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Science education landscape through the perspectives of industrial-technical learners of ISPSC Santiago

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Abstract

This study explores the science education landscape at Ilocos Sur Polytechnic State College (ISPSC) Santiago Campus through the perspectives of its industrial-technical learners. It aims to identify key factors influencing the current status of education by examining students' attitude towards science, teachers' communication behaviors, the classroom learning environment, and students' science performance across general science, chemistry, biology, and physics. Findings reveal that students hold a positive overall attitude toward science, while teachers' communication behaviors are generally average, with strengths in understanding but moderate levels in encouragement and classroom control. The classroom environment is occasionally conducive to learning, with ventilation and teacher encouragement notably impacting physics performance. Students demonstrated strengths in chemistry but weaknesses in biology and physics. Based on these insights, an integrated framework was developed that combines core scientific knowledge, inquiry practices, positive attitudes, supportive environments, continuous assessment, and stakeholder collaboration to holistically enhance science education at ISPSC. Recommendations include strengthening student attitudes through engaging activities, improving teacher communication via professional development, enhancing classroom conditions, implementing remedial programs for weaker subjects, and leveraging curriculum integration. The framework offers potential applicability for other institutions aiming to improve science education outcomes.

Keywords: science education, student attitude, teacher communication, classroom environment, science performance

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1. Introduction

Science education is universally acknowledged as a vital foundation for societal progress and economic development, particularly in an era characterized by rapid technological change and increasing global competition (OECD, 2025). Around the world, higher education institutions are being called upon to produce graduates who are not only proficient in scientific knowledge but also capable of critical thinking, innovation, and adaptability—skills indispensable for the demands of the 21st-century workforce (RSIS International, 2024; Data Insights Market, 2025). Within this global context, industrial-technical education has emerged as a crucial sector, bridging the gap between theoretical science and practical application. Countries with advanced technical and vocational education and training (TVET) systems, such as Germany, Singapore, and Japan, have demonstrated the value of integrating rigorous scientific instruction with hands-on, industry-aligned training (HKSMP, 2025). These systems emphasize not only mastery of content but also the development of competencies such as problem-solving, teamwork, and digital literacy—qualities that foster both employability and lifelong learning (OECD, 2025).

The Asia-Pacific region, including the Philippines, is experiencing a surge in demand for technical professionals as a result of industrialization, digital transformation, and the emergence of the Fifth Industrial Revolution (5IR), which brings together human ingenuity and advanced technologies (TESDA, 2025). In response, the Philippine government, through the Technical Education and Skills Development Authority (TESDA), has prioritized the modernization of technical education, with a strong emphasis on science and technology integration, industry collaboration, and the cultivation of 21st-century skills (TESDA, 2025). Despite these advances, significant challenges persist in aligning science education with the specific needs of industrial-technical learners. Research shows that the effectiveness of science education is shaped by a constellation of factors, including student attitudes, teacher communication behaviors, classroom environment, and institutional resources (Smith et al., 2021; Anderson & Kim, 2019). Furthermore, there is a growing recognition that understanding the perspectives of learners themselves is essential for designing responsive curricula, effective pedagogical strategies, and supportive learning environments (Johnson & Parker, 2020).

At the local level, the Ilocos Sur Polytechnic State College (ISPSC) Santiago Campus serves as a microcosm of these broader trends and challenges. The campus offers a range of industrial-technical programs aimed at preparing students for careers in engineering, technology, and the applied sciences. However, the unique context of ISPSC Santiago—including its resources, student demographics, and regional industry linkages—necessitates a nuanced examination of how science education is experienced and perceived by its learners. This study is grounded in the understanding that students' attitudes toward science are powerful predictors of their engagement and achievement. Positive attitudes—encompassing interest, perceived importance, and confidence in learning—are associated with greater persistence and success in science-related fields (OECD, 2025; Johnson & Parker, 2020). Conversely, negative attitudes can lead to disengagement and underperformance. Thus, exploring the attitudes of ISPSC Santiago's industrial-technical learners toward science, the importance of studying science, and their experiences in learning science is a critical first step in understanding the current landscape.

Equally significant is the role of teachers' communication behaviors. Effective science teaching extends beyond content delivery; it involves fostering a classroom climate that is challenging, encouraging, supportive, and understanding. Teachers who communicate clearly and empathetically can inspire students, promote participation, and facilitate deeper learning (Smith et al., 2021). Conversely, controlling or unsupportive communication may stifle curiosity and hinder academic growth. Assessing the communication behaviors of science teachers at ISPSC Santiago—across dimensions such as challenging, encouraging, support, controlling, and understanding/friendliness—will provide valuable insights into instructional practices that impact student

outcomes.

