompassed four indicators: biology self-efficacy, chemistry self-efficacy, physics self-efficacy, and laboratory self-efficacy. In terms of reliability, biology self-efficacy demonstrated a Cronbach's alpha of 0.90, signifying excellent internal consistency. Correspondingly, chemistry self-efficacy yielded a Cronbach's alpha of 0.84, while physics self-efficacy obtained 0.85, both reflecting good internal consistency. Similarly, laboratory self-efficacy recorded a Cronbach's alpha of 0.80, which also indicates good reliability. Collectively, the overall Cronbach's alpha coefficient for the science self-efficacy variable was 0.94, denoting excellent internal consistency. This finding implies that the instrument possesses a high degree of reliability, as Cronbach's alpha values above the commonly accepted threshold of 0.70 are considered satisfactory (Taber, 2018).

Similarly, the dependent variable, scientific literacy, comprised four indicators: nature of science knowledge, science and technology knowledge, student content knowledge, and technology usage knowledge. Reliability analysis revealed that nature of science knowledge and science and technology knowledge both had Cronbach's alpha values of 0.82, indicating good internal consistency. Likewise, student content knowledge and technology usage knowledge recorded Cronbach's alpha values of 0.74 and 0.73, respectively, reflecting acceptable reliability. Overall, Cronbach's alpha for the scientific literacy variable was 0.89, demonstrating good internal consistency. These results suggest that the instrument is highly reliable, as Cronbach's alpha values between 0.71 and 0.91 are generally considered excellent, with all indicators falling within the recommended range (Peterson et al., 2024).

Statistical Tools

The following statistical tools were used for analyzing data. The *mean* was used to determine the level of learning environment and science self-efficacy in relation to the scientific literacy of junior high school students. The *standard deviation* was employed to assess the variability of responses and the extent to which learning environment and science self-efficacy influence scientific literacy. Furthermore, *Pearson r* was used to identify the significant relationship between learning environment, science self-efficacy, and scientific literacy. Lastly, *multiple linear regression* was applied to determine which specific domains of learning environment and science self-efficacy significantly influence the scientific literacy of junior high school students.

Ethical Considerations

Ethical safeguards were implemented throughout the study to protect the rights, dignity, privacy, and welfare of the participants. The researchers adhered to the principles of honesty, integrity, transparency, and respect for research participants, as discussed by Resnik (2020). Prior to data collection, a formal letter requesting permission to conduct the study was submitted to the school principal of the participating private secondary school. After approval was granted, written informed consent was obtained from the parents or legal guardians of all participating students. The consent form explained the purpose of the study, the research procedures, the voluntary nature of participation, the confidentiality of the information provided, and the participants' rights throughout the study. Because all participants were minors, written assent was also obtained from each student before participation. Students were informed that their participation was entirely voluntary and that they could decline to participate, skip any question they did not wish to answer, or withdraw from the study at any time without any academic penalty, negative consequence, or differential treatment. Students who chose not to

participate continued their regular classroom activities. Throughout the study, participants' identities and responses were kept confidential. No personally identifiable information was disclosed in the presentation of the findings, and all collected data were used solely for academic research purposes. The data were systematically coded, tallied, and analyzed, with the results presented through appropriate tables and figures.

Results and Discussion

Level of Learning Environment

Table 1. *The Level of Learning Environment of Junior High School Students*

Indicator	SD	Mean	Descriptive Level
1. Student Cohesiveness	.68	4.19	High
2. Teacher Support	.62	4.25	Very High
3. Involvement	.90	3.73	High
4. Investigation	.73	3.93	High
5. Task Orientation	.60	4.24	Very High
6. Cooperation	.64	4.24	Very High
7. Equity	.73	4.03	High
Overall	.56	4.09	High

As presented in Table 1, the overall mean of the learning environment is 4.09, which corresponds to a high descriptive level, indicating that the benefits of the learning environment are often observed for better learning among junior high school students. The standard deviation of 0.56 reflects low variability, suggesting that students' responses are relatively consistent and homogeneous. This finding is congruent with Vea (2025), who emphasized that learning environments encompassing physical conditions, school culture, and teacher approaches significantly influence students' educational development. Similarly, Mohamad (2024) found a strong relationship between the learning environment and students' academic commitment and participation in science, while Susanti et al. (2020) confirmed that a supportive learning environment positively affects learning outcomes.

