Online ISSN: 3082-5121

Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields

https://journals.aloysianpublications.com

Volume 2 Issue 9 (2026)

Assessment of Laboratory Skills and Engagement of BSEd Students Towards the Development of Interventions for Effective Science Teaching

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Publication Date: September 27, 2026 DOI: **10.5281/zenodo.22996827**

Abstract

This study assessed the level of the perceived laboratory skills and laboratory engagement of BSEd Major in Science students at Eastern Samar State University and examined the influence and differences between these variables as a basis for developing an intervention program. Anchored on Experiential Learning Theory, Constructivist Learning Theory, and Self-Efficacy Theory, the study employed a descriptive-correlational research design. Data were collected using a researcher-made, expert-validated questionnaire measuring laboratory skills in terms of knowledge, practical skills, confidence, and attitude, and student engagement in terms of behavioral, emotional, and cognitive dimensions. Descriptive results showed that perceived laboratory skills were generally high, with attitude rated very high. Similarly, perceived student's laboratory engagement across behavioral, emotional, and cognitive dimensions was very high, indicating active participation, strong interest, and deep cognitive involvement in laboratory activities. Regression analysis revealed that laboratory skills significantly predicted all dimensions of perceived student's laboratory engagement, although the direction and strength of influence varied. Attitude emerged as the most consistent and strongest predictor, while knowledge also played a significant role. Practical skills/exposure and confidence showed mixed effects, including some negative relationships across engagement dimensions. Furthermore, repeated measures ANOVA revealed a significant difference among the four dimensions of laboratory skills, indicating unequal development across knowledge, practical skills, confidence, and attitude. Based on these findings, Project LENS (Laboratory Engagement and Skill Enhancement for Science Teaching) was proposed to enhance laboratory skills and sustain student engagement through targeted, structured interventions.

Keywords: *BSEd students, intervention program, laboratory skills, Science, student engagement*

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 9 (2026)

Introduction

Quality education is recognized by the United Nations as the foundation of relevant learning outcomes. To achieve this, teachers must be prepared to teach effectively, inclusively, and through inquiry (Adipat & Chotikapanich, 2022). In science education, this preparation requires connecting scientific concepts with observation and experimentation and grounding reasoning in real evidence. Inquiry-based approaches are therefore central to the development of future science teachers.

Laboratory learning is a critical component of science teacher preparation. In the Bachelor of Secondary Education (BSEd) science program of Eastern Samar State University (ESSU), coursework integrates substantial laboratory work (ESSU, 2024). These courses train students to conduct experiments, operate apparatus, analyze results, and uphold safety procedures. Laboratory competence involves four domains: conceptual knowledge, practical skills, confidence, and attitude. Conceptual knowledge enables the understanding of scientific concepts and the connection between procedures and outcomes (Gao & Lloyd, 2020; Pols & Dekkers, 2024). Practical skills include technical proficiencies such as preparing solutions, measuring substances, pipetting, using apparatus, collecting data, and conducting experiments. Confidence, or laboratory self-efficacy, shapes persistence and readiness in scientific tasks (Walsh et al., 2022; Naidoo & Naidoo, 2021). Attitude influences motivation, curiosity, responsibility, and safety awareness (Adarlo et al., 2022; Gericke et al., 2022).

These competencies are closely related to student engagement. Engagement encompasses participation, collaboration, critical thinking, self-regulation, and problem-solving, and it reinforces laboratory competence. Competence in turn fosters deeper engagement (Alemneh et al., 2025; Pontigon & Talanquer, 2025). However, inquiry-based learning alone cannot ensure competence, particularly in contexts where laboratory facilities are limited. Many Philippine schools face constraints in equipment, materials, utilities, and supervision, which hinder inquiry and reduce students' familiarity, confidence, and participation (Abas & Marasigan, 2024; Borja & Marasigan, 2020). Safety concerns, including chemical handling and waste management, further complicate laboratory practice (Alansari, 2023; Mendez, 2023). Previous studies have often examined laboratory skills, safety, confidence, attitudes, and engagement separately, leaving a gap in understanding their interrelationship in local teacher education programs.