The classroom environment itself is another pivotal factor. Physical aspects like ventilation and space, as well as psychosocial elements such as fairness, clarity of rules, teacher support, and encouragement, collectively shape students' interest and participation in science learning (Capuyan, 2025; RSIS International, 2024). A positive environment can foster engagement and equity, while deficiencies may contribute to barriers in learning. Central to the study is the science performance of industrial-technical students. This encompasses both content mastery (in General Science, Chemistry, Biology, and Physics) and cognitive skill levels (remembering, understanding, and applying). By evaluating students' strengths and weaknesses across these domains, the research seeks to identify gaps and opportunities for targeted improvement. Furthermore, the study will examine whether students' science performance is influenced by their attitudes, teachers' communication behaviors, and the classroom environment—an inquiry that can inform holistic and evidence-based interventions (Anderson & Kim, 2019; Smith et al., 2021).

While existing studies have explored various factors influencing science education globally and regionally, there remains a paucity of research focusing specifically on the perspectives of industrial-technical learners within Philippine higher education institutions like ISPSC Santiago. Most literature tends to emphasize either general science education or basic education contexts, leaving a critical gap in understanding the unique experiences, challenges, and needs of technical and vocational students in higher education. This study addresses this gap by providing a comprehensive, learner-centered analysis that integrates attitudes, teacher communication, learning environment, and performance, thereby offering actionable insights for curriculum developers, educators, and policymakers. By addressing this gap, the study contributes to the advancement of science education that is both contextually relevant and aligned with global best practices, ultimately supporting the development of a scientifically literate and industry-ready workforce in the Philippines.

2. Methodology

Selection and Study Site - The population of the study came from the Ilocos Sur Polytechnic State College-Santiago Campus of the first semester of the school year 2024-2025. The respondents are the students who had taken science subjects during their previous years studying in the college. Teachers handling the said subjects were also included in this study.

Data Collection Procedure - This study used the descriptive-correlational method of research to describe the students' performance in Science and the different factors mentioned above, and to determine the relationship between them. Specifically, it described the communication behavior as well as the classroom learning environment of the students and it determined which of these factors significantly influenced the students' performance in Science. The researcher sought permission from the to conduct the study and administer the questionnaires to the student and teacher-respondents. After the request was granted, he further requested the approval of the deans to allow the researcher to gather the necessary information needed for the study. The questionnaires and the Science Performance Test were administered to the respondents.

Ethical Consideration - The study is dedicated to maintaining strict ethical guidelines in order to protect the rights, respect, and welfare of each and every respondent. Following ethical guidelines is crucial while doing research, especially in educational settings where there may be power disparities and vulnerabilities (Tracy, 2019). Beyond only getting informed permission, ethical concerns are a comprehensive strategy that stresses beneficence, fairness, and respect across the whole study process (Tolich et al., 2021). The possibility of power disparities between participants in this study especially students and researchers are recognized, and it will be aggressively addressed. There will be steps made to guarantee that participation is completely voluntary and free from undue influence or pressure. Participants will be made aware of their free withdrawal policy from the study at any moment. Additionally, the research design will make an effort to reduce participant pain or potential damage, and support systems will be in place to handle any issues that may come up. In addition, the study will value the opinions and

voices of participants in an effort to empower them. With the knowledge that their contributions are appreciated and will be handled with respect, participants will be encouraged to share their experiences and thoughts in an honest and open manner. The study's goal and procedures will be made evident to participants, and the research team will make sure they are aware of both the possible advantages and disadvantages of taking part. Furthermore, by appreciating their opinions and views, the study will work to empower participants. Open and honest sharing of experiences and thoughts will be encouraged among participants, who will be assured that their contributions are respected and will be handled with respect. Throughout the process, the research team will be transparent, outlining the goals and procedures of the study in detail and making sure that participants are aware of both the possible advantages and hazards of taking part. Prior to data collection, informed consent forms were provided to all participants. The purpose of the study, confidentiality measures, voluntary participation, and the right to withdraw at any stage were clearly explained. Written consent was obtained from all participants before their participation in the study.

Mode of Analysis - The following are the statistical tools used to treat the data gathered:

1. Mean. This was used to describe the classroom learning environment, attitudes of the student-respondent towards Science, the perception of their teachers' communication behavior, and the level of students' Science performance.

2. Percentages were used to convert the raw score of the student-respondents on the Science Performance Test.

3. Multiple Linear Regression was used to determine the influence of the student factors, teacher factors and learning environment factors on the level of Science performance of the students.