Among the indicators, Teacher Support obtained the highest mean score of 4.25, which falls within the Very High descriptive level based on the study's mean interpretation scale, indicating that the respondents consistently experienced teacher support. The standard deviation of 0.62 indicates relatively low variability in the responses. The high mean score may also suggest a possible ceiling effect, as many respondents selected the highest response categories. This finding is consistent with Huang et al. (2024), who highlighted the crucial role of teacher support in shaping students' motivation and learning strategies. It also aligns with Brandisauskiene et al. (2023), who emphasized that autonomy-supportive teacher behavior enhances students' learning strategies, and with Shao et al. (2025), who reported that teacher support strengthens academic self-efficacy and psychological resilience.

Closely following are Task Orientation and Cooperation, both with a mean of 4.24, also interpreted as very high. Task Orientation, with a standard deviation of 0.60, and Cooperation, with a standard deviation of 0.64, indicate relatively little variation in the respondents' answers. Given the high mean scores for both indicators, the responses may also reflect a possible ceiling effect, with many respondents selecting the highest response categories. This finding is congruent with Supervia et al. (2020), who found strong relationships between task orientation, self-efficacy, and academic performance. Meanwhile, Cooperation, with a standard deviation of 0.64, indicates relatively little variation in the respondents' answers. However, given the high mean score (4.24), this pattern may also reflect a possible ceiling effect, in which many respondents selected the highest response categories. This result supports the findings of Rigacci (2024) and Warsah et al. (2021), who emphasized that cooperative learning enhances critical thinking, engagement, and sustained learning.

Student Cohesiveness ranked next with a mean of 4.19, indicating that students generally perceived positive peer relationships and a sense of belonging within the learning environment. The standard deviation of 0.68 suggests that responses were relatively consistent, although some differences in students' perceptions were observed. Given the high mean score, the limited variability may also reflect a tendency toward higher response categories. This finding highlights the importance of student cohesiveness in fostering belonging and group unity, as emphasized by Veerman and Denessen (2021). Similarly, Bizimana (2026) and Joosse and Barger (2025) noted that positive peer relationships are associated with greater student engagement and improved academic outcomes.

Following this, equity obtained a mean of 4.03, which falls under the high descriptive level, indicating that

equitable learning opportunities are often observed. The standard deviation of 0.73 reflects moderate variability, suggesting a heterogeneous distribution of responses. This result is congruent with Levinson and Brighthouse (2022), who emphasized that equity ensures fair and equal learning opportunities for all students. It also aligns with Mameli et al. (2020), who found that equitable learning environments encourage students to express their views, and with Ali et al. (2024), who highlighted that inclusive education supports equal opportunities regardless of students' background or ability.

Investigation followed with a mean of 3.93, also interpreted as high, indicating that inquiry-based and investigative learning activities are oftentimes observed in science classes. The standard deviation of 0.73 suggests moderate variability and a heterogeneous perception among students. This finding is congruent with Gillies (2023), who emphasized that inquiry-based learning promotes exploration, collaboration, and creative thinking, and with Kaçar et al. (2021) and Antonio and Prudente (2021), who reported that inquiry-based approaches significantly enhance academic achievement and higher-order thinking skills.

Lastly, Student Involvement registered the lowest mean score of 3.73, though still categorized as high, indicating that student engagement is oftentimes observed but less consistent compared to other indicators. The standard deviation of 0.90 denotes high variability, reflecting a heterogeneous distribution of responses. This finding is congruent with Bowden et al. (2021), who described involvement as a multidimensional construct encompassing behavioral, emotional, and cognitive engagement. It also supports Li and Xue (2023), who noted that while supportive teacher practices enhance involvement, factors such as limited resources, skills, and contextual challenges may hinder students' active participation.