Eastern Samar State University provides a relevant setting to address this gap. As a producer of future science teachers who may be deployed to schools with varying laboratory resources, ESSU emphasizes Quality Education and Human Capital Development (ESSU, 2023). Investigating the interplay between laboratory competence and engagement among its BSEd science students can inform curriculum design, laboratory management, and student development strategies.

This paper was conducted to determine the laboratory competence of BSEd science students in terms of knowledge, practical skills, confidence, and attitude. It also examined their behavioral, emotional, and cognitive engagement and analyzed the correlation between competence and engagement. The findings were used to propose an intervention aimed at strengthening science teacher education at Eastern Samar State University.

Materials and Methods

Research Design

The research utilized a descriptive quantitative research approach to investigate and study the laboratory skills and student engagement among Bachelor of Secondary Education (BSEd) Science students at Eastern Samar State University. Such a research design is advantageous as it enables the researcher to obtain information on the different states of the variables without changing any of them experimentally. The objective observation process allowed the researchers to get valuable evidence on the laboratory skills of future teachers and their involvement in learning that will later contribute to the development of science teacher education programs.

The descriptive quantitative approach was especially effective in this study because it helped to measure students' laboratory skills that can be evaluated from the point of view of knowledge, skills, confidence, and attitude in a systematic way and define the level of students' engagement in learning activities based on behavioral, emotional, and cognitive aspects of engagement. Data analysis through the statistical techniques made it possible to identify the patterns, differences, and predictive relationships among the assessed variables. Therefore, such an approach is an evidence-based one and satisfies the purpose of the research.

Population and Sampling Technique

The respondents in the study were 135 BSEd Science students of Can Avid Campus of Eastern Samar State University in the course of the research. They were selected because they had first-hand experience with laboratory classes and other activities which were critical aspects of the study. As a result, the respondents who took part in the study are those who gave their informed consent. Students who had other major areas of study were excluded to ensure uniformity in the experiences and findings of the study. The total enumeration sampling technique was utilized thereby representing the whole population of BSEd Science students in the study.

Instrumentation

A researcher-designed survey questionnaire was used to collect the data in two sections, including (a) laboratory skills and (b) student engagement. All statement items were developed according to the existing literature and localized settings in the university. A four-point Likert scale was used for responses as follows: *Strongly Agree (4), Agree (3), Disagree (2)*, and *Strongly Disagree (1)*. The tool went through expert validation and pilot testing on 30 non-participating subjects to test its clarity, relevance, and appropriateness. Reliability was measured by Cronbach's alpha being a total of 0.997 which means excellent internal consistency.

Data Gathering Procedures

Before gathering data, the investigator obtained approval from the ethics committee in charge of research and gained authorization from the academic institution. Consent documents were sent to people who could give their views. Once the process of validation of the survey tool was performed, paper questionnaires were distributed. Two to four weeks were granted to potential participants for filling in the questionnaires, which were collected afterward to make it possible to count and analyze the answers.

Analysis of Data

The collected data were analyzed and computed using SPSS to ensure accuracy and consistency. Validation checks were performed to confirm that the dataset was complete and suitable for statistical analysis. Descriptive statistics, specifically the mean and standard deviation, were applied to determine the levels of laboratory skills in terms of knowledge, practical skills, confidence, and attitude, as well as student engagement across behavioral, emotional, and cognitive dimensions. These measures provided a clear overview of how respondents perceived their competencies and engagement.

To examine deeper relationships among the variables, inferential analyses were conducted. A one-way repeated measures ANOVA was used to identify significant differences among the dimensions of laboratory skills within the same group of respondents. Linear regression analysis was then employed to determine the predictive influence of laboratory skills on student engagement. All statistical tests were carried out at the 0.05 level of significance, and findings were interpreted in line with the study objectives to ensure valid, evidence-based conclusions that could inform interventions for improving science teacher education.