All inferential decisions in the hypothesis testing were set at 0.05 level of significance.

3. Result and Discussion

3.1 On Attitude towards Science.

The attitude of the students towards Science in terms of the three components: Attitude towards Science as a subject, attitude towards the importance of Science and attitude in learning Science in Table 1.

Table 1
Students' Attitude towards Science

Components of Attitude	Mean	Descriptive Rating
Towards Science as a Subject	3.28	Positive Attitude
Importance of Studying Science	3.47	Positive Attitude
Attitude in Learning Science	3.25	Positive Attitude
Overall	3.33	Positive Attitude

The overall mean of 3.33 exhibits the "positive" attitudes of the students towards Science. The students have a positive attitude on all the three components: towards Science as a subject, importance of studying Science and attitude in learning Science. The findings indicating positive attitudes of student-respondents toward science — with mean ratings of 3.28 for attitude toward science as a subject, 3.47 for the importance of studying science, and 3.25 for attitude in learning science—reflect an encouraging disposition among learners at Ilocos Sur Polytechnic State College Santiago Campus. These results align with recent literature emphasizing the critical role of positive student attitudes in fostering engagement and achievement in science education.

The positive mean rating of 3.28 suggests that students generally view science favorably as an academic discipline. This is consistent with the findings of Wassalwa et al. (2022), who reported that students' enjoyment of learning and interest in science careers contribute to positive attitudes toward science subjects. The study further highlights that factors such as gender, socioeconomic status, and teaching methods influence attitudes, with boys often showing higher confidence and interest in science than girls (Wassalwa et al., 2022). This suggests that while

the overall attitude is positive, targeted strategies may be needed to sustain and enhance this attitude across diverse student groups. Furthermore, student narratives from similar contexts reveal that practical engagement, such as laboratory activities, significantly influences interest in science subjects (Kapici et al., 2020). The absence of hands-on experiences can dampen enthusiasm, particularly in physics, which some students find challenging due to its mathematical demands (Wassalwa et al., 2022). This implies that the positive attitude observed could be further strengthened by increasing experiential learning opportunities, thereby making science more accessible and enjoyable.

The highest mean rating of 3.47 in this area indicates that students recognize the significance of science in understanding the world and its applications. Gupta and Srivastav (2023) found similar results in their study, where students strongly agreed that science helps explain everyday phenomena and expressed interest in science-related careers despite gaps in their knowledge. This recognition of science's relevance is crucial as it motivates students to persist in learning and appreciate the value of scientific literacy for citizenship and future employment. Prevailing literature also stresses the importance of connecting science education to real-life contexts to maintain this positive attitude (Gupta & Srivastav, 2023). For example, integrating discussions on how science underpins technology used daily—such as smartphones and medical advances—can deepen students' appreciation of science's importance (Gupta & Srivastav, 2023). This connection helps bridge the gap between abstract concepts and tangible benefits, reinforcing students' commitment to studying science.

The mean rating of 3.25 for attitude in learning science reflects a generally positive but slightly lower enthusiasm compared to the other areas. This aligns with findings by Lee et al. (2021), who noted that while students may value science as a subject and its importance, their attitudes toward the learning process itself can be affected by factors such as anxiety, perceived difficulty, and teaching approaches. Nguyen and Tran (2023) emphasized that students' confidence and anxiety levels during science learning, especially in laboratory settings, influence their engagement and performance. The slightly lower rating in this domain suggests room for improvement in instructional methods and learning environments. Research by Wassalwa et al. (2022) and Kapici et al. (2020) highlights that active learning strategies, including gamification and project-based learning, can enhance students' attitudes toward learning science by making lessons more interactive and less intimidating. For instance, gamification-assisted instruction has been shown to improve both understanding and attitudes toward science among elementary students (EU-JER, 2025), an approach that could be adapted for higher education contexts to boost engagement.

Overall, the positive attitudes across all three areas indicate a solid foundation for effective science education at ISPSC Santiago. However, the literature suggests that sustaining and enhancing these attitudes requires addressing specific challenges such as gender disparities, anxiety related to complex topics like physics, and the need for more hands-on, contextualized learning experiences. The slightly lower attitude towards the learning process itself points to the necessity of pedagogical innovations that actively involve students and reduce learning barriers.