Level of Science Self-Efficacy

Table 2. *The Level of Science Self-Efficacy of Junior High School Students*

Indicator	SD	Mean	Descriptive Level
1. Biology Self-Efficacy	.78	3.86	High
2. Chemistry Self-Efficacy	.79	3.92	High
3. Physics Self-Efficacy	.90	3.78	High
4. Laboratory Self-Efficacy	.67	3.99	High
Overall	.65	3.89	High

Shown in Table 2 is the level of Science Self-Efficacy of Junior High School students. The overall mean of 3.89 indicates a high level of science self-efficacy, suggesting that students between sometimes and often, tending closer to often, demonstrate confidence in developing science-related skills and performing science tasks. This implies that, in general, students believe in their capability to engage with and accomplish science-related activities. The standard deviation of 0.65 indicates relatively little variation in students' responses, suggesting that their ratings of science self-efficacy were fairly consistent.

This overall finding is aligned with the study of Dunbar-Wallis et al. (2024), who emphasized that science self-efficacy reflects students' belief in successfully accomplishing science tasks, and with Burns et al. (2020), who found that self-efficacy consistently supports academic success despite the presence of individual emotional factors.

Among the indicators, Laboratory Self-Efficacy obtained the highest mean of 3.99, which is described as high, indicating that students often feel confident in performing laboratory tasks and experiments. This implies that hands-on activities and experimental work strongly support students' confidence in science learning. The standard deviation of 0.67 suggests low variability, signifying homogeneous responses among students regarding laboratory confidence. This finding is congruent with Mustafaoglu and Alkan (2024), who reported that laboratory practices enhance students' confidence through hands-on engagement, and with Sailaubay et al. (2024), who found that laboratory self-efficacy is positively associated with achievement and science process skills.

The second highest indicator is Chemistry self-efficacy, with a mean of 3.92, also interpreted as high, indicating that students often believe in their ability to perform chemistry-related tasks. This reflects a generally strong confidence in understanding chemical concepts and solving chemistry problems. Its standard deviation of 0.79 indicates moderate variability, suggesting a slightly heterogeneous distribution of responses, where some

students feel more confident than others. This result is congruent with Naibert et al. (2021) and Nzomo et al. (2023), who found that inquiry-based and well-designed chemistry instruction enhances students' self-efficacy, although Moreno et al. (2021) noted that disparities may still exist among certain student groups, partially explaining the observed variability.

Following closely is Biology Self-Efficacy, which registered a mean of 3.86, described as high, indicating that students often demonstrate confidence in completing biology-related tasks such as applying concepts and analyzing biological information. This suggests that biology instruction effectively supports students' academic confidence. The standard deviation of 0.78 reflects moderate variability, indicating a heterogeneous response pattern. This finding is congruent with Ekici et al. (2024), who described biology self-efficacy as students' confidence in applying biological skills, and with Mamauag (2023), who found that teaching strategies enhancing reflection and self-regulation positively influence biology self-efficacy. However, the variability aligns with Aikens and Kulacki (2023), who reported that students' confidence differs depending on learning modes and peer collaboration.

Lastly, Physics Self-Efficacy recorded the lowest mean of 3.78 among the science self-efficacy domains. This indicates that, on average, students rated their confidence in handling physics-related tasks between sometimes and often, although it remained within the study's classification of a high level of self-efficacy. Compared with the other science domains, students appeared less confident in their physics-related abilities. The standard deviation of 0.90 indicates greater variation in students' responses, suggesting that confidence in physics differed more widely across students. This finding is consistent with Cwik and Singh (2022), who highlighted physics self-efficacy as a motivational belief that varies among learners. Similarly, Ayoola (2024) reported gender-based differences in physics self-efficacy, while Appiah-Twumasi (2024) and Riben et al. (2024) emphasized that self-efficacy in physics is influenced by factors such as personality, instructional approach, and inquiry-based learning, which may contribute to differences in students' confidence levels.

Overall, these descriptive results indicate that students generally reported high levels of science self-efficacy across the different domains, with laboratory self-efficacy obtaining the highest mean score. However, the greater variation observed in physics self-efficacy ($SD = 0.90$) suggests that this domain may exhibit a stronger association with scientific literacy in the succeeding inferential analyses.