Results

Perceived Level of Laboratory Skills

Table 1.
Perceived Level of Laboratory Skills

Dimension	Mean (M)	Standard Deviation (SD)	Interpretation / Level
Knowledge	3.14	0.57	Very High
Practical Skills / Exposure	2.95	0.86	High
Confidence	2.93	0.64	High
Attitude	3.51	0.498	Very High

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Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
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The results show that knowledge (M = 3.14, SD = 0.57) and attitude (M = 3.51, SD = 0.498) were interpreted as *very high*, while practical skills/exposure (M = 2.95, SD = 0.86) and confidence (M = 2.93, SD = 0.64) were rated only *high*. This pattern suggests that students possess strong conceptual understanding and positive dispositions toward laboratory work, but their actual technical proficiency and self-efficacy are comparatively weaker. Gao and Lloyd (2020) emphasize that conceptual knowledge is foundational in bridging procedures and outcomes, which explains why students may excel in theoretical comprehension even when practical exposure is limited. Similarly, Gericke et al. (2023) note that laboratory work often reinforces attitudes of curiosity and responsibility, aligning with the very high rating in attitude.

The relatively lower scores in practical skills highlight a persistent challenge in Philippine laboratory education. Abas and Marasigan (2024) and Borja and Marasigan (2020) documented that many public schools face inadequate facilities, equipment, and supervision, which restrict opportunities for hands-on practice. This limitation likely contributes to the students' moderate ratings in practical skills and confidence, as insufficient exposure reduces familiarity with apparatus and procedures. Pontigon and Talanquer (2025) further argue that engagement in laboratory activities is strongly tied to opportunities for practice and feedback, reinforcing the idea that limited resources hinder skill acquisition.

Confidence, rated at a high but not very high level, reflects the influence of laboratory self-efficacy. Walsh et al. (2022) and Naidoo and Naidoo (2023) explain that confidence grows through purposeful practice, feedback, and reflection. The current findings suggest that while students are motivated and willing, they may lack consistent opportunities to build resilience in handling complex or unfamiliar tasks. This aligns with Alemneh et al. (2025), who found that engagement and confidence mutually reinforce each other, but only when students are provided with structured laboratory experiences.

The very high rating in attitude is particularly significant. Positive attitudes toward laboratory work, including curiosity, motivation, and safety awareness, are critical for sustaining engagement (Adarlo et al., 2022; Gericke et al., 2023). Even in contexts with limited facilities, students' strong attitudes may serve as a compensatory factor, driving them to maximize available resources. This finding resonates with Alam and Mohanty's (2024) framework of self-regulated cognitive engagement, which highlights the role of motivation and responsibility in sustaining learning despite external constraints.

Overall, the data reveal a competence–engagement gap: students demonstrate strong knowledge and attitudes but only moderate practical skills and confidence. This imbalance underscores the need for interventions that strengthen laboratory exposure and self-efficacy. As Abas and Marasigan (2024) argue, improving laboratory readiness requires not only infrastructure but also systematic planning and supervision. Addressing these gaps can ensure that students' positive attitudes and conceptual knowledge translate into practical competence and confidence, thereby enhancing their readiness as future science educators.

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Student Engagement in Laboratory Activities

Table 2.
Student Engagement in Laboratory Activities

Dimension	Mean (M)	Standard Deviation (SD)	Interpretation / Level
Behavioral Engagement	3.44	0.49	Very High
Emotional Engagement	3.57	0.53	Very High
Cognitive Engagement	3.31	0.52	Very High

The findings reveal that students demonstrated *very high* levels of engagement across all three dimensions: behavioral (M = 3.44, SD = 0.49), emotional (M = 3.57, SD = 0.53), and cognitive (M = 3.31, SD = 0.52). This indicates that students are not only actively participating in laboratory activities but also experiencing strong emotional investment and cognitive involvement. Fredricks, Blumenfeld, and Paris (2004) conceptualize engagement as a multidimensional construct, encompassing behavioral participation, emotional attachment, and cognitive investment. The results align with this framework, suggesting that ESSU students are holistically engaged in laboratory learning.