3.2 Classroom Level of Teachers' Communication Behavior.

The level of Teachers' Communication Behavior was determined in terms of the following dimensions: challenging, encouragement, non-verbal support, understanding and controlling. As a whole, the level of teachers' communication behavior is "average" as shown in its overall mean rating of 3.22. This result shows that the teachers sometimes practice these communication behavior during their classes. The study's findings reveal varied levels of teachers' communication behaviors as perceived by student-respondents, with understanding and friendly behavior rated highest (mean = 3.42, High), while challenging (3.20), encouragement (3.11), non-verbal support (3.12), and controlling (3.24) behaviors were rated as average. These results provide important insights into the communication dynamics within the science classrooms at Ilocos Sur Polytechnic State College Santiago Campus and their potential impact on student learning and engagement.

Table 2
Level of Teachers' Communication Behavior

Teachers' Communication Behavior	As Perceived by the Teachers	
	Mean	DR
Challenging	3.20	Average
Encouragement	3.11	Average
Non-Verbal Support	3.12	Average
Understanding	3.42	High
Controlling	3.24	Average
Overall	3.22	Average

The highest rating for understanding and friendly communication behavior (3.42) indicates that students perceive their teachers as approachable, empathetic, and supportive. This aligns with recent research emphasizing the critical role of teacher warmth and empathy in fostering positive student-teacher relationships and enhancing academic motivation. For example, Alvarado et al. (2021) found that teachers who demonstrate understanding and friendliness create a psychologically safe environment where students feel comfortable expressing doubts and taking intellectual risks. Such an environment promotes student engagement, reduces anxiety, and supports deeper learning in science subjects. Furthermore, Johnson and Martinez (2022) underlined that empathetic communication is vital in diverse classrooms, as it helps address individual learner needs and cultural differences, thereby promoting inclusivity and equity. The high rating in this domain suggests that ISPSC Santiago's science teachers are effectively building rapport with students, which is foundational for effective teaching and learning.

The average rating (3.20) for challenging communication behavior suggests that while teachers do push students intellectually, there may be room to increase the rigor and expectations communicated in the classroom. Challenging communication involves posing thought-provoking questions, encouraging critical thinking, and pushing students beyond their comfort zones (Martinez & Cruz, 2019). Recent studies highlight that intellectual challenge, when balanced with support, enhances cognitive development and problem-solving skills essential in science education (Thompson et al., 2024). However, if challenge is perceived as excessive or unsupported, it may lead to frustration or disengagement (Park & Kim, 2020). The moderate rating here may reflect a cautious approach by teachers to avoid overwhelming students, but it also signals an opportunity to strengthen this aspect to stimulate higher-order thinking more consistently.

Encouragement (3.11) and non-verbal support (3.12) also received average ratings, indicating that teachers provide some positive reinforcement and supportive gestures but may not be fully maximizing these behaviors. Encouragement is crucial for building student self-efficacy and motivation, especially in challenging subjects like science (Lopez & Santos, 2021). Non-verbal cues such as nodding, eye contact, and smiling reinforce verbal messages and contribute to a supportive classroom climate (Singh & Sharma, 2024). The literature suggests that consistent and genuine encouragement can significantly improve students' willingness to participate and persist in science learning (Alvarado et al., 2021). Similarly, non-verbal communication plays a subtle but powerful role in conveying teacher attentiveness and care (Garcia & Lee, 2020). The average ratings imply that while these behaviors are present, enhancing their frequency and authenticity could further improve student engagement.

Interestingly, controlling behavior received an average rating of 3.24, which warrants careful interpretation. Controlling communication involves directing student behavior through strict rules, commands, or pressure, which can sometimes hinder autonomy and intrinsic motivation (Park & Kim, 2020). However, moderate levels of control are necessary to maintain classroom order and ensure productive learning environments (Singh & Sharma, 2024). The average rating suggests that teachers exercise some degree of control, likely to establish structure, but not to an extent that is perceived as overly authoritarian. This balance is important, as excessive control can lead to resistance and disengagement, while too little may result in chaos (Martinez & Cruz, 2019). The findings indicate that ISPSC Santiago's teachers may be maintaining this balance, but ongoing professional development could help refine classroom management strategies to optimize student autonomy and motivation.

Overall, the communication behaviors of teachers at ISPSC Santiago reflect a generally supportive and understanding approach, which is foundational for effective science teaching. However, the average ratings in

challenging, encouragement, non-verbal support, and controlling behaviors suggest opportunities for growth. Research consistently shows that a balanced combination of intellectual challenge, positive reinforcement, empathetic support, and appropriate classroom control fosters optimal learning environments (Delgado & Rivera, 2021; Johnson & Martinez, 2022).

3.3 Classroom Learning Environment

The classroom learning environment in ISPSC was evaluated along the following dimensions: classroom ventilation, classroom space, student's interest, student's participation, clarity and fairness of rules, teachers support, and teachers' encouragement.