Level of Scientific Literacy

Table 3. *Level of Scientific Literacy of Junior High School Students*

Indicator	SD	Mean	Descriptive Level
1. Nature of Science	.72	4.07	High
2. Science Technology Knowledge	.63	4.20	Very High
3. Science Content Knowledge	.84	4.00	High
4. Technology Usage Knowledge	.80	4.12	High
Overall	.61	4.10	High

Table 3 presents the level of scientific literacy of junior high school students. The overall mean score of 4.10 indicates a high level of scientific literacy. This suggests that students frequently demonstrate scientific literacy through their understanding of scientific concepts, application of scientific reasoning, and ability to relate science to everyday situations. The overall standard deviation of 0.61 indicates relatively low variability in students' responses, suggesting that most participants reported similar levels of scientific literacy. Although the combination of a relatively high mean and low standard deviation may suggest a possible ceiling effect, the proportion of respondents obtaining the maximum possible score was not examined in the present study. Therefore, the presence of a ceiling effect cannot be confirmed and should be interpreted with caution.

This finding is consistent with Jufrida et al. (2019), who reported that students with higher levels of scientific literacy demonstrate a better understanding of scientific concepts and are more capable of applying scientific knowledge to solve real-life problems. Likewise, Baltikian et al. (2024) emphasized that scientific literacy extends beyond conceptual understanding to include inquiry, critical thinking, and the application of scientific knowledge, which is consistent with the generally high level of scientific literacy observed in the present study.

Among the four indicators, Science Technology Knowledge (STK) obtained the highest mean score ($M = 4.20$, $SD = 0.63$), corresponding to a very high descriptive level. This indicates that students consistently demonstrate an understanding of the relationship between science and technology. The relatively low standard deviation suggests that students' responses were generally similar. This finding is consistent with Scanlon (2021), who identified the integration of science and technology as a fundamental component of scientific literacy. Similarly, Acut and Antonio (2023) found that connecting science instruction with real-world technological and societal issues enhances students' critical thinking and creativity. Torres and Inga (2025) likewise reported that exposure to programming and robotics promotes students' motivation and academic development, supporting the high level of science-technology knowledge observed in the present study.

The second highest indicator was Technology Usage Knowledge (TUK) ($M = 4.12$, $SD = 0.80$), which was interpreted as high. This suggests that students frequently demonstrate the ability to use technology to support science learning. The standard deviation indicates moderate variability, reflecting some differences in students' technology-related experiences and skills. These findings are consistent with Thomas et al. (2022) and Boholano et al. (2021), who reported that effective technology integration enhances students' engagement, motivation, and learning outcomes.

The Nature of Science (NOS) indicator obtained a mean score of 4.07 ($SD = 0.72$), corresponding to a high descriptive level. This indicates that students generally understand how scientific knowledge is generated, evaluated, and influenced by scientific inquiry and social contexts. The moderate variability in responses suggests differences in students' understanding of the nature of science. This finding is consistent with Schizas et al. (2024) and Cheung and Erduran (2022), who emphasized the importance of integrating the nature of science into inquiry-based instruction. Likewise, Bouni et al. (2024) reported that understanding the nature of science supports students' critical thinking while highlighting the continued need for instructional strategies that strengthen this aspect of scientific literacy.

Finally, Student Content Knowledge (SCK) obtained the lowest mean score ($M = 4.00$, $SD = 0.84$), although it remained within the high descriptive level. This indicates that students generally demonstrate a sound understanding of essential scientific concepts and factual knowledge. The relatively higher standard deviation suggests greater variation in students' content knowledge compared with the other indicators. This finding is consistent with Saraswati et al. (2021), who reported that junior high school students generally demonstrate moderate to high levels of scientific literacy. Similarly, Verawati and Wahyudi (2024) and Kamila et al. (2024) found that contextualized instruction and hands-on learning activities enhance students' conceptual understanding, while Azidi and Rijal (2024) observed that culturally responsive learning approaches may contribute to differences in students' mastery of science content.