The highest rating was observed in emotional engagement, which reflects students' enthusiasm, interest, and motivation in laboratory activities. This finding resonates with Adarlo, De Leon, and Favis (2022), who emphasized that positive attitudes toward science strongly predict course engagement and science literacy. Emotional engagement is critical because it sustains curiosity and resilience, even when laboratory resources are limited. Alam and Mohanty (2024) further highlight that self-regulated cognitive engagement is strengthened when students are emotionally invested, underscoring the importance of fostering motivation and responsibility in science education.

Behavioral engagement, also rated very high, indicates that students are consistently participating, following procedures, and collaborating during laboratory sessions. Alemneh et al. (2025) found that structured laboratory activities enhance participation and collaboration, which in turn reinforce skill development. This suggests that ESSU's laboratory coursework provides sufficient opportunities for students to demonstrate active involvement. However, as Abas and Marasigan (2024) noted, laboratory readiness in Philippine schools is often constrained by facilities and supervision. The strong behavioral engagement observed here may reflect students' willingness to maximize available resources despite such limitations.

Cognitive engagement, while slightly lower than the other dimensions, still reached a very high level. This dimension reflects students' ability to think critically, apply concepts, and regulate their learning during laboratory tasks. Pontigon and Talanquer (2025) argue that cognitive engagement in laboratory settings is closely tied to inquiry-based practices, where students must connect procedures with conceptual understanding. The slightly lower mean may suggest that while students are motivated and participatory, they face challenges in sustaining

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Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
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deep cognitive processing, possibly due to limited exposure to advanced laboratory tasks or equipment, as highlighted by Borja and Marasigan (2020).

Overall, the results demonstrate that ESSU students are highly engaged in laboratory activities, with emotional and behavioral dimensions particularly strong. This engagement is a promising indicator of their readiness as future science educators, as it reflects both motivation and active participation. However, the relatively lower cognitive engagement points to the need for interventions that strengthen inquiry-based learning and critical thinking. As Efendi and Jayanti (2024) emphasize, optimizing laboratory management and providing structured opportunities for deeper cognitive involvement can enhance student learning outcomes. Addressing this gap will ensure that engagement translates into both competence and long-term professional readiness.

Significant Difference in Dimensions of Laboratory Skills

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Table 3.

Test of Difference in the Laboratory Skills Among BSEd Major in Science Students

Source of Variation	**Sum of Squares**	**df**	**Mean Square**	**F**	**p-value**	**VI**
Laboratory Skills Dimensions	29.10	3	9.7129	155.00	< .001	Significant
Error (Residual)	25.10	402	0.0625			

Note: VI=Verbal Interpretation; Significant at p<.05

The results of the repeated measures ANOVA, $F(3, 402) = 155.00$, $p < .001$, indicate that the BSEd Science majors' laboratory skills varied significantly across the four dimensions. This finding confirms that students do not develop their competencies uniformly, with some skills being more advanced than others. Jimenez and August (2025) highlight that inequalities in laboratory skill development are common, often shaped by differences in instructional practices, exposure to laboratory tasks, and the availability of resources. In this study, the significant variation suggests that while students may excel in conceptual knowledge and attitude, their practical skills and confidence are comparatively less developed, reflecting the uneven distribution of opportunities for skill acquisition.

This disparity underscores the importance of targeted interventions in science teacher education. Abas and Marasigan (2024) emphasize that laboratory readiness in Philippine schools is often constrained by inadequate facilities and supervision, which limits students' ability to practice technical skills consistently. Similarly, Pontigon and Talanquer (2025) argue that engagement in laboratory activities enhances competence only when students are provided with structured opportunities for practice and feedback. The significant differences observed here imply that curriculum design must address these gaps by strengthening practical exposure and confidence-building activities, ensuring that students' strong knowledge base and positive attitudes are matched with equally robust technical proficiency and self-efficacy.