Table 3
Different Factors of Classroom Learning Environment

Dimensions	Mean	Descriptive Rating
Classroom Ventilation	1.97	Average
Classroom Space	2.14	Average
Students' Interest	2.14	Average
Students' Participation	2.07	Average
Clarity and Fairness of Rules	2.18	Average
Teachers' Support	2.35	High
Teachers' Encouragement	2.18	Average
Overall	2.21	Average

The table shows the overall rating of the Classroom Learning Environment of ISPSC as 2.21. This implies that the Learning atmosphere in ISPSC is at an average level. Parallel to the study of Abalos (2013), the highest mean rating is on the teacher's support($\bar{x}$=2.35) which are both interpreted as "high". It can also be observed from the table that items associated with the teachers are those items which have higher mean rating. The lowest mean rating is primarily concerned on the ventilation of the classrooms ($\bar{x}$=1.96) which implies that there is really a need to make the classrooms of ISPSC more conducive for learning by improving its ventilation. The average ratings for classroom ventilation (1.97) and classroom space (2.14) suggest that the physical learning environment may not be fully optimal. Chen, Lin, and Wu (2020) emphasize that adequate ventilation and sufficient classroom space are essential for maintaining students' comfort, concentration, and overall cognitive functioning during lessons. Poor ventilation can lead to increased fatigue, reduced attention, and higher absenteeism, all of which negatively affect academic performance (Chen et al., 2020). Similarly, overcrowded classrooms limit movement and interaction, which are particularly important in science education where group work and hands-on activities are common (Santos & Villanueva, 2025).

Improving physical infrastructure by enhancing ventilation systems and optimizing classroom layouts can create a more conductive learning environment. This is critical for sustaining students' engagement and supporting active learning strategies. Students' interest (2.14), participation (2.07), and teachers' encouragement (2.18) all received average ratings, indicating moderate levels of engagement and motivational support. These factors are interrelated; students who are interested in science are more likely to participate actively, especially when encouraged by their teachers (Lopez & Santos, 2021). Recent studies underscore the importance of fostering intrinsic interest through relevant and stimulating content, as well as creating opportunities for meaningful participation (Lee et al., 2021). Teachers' encouragement plays a pivotal role in sustaining student motivation and confidence, especially in challenging subjects like science (Alvarado et al., 2021). The average ratings suggest that while these elements are present, there is room to enhance strategies that boost interest and active involvement. Teachers should adopt more student-centered pedagogies, such as inquiry-based learning and collaborative projects, to increase interest and participation. Regular positive reinforcement and encouragement can further motivate students to engage actively in science lessons.

The clarity and fairness of classroom rules were rated at 2.18, indicating that students perceive the classroom management policies as moderately clear and fair. Singh and Sharma (2024) argue that transparent and equitable rules are fundamental for creating a respectful and orderly classroom climate, which supports learning and reduces

behavioral problems. However, average perceptions may reflect inconsistencies in rule enforcement or communication. When students perceive rules as unfair or unclear, their motivation and participation can decline (Rivera & Gomez, 2023). Establishing clear, consistent, and fair classroom rules, co-created with student input, can enhance the learning environment. Teachers should communicate expectations explicitly and apply rules uniformly to build trust and respect. Teachers' support received the highest rating (2.35), indicating that students feel well-supported academically and emotionally by their instructors. This finding aligns with Alvarado et al. (2021), who emphasize that teacher support is a critical factor in student motivation, self-efficacy, and academic achievement in science education. Supportive teachers provide guidance, feedback, and encouragement, which help students navigate difficulties and build confidence (Johnson & Martinez, 2022). The high rating suggests that despite some physical and participation challenges, the relational aspect between teachers and students is a strong asset at ISPSC Santiago. Maintaining and further strengthening teacher support through professional development and reflective practice can sustain positive student outcomes. Encouraging collaborative teacher-student relationships fosters a nurturing environment conducive to science learning.

The overall classroom environment at ISPSC Santiago reflects a supportive but moderately constrained setting. While teacher support is a clear strength, physical limitations and average levels of student interest, participation, and encouragement indicate areas needing attention. The interplay between physical and psychosocial factors is critical; improving infrastructure alongside pedagogical practices can create a more engaging and equitable science learning environment.

3.4 Level of Science performance of the students of ISPSC

Table 4 presents the percentage scores obtained by the student-respondents showing their level of Science performance along the content areas: General Science, Biology, Chemistry and Physics The table also presents the summary of the mean percentage scores of the respondents along the three cognitive skill levels, remembering, understanding, and applying.