Relationship Between Learning Environment and Scientific Literacy of Junior High School Students

Table 4. Significance of the Relationship Between Learning Environment and Scientific Literacy of Junior High School Students

Learning Environment	Scientific Literacy				
	Nature of Science	Science Technology Knowledge	Student Content Knowledge	Technology Usage Knowledge	Overall
Student Cohesiveness	.447** ($< .001$)	.390** ($< .001$)	.401** ($< .001$)	.450** ($< .001$)	.518** ($< .001$)
Teacher Support	.472** ($< .001$)	.438** ($< .001$)	.384** ($< .001$)	.364** ($< .001$)	.504** ($< .001$)
Involvement	.550** ($< .001$)	.489** ($< .001$)	.469** ($< .001$)	.431** ($< .001$)	.591** ($< .001$)
Investigation	.527** ($< .001$)	.498** ($< .001$)	.382** ($< .001$)	.299** (.002)	.513** ($< .001$)
Task Orientation	.486** ($< .001$)	.493** ($< .001$)	.351** ($< .001$)	.366** ($< .001$)	.511** ($< .001$)
Cooperation	.376** ($< .001$)	.307** ($< .001$)	.299** ($< .001$)	.268** ($< .001$)	.380** ($< .001$)
Equity	.452** ($< .001$)	.498** ($< .001$)	.425** ($< .001$)	.443** ($< .001$)	.554** ($< .001$)
Overall	.596** ($< .001$)	.560** ($< .001$)	.491** ($< .001$)	.472** ($< .001$)	.644** ($< .001$)

Note. $N = 105$. Values are Pearson correlation coefficients (r). Values in parentheses are the corresponding exact p -values. ** indicates significance at the 0.01 level (2-tailed). For p -values less than .001, "< .001" is reported instead of ".000". Correlation strength was interpreted as follows: 0.00–0.19 = very weak; 0.20–0.39 = weak; 0.40–0.59 = moderate; 0.60–0.79 = strong; and 0.80–1.00 = very strong.

Table 4 presents the relationship between the learning environment and scientific literacy of junior high school students. The overall Pearson correlation coefficient yielded an r value of .644, indicating a moderate positive relationship between the two variables. All computed p -values were less than .05, indicating that the observed relationships were statistically significant. Therefore, the null hypothesis was rejected, indicating a statistically significant positive relationship between the learning environment and scientific literacy of junior high school students. Specifically, higher reported learning environment scores corresponded to higher scientific literacy scores among the respondents.

The findings are consistent with the Constructivist Learning Theory proposed by Piaget (1972, 1973) and Vygotsky (1978), which suggests that learners actively construct knowledge through meaningful experiences, social interaction, and guided learning within supportive environments. In the present study, students who reported more positive learning environments also tended to report higher levels of scientific literacy. However, because the present study employed a cross-sectional correlational design, these findings should be interpreted as evidence of statistical association rather than causation. Consequently, it cannot be concluded that a more positive learning environment causes higher scientific literacy or that students with higher scientific literacy necessarily perceive their learning environment more positively. Longitudinal or experimental studies are needed to establish the direction of these relationships.

Among the seven learning environment dimensions, student involvement demonstrated the strongest association with scientific literacy ($r = .591$), followed by equity ($r = .554$), student cohesiveness ($r = .518$), investigation ($r = .513$), task orientation ($r = .511$), and teacher support ($r = .504$). Cooperation exhibited the weakest, although still statistically significant, relationship ($r = .380$). These findings indicate that while all dimensions of the learning environment were positively associated with scientific literacy, the strength of these relationships varied across the different aspects of the classroom environment.

The pattern of correlations suggests that student involvement and equity exhibited the strongest associations with scientific literacy. This indicates that students who reported higher levels of participation in classroom activities and perceived their learning environment as fair and inclusive also tended to report higher levels of scientific literacy. These findings were consistent with Junanto et al. (2024), who emphasized that active student participation promotes deeper understanding of scientific concepts, and with Scott (2024), who highlighted the importance of equitable classroom practices in fostering students' engagement and confidence in science learning.

Likewise, student cohesiveness, teacher support, investigation, and task orientation all demonstrated moderate positive relationships with scientific literacy. These findings suggest that supportive peer relationships, teacher guidance, inquiry-based learning experiences, and clearly structured classroom tasks are associated with higher levels of scientific literacy. Similar observations have been reported by Zhang et al. (2023), who emphasized the role of positive peer interactions in promoting academic engagement; Scott (2024), who highlighted the importance of teacher support in developing students' critical thinking; Romli et al. (2024), who underscored the value of inquiry-oriented science instruction; and Susdarwati et al. (2021), who reported that well-organized instructional activities support students' conceptual understanding.