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Table 4.
Post Hoc Pairwise Comparisons of Laboratory Skills Dimensions (Tukey HSD)

Comparison	Mean Difference	SE	df	t	p-value	VI
Knowledge vs Practical Skills	0.1882	0.0309	134	6.089	< .001	Significant
Knowledge vs Confidence	0.2092	0.0167	134	12.558	< .001	Significant
Knowledge vs Attitude	-0.3699	0.0281	134	-13.177	< .001	Significant
Practical Skills vs Confidence	0.0210	0.0242	134	0.866	0.822	Not Significant
Practical Skills vs Attitude	-0.5581	0.0440	134	-12.680	< .001	Significant
Confidence vs Attitude	-0.5791	0.0318	134	-18.207	< .001	Significant

Note: VI=Verbal Interpretation; Significant at p<.05

The post hoc analysis confirmed that attitude emerged as the strongest laboratory skill dimension, significantly higher than practical skills (MD = -0.5581, p < .001) and confidence (MD = -0.5791, p < .001). This finding underscores the role of positive scientific attitudes in sustaining engagement and performance. Adarlo et al. (2022) emphasized that curiosity, motivation, and responsibility are critical drivers of student involvement in laboratory activities, while Berkman and Renuka (2024) found that scientific attitudes strongly predict achievement in science. The significant differences suggest that while students may not always have equal proficiency in technical skills or confidence, their strong attitudes toward laboratory work provide a foundation for persistence and resilience, even in contexts with limited resources.

In contrast, the comparison between practical skills and confidence yielded no significant difference (MD = 0.0210, p = .822), indicating that these dimensions are closely related and develop in tandem. Parthiban and Stanly (2025) argue that hands-on experiments reinforce both technical proficiency and self-efficacy, which explains the parallel growth observed here. However, the significant differences between knowledge and the other dimensions highlight the uneven development of laboratory competence. Agustian (2024) stresses the need to balance cognitive, practical, and affective domains in laboratory education to ensure holistic competence. Thus, while students demonstrate strong knowledge and attitudes, targeted interventions are necessary to elevate practical skills and confidence to comparable levels, thereby achieving a more integrated and sustainable laboratory readiness.

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Table 5.

Laboratory Skills as Predictors of Student Engagement in Laboratory Activities

Predictors		Laboratory Skills			
Student Engagement		Knowledge	Practical Skills/Exposure	Confidence	Attitude
Behavioral Engagement	**Estimate**	0.598	-0.200	-0.124	0.804
	SE	0.0549	0.0508	0.0650	0.0331
	T	10.89	-3.93	-1.90	24.26
	p	<.001	<.001	0.059	<.001
	VI	Significant	Significant	Not Significant	Significant
Emotional Engagement	**Estimate**	-0.599	0.379	0.247	0.741
	SE	0.0858	0.0794	0.1015	0.0518
	T	-6.99	4.77	2.43	14.33
	p	<.001	<.001	0.016	<.001
	VI	Significant	Significant	Significant	Significant
Cognitive Engagement	**Estimate**	1.015	-0.153	-0.154	0.336
	SE	0.0654	0.0605	0.0774	0.0395
	t	15.52	-2.52	-1.99	8.50
	P	<.001	0.013	0.049	<.001
	VI	Significant	Significant	Significant	Significant

Note: VI=Verbal Interpretation; Significant at p<.05

The regression results highlight that attitude was the most consistent and strongest predictor of engagement across behavioral ($B = 0.804$, $p < .001$), emotional ($B = 0.741$, $p < .001$), and cognitive dimensions ($B = 0.336$, $p < .001$). This finding reinforces the idea that affective dispositions such as curiosity, motivation, and responsibility are central to sustaining student involvement in laboratory activities. Fredricks, Blumenfeld, and Paris (2004) conceptualized engagement as multidimensional, with emotional investment playing a critical role in persistence and achievement. Similarly, Datu and Noltemeyer (2024) found that relatedness and positive attitudes significantly enhance science engagement among Filipino high school students. These results suggest that even when practical skills and confidence are unevenly developed, strong attitudes can compensate by driving active participation and resilience in laboratory learning.