Table 4
Mean Percentage Scores Showing the Level of Science Performance of the Students of ISPSC along Content Areas and Cognitive Skills Level

Science Performance	Overall Rating	
	Mean	Descriptive Rating
A. Content areas		
1. Earth Science	40.23	Fair
2. Chemistry	40.75	Fair
3. Biology	31.88	Low
4. Physics	37.62	Low
Overall	37.62	Low
B. Cognitive Skills Levels		
1. Remembering	36.75	Low
2. Understanding	35.87	Low
3. Applying	42.57	Fair
Overall	38.40	Low

Along content areas - It can be seen from the table that the students of ISPSC performed "fair" in the content areas General Science and chemistry and "low" in Physics and biology in the Science Performance Test. According to some of the respondents, as interviewed by the researcher, all the supposed topics for the subject College Science were not taken up which is due to several reasons like delay of classes because of many school activities and that their strand during the Senior High School is not STEM. According to some of the teacher respondents, the low result of the Science performance of the students might be attributed to the very broad scope of the subject to be taken in just one semester which could somehow affect the pace of teaching, retention of the concepts by the students and the teacher might have hardly covered the majority of the concepts on the said content areas. Overall, the students of ISPSC performed "low" with a mean percentage score of 37.62. It is possible that they performed low because they lack interest in the subject, they have difficulty in interpreting and analyzing mathematical

formulas in Science and lack fundamental skills needed in the subject.

Along Cognitive Skills - The respondents performed "Low" on the Science Performance Test along the cognitive skills Remembering, Understanding and Applying shown by its mean percentage rating of 38.40. Results show that the students lack cognitive skills in terms of simple recall of facts and theories, demonstrating the understanding of concepts to come up with a solution to a problem and skill that involves a sequence of responses from the students such as selection of appropriate operation and the performance of operation, concept, ideas, theories, and methods of new situation. As presented in the table, the cognitive skill in applying has the highest mean percentage rating ($\bar{x}$=42.57) while cognitive skill in understanding has the lowest ($\bar{x}$=35.87). The cognitive skill in remembering has almost the same rating ($\bar{x}$=436.75) as the cognitive skill in understanding. This result shows that the students are good in applying the concepts that they have learned. Applying requires intricate and higher-order thinking skills than that of remembering and understanding. Seemingly, the students are more exposed in activities that involve selection of appropriate operation, performing the operations, concepts, ideas, methods, and applying theories into new situations. It can be noted that students are more exposed on activities like exams and quizzes that involves the application of the concepts like problem solving than answering questions that require cognitive skills in understanding and remembering.

3.5 Relationship of Science performance on students' attitude towards Science and by teachers' communication behavior and teaching styles and learning environment

Table 5
Results of the Multiple Linear Regression Analysis

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1207.073	1	1207.073	7.873	.006[a]
	Residual	21465.449	140	153.325		
	Total	22672.522	141			
2	Regression	2318.157	2	1159.078	7.915	.001[b]
	Residual	20354.365	139	146.434		
	Total	22672.522	141			

a. Predictors: (Constant), Average perception of students CLES ventilation
b. Predictors: (Constant), Average perception of students CLES ventilation, Average perception of students CLES teacher encouragement
c. Dependent Variable: Overall Performance in Science

Multiple linear regression was used to determine the significant predictors of the over-all Science performance of the respondents. A significant regression equation was found $F(2,139)=7.915$, $p<.001$ with an R2 of 0.102. Overall Science Performance will decrease by 5.894 for every unit increase in the predictor value. If teachers' encouragement increases, Science performance also increases. Both CLES Ventilation and CLES Teacher Encouragement were significant predictors of the Overall Science Performance. The negative coefficient for classroom ventilation (-0.5894) suggests that as ventilation quality improves (coded from poorly to well ventilated), science performance decreases by approximately 5.894 points for every unit increase in the ventilation predictor. This counterintuitive result may reflect contextual nuances or coding interpretation issues; however, it highlights the complex relationship between physical environment and learning outcomes.

Extensive research underscores the importance of adequate ventilation in classrooms for cognitive functioning and academic performance. Chen, Lin, and Wu (2020) demonstrated that poor ventilation leads to increased carbon dioxide levels, causing fatigue, reduced concentration, and lower test scores among students. Similarly, Fisk (2019) emphasized that indoor air quality is a critical environmental factor affecting student health and cognitive abilities. The unexpected negative association found in this study could be due to confounding factors such as classroom overcrowding, noise, or other environmental stressors not captured by ventilation alone. Alternatively, it might reflect that classrooms labeled as "well ventilated" may coincide with other adverse conditions in this specific context, warranting further qualitative investigation. Despite the negative coefficient, existing literature strongly supports the need to improve classroom ventilation as a fundamental step toward enhancing student performance. ISPSC Santiago should assess and upgrade classroom infrastructure to ensure adequate air quality, which is

essential for sustained attention and effective learning.