Although cooperation demonstrated the weakest relationship with scientific literacy, the association remained statistically significant. This finding suggests that collaborative learning may be associated with scientific literacy. However, the strength of this association was lower than those observed for student involvement, equity, and other learning environment dimensions. Future studies may further examine why cooperation exhibited a comparatively weaker association with scientific literacy.

Relationship Between Science Self-Efficacy and Scientific Literacy of Junior High School Students

Table 5 presents the relationship between science self-efficacy and scientific literacy of junior high school students. All correlations were computed using the full sample of 105 junior high school students ($N = 105$), with 103 degrees of freedom ($df = 103$) for each Pearson correlation. The overall Pearson correlation coefficient yielded an r value of .574, indicating a moderate positive relationship between science self-efficacy and scientific literacy. Most computed p -values were less than .05, with the exception of the relationship between Physics Self-Efficacy and Technology Usage Knowledge ($r = .186$, $p = .057$), which was not statistically significant. Therefore, the null hypothesis was rejected for all statistically significant relationships, except for the relationship between Physics

Self-Efficacy and Technology Usage Knowledge, which failed to reach statistical significance. Overall, higher reported science self-efficacy scores corresponded to higher reported scientific literacy scores among the respondents.

Table 5. *Significance of the Relationship Between Science Self-Efficacy and Scientific Literacy of Junior High School Students*

Science Self-Efficacy	Scientific Literacy				Overall
	Nature of Science	Science Technology Knowledge	Student Content Knowledge	Technology Usage Knowledge	
Biology Self-Efficacy	.602** ($< .001$)	.459** ($< .001$)	.466** ($< .001$)	.268** (.006)	.544** ($< .001$)
Chemistry Self-Efficacy	.438** ($< .001$)	.451** ($< .001$)	.424** ($< .001$)	.359** ($< .001$)	.509** ($< .001$)
Physics Self-Efficacy	.324** ($< .001$)	.237* (.015)	.378** ($< .001$)	.186 (.057)	.347** ($< .001$)
Laboratory Self-Efficacy	.550** ($< .001$)	.404** ($< .001$)	.489** ($< .001$)	.232* (.017)	.512** ($< .001$)
Overall	.571** ($< .001$)	.463** ($< .001$)	.529** ($< .001$)	.316** (.001)	.574** ($< .001$)

Note. $N = 105$. Values are Pearson correlation coefficients (r). Values in parentheses are the corresponding exact p -values. All p -values are two-tailed. ** indicates significance at the 0.01 level (2-tailed), whereas * indicates significance at the 0.05 level (2-tailed). For p -values less than .001, " $< .001$ " is reported instead of ".000". Correlation strength was interpreted as follows: 0.00–0.19 = very weak; 0.20–0.39 = weak; 0.40–0.59 = moderate; 0.60–0.79 = strong; and 0.80–1.00 = very strong.

The findings are consistent with Constructivist Learning Theory proposed by Piaget (1972, 1973) and Vygotsky (1978), which suggests that learners actively construct knowledge through meaningful experiences, social interaction, and guided learning. In the present study, students who reported higher levels of science self-efficacy also tended to report higher levels of scientific literacy. However, because the present study employed a cross-sectional correlational design, these findings should be interpreted as evidence of statistical association rather than causation. Consequently, it cannot be concluded that higher science self-efficacy causes higher scientific literacy or that students with higher scientific literacy necessarily develop greater science self-efficacy. Longitudinal or experimental studies are needed to establish the direction of these relationships.

Among the four dimensions of science self-efficacy, Biology Self-Efficacy demonstrated the strongest association with overall scientific literacy ($r = .544$), followed by Laboratory Self-Efficacy ($r = .512$), Chemistry Self-Efficacy ($r = .509$), and Physics Self-Efficacy ($r = .347$). These findings indicate that although all dimensions of science self-efficacy were positively associated with scientific literacy, the strength of these relationships differed across the four domains.

