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Knowledge, Attitudes, and Practices of Science Education Students Towards Science Laboratory: A Basis for Material Development

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Abstract

This research evaluates the knowledge, attitudes, and laboratory practices of science education students to serve as a basis for the development of innovative instructional materials. Specifically, it seeks to determine if demographic profiles significantly impact these areas and whether students' knowledge and attitudes correlate with safety compliance and technical proficiency. This study employed a descriptive-correlational research design involving science education students from the College of Teacher Education at a state university in Zambales, Philippines. Data were gathered through validated attitude surveys and skill-assessment checklists, and subsequently analyzed using mean scores, ANOVA to evaluate differences across demographic profiles, and Pearson r to conduct correlational analysis.

The study concludes that while interest and safety compliance are uniform across demographics, a significant gender-based disparity in confidence exists, indicating that self-efficacy is heavily influenced by socialization. Moreover, a strong positive correlation proves that a positive psychological orientation is the primary driver of technical manipulation and safety adherence, regardless of academic seniority. The college could implement inclusive peer-mentoring or seminar-workshop to equalize student confidence. These student-centered strategies are essential to bridge the "knowledge-practice gap," ensuring theoretical mastery translates into proficient laboratory execution. Moreover, developmental intervention materials are crucial to bridge gap with theoretical knowledge to practical mastery.

Keywords: *Science Education, Laboratory Management; Self-efficacy.*

INTRODUCTION

Science education in the Philippines faces a significant challenge, as evidenced by concerning scores in international benchmarks that reveal a clear systemic gap (Cabacungan & Calzada, 2025). Data from PISA 2018 and 2022 assessments consistently show students performing at risk, highlighting an urgent need to revitalize our teaching strategies (Romano, 2025). Furthermore, TIMSS assessments confirm that Filipino students continue to struggle with complex scientific inquiry—a difficulty made worse by the limited availability and effective use of physical laboratory resources (Caidoy, 2023).

These infrastructural deficiencies often force educators to rely on substitute instructional methods, such as demonstrations or virtual tools, to mitigate the lack of authentic experimentation (Monta & Perdio, 2025). This persistent lack of physical laboratory resources not only constrains the practical application of theoretical concepts but also negatively impacts the comprehensive development of scientific proficiency among learners (Pacadaljen, 2024).

This means that the laboratory serves as a critical pedagogical space where pre-service teachers bridge theoretical knowledge with practical scientific inquiry, fundamentally shaping their professional development and instructional efficacy (Çıbık & İNCE, 2021; Kumlu, 2022). However, the extent to which these future educators translate their scientific conceptual understanding into effective laboratory practices remains a primary concern for curriculum designers seeking to align training with authentic scientific standards (Kızkapan et al., 2023), (Wola et al., 2023).

Furthermore, disparities in pre-service teachers' mastery of scientific and engineering practices highlight an urgent need for targeted pedagogical interventions that transcend basic theoretical instruction (Tahani, 2021).

With the situation of science laboratories in public universities in the Philippines, specifically for College of Teacher Education, there are persistent challenges regarding resource inadequacy and the maintenance of essential equipment, which often necessitate the integration of improvised laboratory approaches to ensure meaningful hands-on learning experiences (Demandante & Lagura, 2026).

Understanding how the attitudes and knowledge of science education students shape their ability to navigate these laboratory challenges is essential (Karpudewan et al., 2022). This study evaluates current instructional practices among pre-service teachers, providing a firm foundation for developing innovative, self-instructional materials that effectively bridge the gap in resources (Acanto, 2024). By analyzing both attitudes and practical engagement, this research aims to identify and address the critical training gaps that prevent students from fully applying scientific principles in their future classrooms.

RESEARCH PROBLEM

The main goal of this study is to evaluate the knowledge, attitudes, and laboratory practices of science education students to serve as a basis for the development of innovative self-instructional materials.

Specifically, it seeks to answer the following questions:

1. What is the profile of the science education students in terms of;

    1.1. Gender

    1.2. Year Level

    1.2 Prior Laboratory Experience

2. What is the level of laboratory knowledge of the students regarding;

    2.1. Laboratory safety protocols and hazard mitigation;

    2.2 Identification of essential laboratory equipment;

    2.4 Proper handling of laboratory apparatus; and

    2.4 Execution of fundamental experimental procedures using it?

3. What are the attitudes of the pre-service teachers towards science laboratory work in terms of:

    3.1 Interest and motivation;

    3.2 Science lab confidence; and

4. What is the status of the students' laboratory practices concerning:

    4.1 Compliance with safety regulations during experiments;

    4.2 Technical skills in manipulating equipment?

5. Is there significant difference in the knowledge, attitudes, and laboratory practices of the respondents when grouped according to their profile variables?