The analysis also revealed contrasting effects of knowledge, practical skills, and confidence. Knowledge positively predicted behavioral ($B = 0.598$, $p < .001$) and cognitive engagement ($B = 1.015$, $p < .001$), but negatively predicted emotional engagement ($B = -0.599$, $p < .001$). This indicates that conceptual mastery supports participation and critical thinking but may not always foster enthusiasm or emotional connection. In contrast, practical skills and confidence were positively related to emotional engagement ($B = 0.379$ and $B = 0.247$, respectively), yet negatively associated with cognitive engagement ($B = -0.153$ and $B = -0.154$). Alemneh et al. (2025) emphasized that hands-on practice enhances emotional involvement and collaboration, while Efendi and Jayanti (2024) argued that effective laboratory management is

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
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necessary to translate technical proficiency into deeper cognitive learning. Taken together, these findings highlight the complex interplay among laboratory skills, underscoring the need for holistic instructional strategies that balance cognitive, practical, and affective domains to ensure comprehensive student engagement in laboratory activities.

Discussion

The laboratory competence of BSEd Science majors indicated that students were generally well-prepared for laboratory-based learning. They demonstrated high levels of knowledge, practical skills, and confidence, alongside a very high attitude toward laboratory work. These results suggest that students possess sufficient conceptual understanding, practical exposure, and confidence to conduct laboratory activities effectively. Their strong attitudes further reflect positive dispositions toward safety, inquiry, and professional preparation. However, the variations across dimensions highlight that competence is not evenly distributed, pointing to the need for systematic and continuous development to ensure balanced growth in all areas.

Student engagement was evident across behavioral, emotional, and cognitive dimensions. Behavioral engagement reflected consistent participation, cooperation, and adherence to laboratory procedures. Emotional engagement was manifested in students' curiosity, enthusiasm, and enjoyment of laboratory tasks, while cognitive engagement was demonstrated through critical thinking, evidence-based reasoning, and problem-solving. These findings confirm that laboratory activities provided meaningful opportunities for active learning and higher-order thinking. Such engagement is particularly important for BSEd science students, who are expected to transfer these competencies into their future teaching practices, thereby fostering inquiry-based and participatory learning environments for their own students.

A deeper analysis revealed that laboratory skills influenced engagement in different ways. Attitude consistently emerged as the strongest predictor of behavioral, emotional, and cognitive engagement, underscoring its central role in sustaining participation and interest. Knowledge was especially significant in promoting cognitive engagement, while practical skills and confidence showed mixed effects, suggesting that technical proficiency alone does not guarantee deeper learning without conceptual understanding and reflection. Significant differences among skill dimensions further confirmed that competence is multi-dimensional, with attitude being the most distinct and well-developed. To address these gaps, Project LENS (Laboratory Engagement and Skill Enhancement for Science Teaching) was designed as a structured intervention. The program emphasizes guided laboratory experiences, inquiry-based activities, reflection, collaboration, feedback, and competency assessment. Its implementation can motivate students to actively build knowledge, skills, confidence, and attitudes, while providing teacher educators and administrators with a systematic framework for laboratory teaching. Future research should evaluate the long-term impact of Project LENS, explore additional factors influencing laboratory learning, and compare outcomes across institutions and disciplines to strengthen science education policy and practice.