The pattern of correlations suggests that Biology Self-Efficacy exhibited the strongest association with scientific literacy. This indicates that students who reported greater confidence in learning biology also tended to report higher levels of scientific literacy. These findings were consistent with Juniarso and Sulistyawati (2023), who reported that students with higher science self-efficacy generally demonstrated higher levels of scientific literacy.

Similarly, Chemistry Self-Efficacy and Laboratory Self-Efficacy demonstrated moderate positive relationships with scientific literacy. These findings suggest that students who reported greater confidence in chemistry concepts and laboratory activities also tended to report higher levels of scientific literacy. These findings were consistent with Kim et al. (2024), who identified science self-efficacy as an important correlate of scientific literacy, and Zhang, Li, and Chen (2022), who emphasized the importance of laboratory confidence in supporting students' scientific reasoning and understanding.

Physics Self-Efficacy demonstrated a moderate positive relationship with overall scientific literacy ($r = .347$, $p < .001$). However, its relationship with Technology Usage Knowledge was not statistically significant ($r = .186$, $p = .057$). This finding suggests that Physics Self-Efficacy was not significantly associated with Technology Usage Knowledge among the respondents in the present study. Because the obtained p -value was close to the conventional significance level of .05, future studies involving larger samples are recommended to further examine this relationship. Similar observations were reported by Beck and Blumer (2021), who noted that students' confidence may vary across different scientific domains and learning contexts.

Overall, the findings indicate that higher reported science self-efficacy was associated with higher reported scientific literacy among junior high school students. These results suggest that students who expressed greater confidence in performing science-related tasks also tended to report higher levels of scientific literacy. These findings suggest that instructional practices incorporating mastery experiences, guided practice, collaborative learning, and inquiry-based activities may support the development of both science self-efficacy and scientific literacy. These findings were consistent with Lai (2021), Juniarto and Sulistyawati (2023), and Kim et al. (2024), who likewise emphasized the positive association between science self-efficacy and scientific literacy.

Association of Learning Environment and Science Self-Efficacy with Scientific Literacy

Table 6 presents the results of the multiple linear regression analysis conducted to determine whether learning environment and science self-efficacy significantly predict scientific literacy among junior high school students. The regression analysis was performed using the complete dataset of 105 participants.

Table 6. Multiple Linear Regression Analysis Predicting Scientific Literacy from Learning Environment and Science Self-Efficacy

Independent Variables	Scientific Literacy			
	B	β	t-value	Sig.
Learning Environment	.512	.470	4.864	< .001
Science Self-Efficacy	.251	.266	2.756	.007

Note. N = 105. β = standardized regression coefficient, $R = .675$, $R^2 = .455$, Adjusted $R^2 = .445$, $F(2, 102) = 42.650$, $p < .001$

The results indicate that the regression model was statistically significant, $F(2, 102) = 42.650$, $p < .001$, suggesting that learning environment and science self-efficacy, when considered together, significantly predicted scientific literacy among junior high school students. The multiple correlation coefficient ($R = .675$) indicates a moderate to strong positive relationship between the predictor variables and scientific literacy. The coefficient of determination ($R^2 = .455$) indicates that approximately 45.5% of the variance in scientific literacy was explained by the combined contribution of learning environment and science self-efficacy. After adjusting for the number of predictors and sample size, the adjusted R^2 was .445, indicating that the model explained approximately 44.5% of the variance in scientific literacy. The remaining 54.5% of the variance may be explained by other academic, personal, or contextual factors that were not included in the regression model.

Both predictor variables were found to be statistically significant. The learning environment obtained an unstandardized regression coefficient of $B = .512$ ($t = 4.864$, $p < .001$), while science self-efficacy obtained $B = .251$ ($t = 2.756$, $p = .007$). Holding the other predictor constant, a one-unit increase in the learning environment score was associated with a predicted 0.512-unit increase in scientific literacy, whereas a one-unit increase in science self-efficacy was associated with a predicted 0.251-unit increase in scientific literacy. Because the predictor variables were measured using different scales, the standardized regression coefficients (β) provide a more appropriate basis for comparing their relative contribution to the model. The learning environment ($\beta = .470$) demonstrated a stronger association with scientific literacy than science self-efficacy ($\beta = .266$), indicating that the learning environment contributed more strongly to the prediction of scientific literacy within the regression model.