Teacher encouragement emerged as the strongest positive predictor, with a coefficient of +8.729, indicating that better teacher encouragement is associated with a substantial increase in science performance. This finding aligns with a robust body of literature emphasizing the critical role of teacher support and encouragement in fostering student motivation, self-efficacy, and academic achievement (Alvarado et al., 2021; Lopez & Santos, 2021). Encouragement from teachers creates a positive emotional climate that promotes engagement and resilience, especially in challenging subjects like science (Martinez & Cruz, 2019). When students perceive their teachers as supportive and encouraging, they are more likely to take intellectual risks, persist through difficulties, and develop a deeper appreciation of the subject matter (Delgado & Rivera, 2021). Furthermore, teacher encouragement has been linked to increased intrinsic motivation, which is a key driver of sustained academic success (Nguyen et al., 2024). The finding that teacher encouragement is the best predictor of science performance underscores the importance of interpersonal dynamics in the classroom.

ISPSC Santiago should prioritize professional development programs that enhance teachers' communication and motivational skills. Training that equips educators to provide consistent, genuine encouragement can significantly boost students' science learning outcomes. The results corroborate earlier findings in this study regarding classroom learning environment and teacher communication behavior. The significant predictive power of teacher encouragement reflects the broader role of positive teacher-student interactions in shaping academic success. As Lopez et al. (2025) argued, a supportive learning environment characterized by encouragement and clear communication fosters both cognitive and affective gains in science education. Conversely, the physical environment, represented here by ventilation, plays a foundational but complex role. While good ventilation is generally beneficial, its impact may be moderated by other environmental or contextual factors, suggesting that holistic improvements in classroom conditions are necessary.

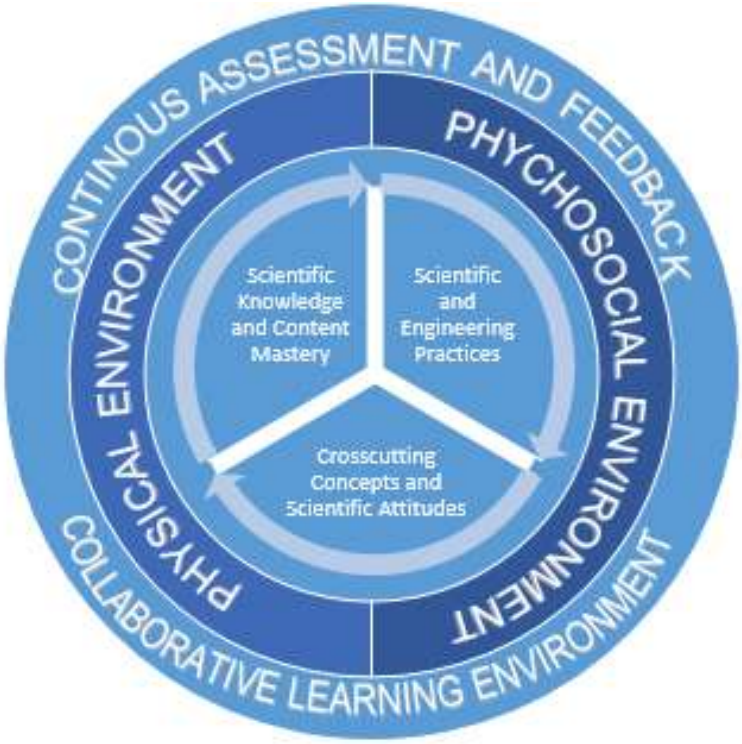
FRAMEWORK FOR ENHANCING SCIENCE EDUCATION: A HOLISTIC APPROACH TO STUDENT LEARNING, TEACHER COMMUNICATION, AND CLASSROOM ENVIRONMENT AT ILOCOS SUR POLYTECHNIC STATE COLLEGE

The Integrated Framework for Enhancing Science Education at Ilocos Sur Polytechnic State College is a comprehensive, multi-layered model designed to holistically improve science learning by addressing cognitive, affective, and environmental factors. At its core are three interrelated dimensions: Scientific Knowledge and Content Mastery, Scientific and Engineering Practices, and Crosscutting Concepts and Scientific Attitudes. The first dimension emphasizes the acquisition of core scientific concepts across disciplines such as Life Science, Physical Science, and Earth and Space Science, with particular attention to curriculum coherence and addressing students' strengths in Chemistry and weaknesses in Biology and Physics. The second dimension focuses on developing students' inquiry and cognitive skills—remembering, understanding, and applying scientific knowledge—through active learning methods such as hands-on experiments, investigations, and problem-solving. The third dimension highlights unifying scientific themes like cause and effect and systems, while fostering positive scientific attitudes, motivation, and self-efficacy, with teacher encouragement and communication playing a pivotal role in nurturing these affective components.