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Conclusion

The study established that BSEd Science students at Eastern Samar State University were generally prepared for laboratory-based learning, with very high ratings in knowledge and attitude and high ratings in practical skills and confidence. Student engagement was consistently very high across behavioral, emotional, and cognitive dimensions, indicating that laboratory activities provided meaningful opportunities for active participation, enthusiasm, and higher-order thinking. Attitude emerged as the most consistent and strongest predictor of engagement, highlighting its central role in sustaining participation, motivation, and critical thinking. These findings confirm that laboratory competence is multi-dimensional and requires balanced development across cognitive, affective, and technical domains.

The results also revealed significant differences among the dimensions of laboratory skills, with attitude being the most distinct and well-developed, while practical skills and confidence were comparatively weaker. Knowledge strongly supported cognitive engagement, while practical skills and confidence were more closely tied to emotional involvement. These variations suggest that while students are conceptually prepared and motivated, their technical proficiency and self-efficacy require further strengthening. The proposed intervention, *Project LENS (Laboratory Engagement and Skill Enhancement for Science Teaching)*, was designed to address these gaps by integrating guided laboratory experiences, inquiry-based activities, reflection, collaboration, feedback, and competency assessment to ensure holistic competence and readiness for effective science teaching.

Table 6.
Project LENS (Laboratory Engagement and Skill Enhancement for Science Teaching)

KRA	Objectives	Activities / Strategies	Persons Involved	Success Indicators
Attitude Development	Cultivate positive attitudes toward laboratory work	• Reflective journals and motivational sessions • Reinforcement of safety practices • Recognition and rewards for responsible lab behavior	Faculty, Laboratory Instructors, Students	• Increased student motivation and enthusiasm • Positive perceptions of laboratory safety and inquiry • Improved participation rates
Knowledge Enhancement	Strengthen conceptual understanding of laboratory procedures	•Pre-laboratory discussions •Guided inquiry worksheets • Concept-based exercises and	Faculty, Science Teacher Educators, Students	• Higher scores in concept-based assessments • Improved reasoning and critical thinking

KRA	Objectives	Activities / Strategies	Persons Involved	Success Indicators
		return demonstrations		• Stronger integration of theory and practice
Practical Skills Training	Refine technical proficiency and laboratory exposure	• Scaffolded, inquiry-based experiments • Hands-on practice with equipment • Reflective laboratory activities	Laboratory Instructors, Students	• Increased competence in laboratory techniques • Reduced procedural errors • Greater independence in performing experiments
Confidence Building	Enhance self-efficacy and mastery in laboratory tasks	• Peer-assisted learning • Guided practice and feedback • Competence-based reinforcement and recognition	Faculty, Peer Mentors, Students	• Improved self-reported confidence levels • Greater willingness to perform tasks independently • Positive peer collaboration outcomes
Student Engagement	Promote behavioral, emotional, and cognitive engagement	• Cooperative learning activities • Real-life problem-solving tasks • Inquiry-based and contextualized experiments	Faculty, Students, Administrators	• Sustained high levels of behavioral, emotional, and cognitive engagement • Active collaboration and participation • Evidence of higher-order thinking in laboratory outputs
Monitoring & Evaluation	Ensure continuous improvement of laboratory instruction	• Competency assessments • Feedback sessions • Reflection outputs and program reviews	Faculty, Administrators, Students	• Regular documentation of progress • Adjustments based on feedback • Evidence of improved laboratory

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KRA	Objectives	Activities / Strategies	Persons Involved	Success Indicators
				competence over time

Future research should examine the long- term impact of Project LENS on laboratory competence and engagement, as well as explore other factors influencing laboratory learning such as institutional resources, faculty practices, and student backgrounds. Comparative studies across institutions and disciplines would provide broader insights into laboratory education in the Philippine context. For implementation, science teacher educators and administrators should adopt structured laboratory programs that emphasize conceptual understanding, inquiry, positive attitudes, and continuous feedback, while ensuring adequate facilities, equipment, and faculty training. These steps will help sustain high engagement and balanced competence, preparing future science teachers to deliver effective, inquiry- driven laboratory instruction.

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