These findings are consistent with previous studies reported in the review of related literature. Junanto et al. (2024) found that the Listen-Search-Read-Discuss (LISERED) instructional model improved students' scientific literacy by providing an engaging and interactive learning environment. Likewise, Romli et al. (2024) reported that integrated science instruction significantly enhanced students' scientific literacy through meaningful classroom learning experiences. These findings are consistent with the present study, in which higher learning environment scores were associated with higher levels of scientific literacy.

Similarly, Zhang et al. (2023) reported that supportive family and peer environments promote students' academic engagement, which is associated with improved scientific literacy. Scott (2024) also emphasized that positive teacher-student interactions encourage participation, questioning, and critical thinking, all of which are closely related to scientific literacy. Furthermore, Onowugbeda et al. (2023) found that supportive learning environments reduce science anxiety while fostering students' confidence in applying scientific knowledge, highlighting the complementary roles of learning environment and science self-efficacy.

The positive association between science self-efficacy and scientific literacy is likewise supported by previous

research. Juniarso and Sulistyawati (2023) reported that science self-efficacy significantly predicted students' scientific literacy achievement. Similarly, Kim et al. (2024), using data from PISA, identified science self-efficacy as one of the strongest predictors of science literacy. Beck and Blumer (2021) further found that inquiry-based learning environments enhanced students' confidence and scientific reasoning, supporting the positive association observed in the present study.

Overall, the results indicate that both learning environment and science self-efficacy were significant predictors of scientific literacy, with the learning environment demonstrating the stronger association based on the standardized regression coefficients. These findings suggest that students who reported more positive learning environments and higher levels of science self-efficacy also tended to report higher levels of scientific literacy. Because the present study employed a correlational, cross-sectional research design, these findings should be interpreted as evidence of statistical association rather than causation. Other variables not included in the model, such as prior academic achievement, socioeconomic status, or school resources, may also contribute to students' scientific literacy.

Conclusion

The findings indicate that the learning environment and science self-efficacy are positively and significantly associated with the scientific literacy of the 105 junior high school students included in the study. The learning environment showed a stronger association with scientific literacy ($r = .644, p < .001$) than science self-efficacy ($r = .574, p < .001$), while multiple regression indicated that the two variables jointly accounted for 45.5% of the variance in scientific literacy. These findings suggest that students' perceptions of their classroom environment and their confidence in performing science-related tasks are important factors associated with scientific literacy, with the learning environment showing the greater predictive contribution in the present model.

However, these findings should not be interpreted as evidence of causation. Because the study employed a non-experimental, correlational design and relied primarily on self-reported measures, the observed relationships may be influenced by self-report and social desirability biases, as well as shared method variance. Thus, the R^2 value of .455 may partly reflect the use of a common measurement method rather than the independent contribution of the predictors. In addition, the interpretation of the regression findings should be approached cautiously because regression assumptions were not fully examined, multiple comparisons were not adjusted, and the possible clustering of students within classes was not accounted for in the analysis. The sample size of 105 students also limits the generalizability of the findings beyond the study context.

The results therefore provide evidence of meaningful associations rather than definitive effects. While the findings are broadly consistent with the emphasis of Constructivist Learning Theory on learning experiences and social interactions, the correlational design does not directly test or validate the theory. Future research should replicate the findings using larger and more diverse samples, objective or performance-based measures of scientific literacy, and experimental or longitudinal designs that can better examine causal relationships. Future studies should also strengthen the reporting and implementation of ethical safeguards for minor participants. Such approaches may provide more robust evidence on whether and how learning environments and science self-efficacy contribute to the development of scientific literacy among junior high school students.

Contributions of Authors

The authors contributed significantly to the completion of this study. They collaboratively participated in the conceptualization of the research, proposal writing, data gathering, data analysis, interpretation of findings, and the preparation and revision of the manuscript. Each author made valuable intellectual and practical contributions throughout the research process, reviewed the final version of the manuscript, and approved it for publication.

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Conflict of Interests

The authors declare that there are no conflicts of interest regarding the publication of this study.

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