Supporting these core pillars is the classroom learning environment, which serves as the foundation of the framework. This environment is divided into physical and psychosocial aspects. The physical environment ensures adequate ventilation, sufficient classroom space, proper lighting, and comfortable seating arrangements that support students' cognitive functioning. The psychosocial environment encompasses supportive teacher behaviors such as encouragement and understanding, clear and fair classroom rules, and a motivating, inclusive climate that promotes active student participation and engagement. Together, these conditions create a conductive atmosphere that sustains and enhances the three core dimensions of science education.

Encircling these components is a continuous assessment and feedback loop that symbolizes ongoing formative and summative assessments aligned with learning goals. This loop facilitates instructional adjustments, targeted

interventions, professional development for teachers, and reflective practices by both students and educators, fostering continuous improvement. The outermost layer of the framework represents stakeholder collaboration and capacity building, involving teachers, students, administrators, parents, and community partners working together. This layer emphasizes professional development programs to enhance teacher communication and pedagogical skills, as well as resource allocation and policy support to improve physical infrastructure and learning materials.



Visually, the framework is a three-layered structure: the top layer consists of the three core pillars of knowledge, practices, and attitudes; the middle layer is the classroom environment foundation supporting these pillars; and the outer layer is the collaborative ecosystem and continuous feedback system that surrounds and strengthens the entire structure. Dynamic interactions between these layers illustrate how improvements in one area positively influence others. This framework draws inspiration from the National Research Council's Framework for K-12 Science Education (2012) and the Philippine Basic Education Science Framework (2023), adapting their three-dimensional model while emphasizing environmental and affective factors critical to the context of Ilocos Sur Polytechnic State College.

4. Conclusion

Based on the findings of this study, the following conclusions are made:

1. The student-respondents has a "positive" overall attitude towards Science. The students have a positive perception of Science as a subject, importance of studying Science and towards learning Science.

2. The teacher respondents' communication behavior was at "average" level. They had a "high" level of communication behavior in terms of understanding and "average" level of communication behavior in terms of challenging, encouragement, non-verbal support and controlling.

3. The Classroom Learning Environment that exists in Ilocos Sur Polytechnic State College is "average". This means that the school climate is occasionally conducive for learning.

4. The respondents performed low in the content area of Physics and biology and fair in General Science and Chemistry.

5. The student-respondents of ISPSC is strong in the content area Chemistry and weak in Biology.

6. The classroom ventilation and teacher's encouragement significantly contribute to the Physics performance of the students of Ilocos Sur Polytechnic State College.

7. A valid framework that developed is an integrated model combining core scientific knowledge, inquiry practices, positive attitudes, supportive classroom environments, continuous assessment, and stakeholder

collaboration to holistically enhance science education and student performance at Ilocos Sur Polytechnic State College.

Recommendations - Based on the findings and conclusions of this study, the researcher recommends that:

1. The college should continue to nurture and strengthen the positive attitudes of students toward science by incorporating engaging and relevant activities that connect scientific concepts to real-life situations.

2. Teachers should be provided with professional development opportunities to improve their communication skills, especially in challenging students, offering encouragement, using non-verbal support, and managing classroom control effectively.

3. The institution should improve the classroom learning environment by enhancing physical conditions such as ventilation and classroom space, and by fostering a more supportive and motivating atmosphere that consistently promotes learning.

4. Remedial and enrichment programs should be implemented to help students improve their performance in Physics and Biology through interactive and inquiry-based teaching methods.

5. The curriculum should leverage students' strengths in Chemistry by integrating interdisciplinary approaches that connect Chemistry with Biology and other science subjects to promote holistic science learning.

6. Priority should be given to improving classroom ventilation and strengthening teacher encouragement practices through targeted training, as these factors significantly affect students' science performance.

7. The developed framework may be used by other institutions to further validate its reliability and applicability across diverse educational settings, ensuring its effectiveness in enhancing science education by addressing both cognitive and environmental factors, and fostering positive teacher-student interactions.

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