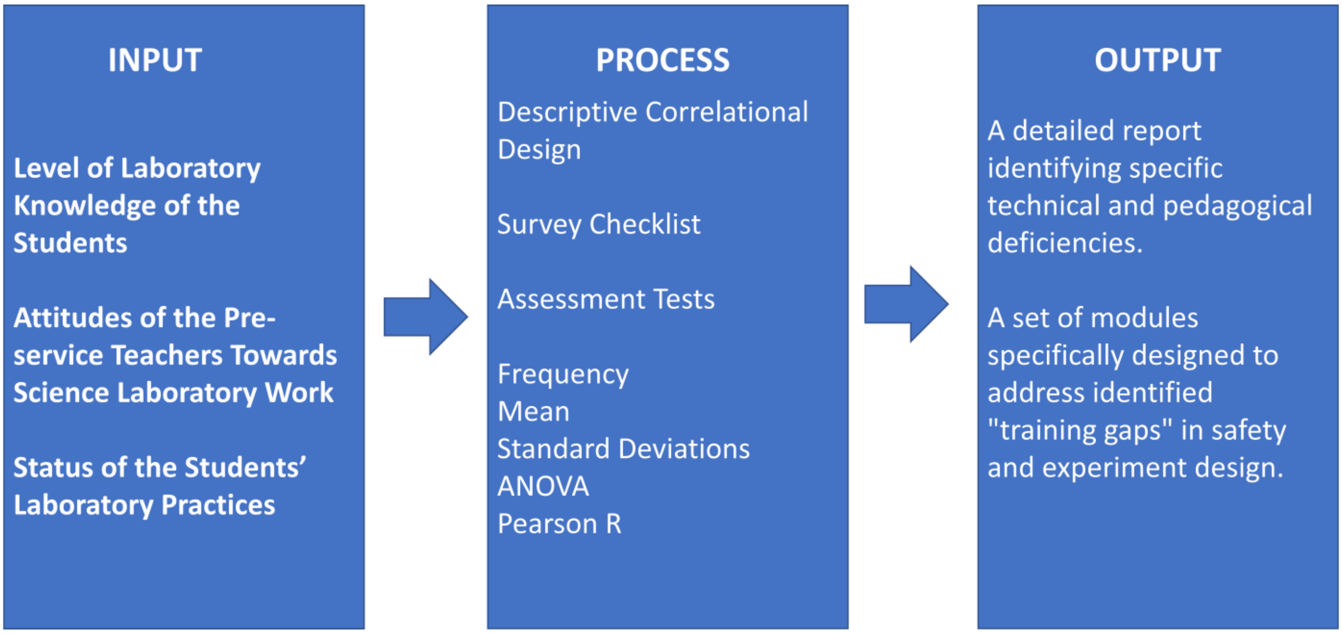
6. Is there a significant relationship between the students' laboratory knowledge, attitudes, and practices towards science laboratory?

7. What intervention instructional material can be developed to enhance the laboratory proficiency and pedagogical self-efficacy of science education students?

THEORETICAL FRAMEWORK

This study is anchored with the Knowledge, Attitudes, and Practices model, which posits that an individual's cognitive understanding and psychological disposition are critical determinants in shaping their behavioral responses toward educational environments (Mihret et al., 2022). Applying this framework to science education, the model underscores that proficiency in laboratory instruction is not merely a product of technical knowledge, but is deeply influenced by the educator's perception of resource availability and their commitment to overcoming institutional constraints (Gonzales et al., 2025; Remigio et al., 2025).

Furthermore, the framework stresses that matching safety knowledge with actual behavior is key to building strong safety habits in different teaching settings (Yanee et al., 2025). Also, the model shows that building lab entrepreneurship and self-confidence helps future teachers see school limits as chances for creative teaching solutions, not blocks to good instruction (Arslan, 2023).



This paradigm shows the interplay between environmental determinants—such as laboratory resources—and personal factors, including student motivation and self-efficacy, which collectively dictate the quality of pedagogical engagement. There are three columns in the framework.

So, combining these ideas with the Laboratory Environment Inventory framework allows a full check of how students' views of their lab space link to their motivation and readiness for independent lab work (Rogers & Fraser, 2022; Serbest & Akkuzu, 2024) This fits the study's problem well. It helps assess the knowledge, attitudes, and lab practices of science education students—especially in resource-poor public universities in the Philippines—by connecting views of the environment to gaps in safety rules, technical skills, and attitudes like interest, anxiety, and value. This guides the creation of new self-teaching materials.

METHODOLOGY

This study employed descriptive-correlational research design to systematically examine the variables and determine the nature of the relationship between laboratory environment factors and the students' behavioral outcomes. There are two types of research instrument used in this study; (a) assessment test and (b) survey checklist. The assessment test evaluates the cognitive domain of laboratory knowledge, whereas the survey checklist captures attitudinal dispositions and self-reported procedural practices. There are 85 science education students from 1st year to 3rd year in a state university in Zambales, Philippines that served as participants of this study. These participants were selected using total enumeration sampling to ensure a comprehensive representation of the target population's experiences across different year levels. Data collection was facilitated through validated instruments, ensuring the reliability of insights regarding laboratory hazards, conceptual understanding, and the practical application of procedural skills. Experts validated the tools, which were also pilot tested with Cronbach's alpha values from 0.78 to 0.92. This shows high internal consistency and reliability. The means and standard deviations are used to describe students' knowledge and attitudes. Pearson's correlation measured relationships between knowledge and lab practices. ANOVA checked for differences in skills and engagement by gender, year level, and prior lab experience.

Profile of the Respondents

The table presents the distribution of science education students across demographic variables, including gender, academic year level, and the extent of their prior exposure to laboratory settings, which provides the necessary context for analyzing potential variations in their pedagogical preparedness.

Table 1: *Frequency and Percentage Distribution of the Respondents by Profile Variables.*

Profile		Frequency	Percentage
Gender	Male	18	21
	Female	63	74
	LGBTQIA++	4	5

Year Level	1st Year	17	20
	2nd Year	44	52
	3rd Year	24	28
Prior Laboratory Engagements in the Past School Year	1 – 5	17	20
	6 – 10	45	53
	11 - 15	22	27

Gender. The table revealed that the majority of the respondents identified as female, accounting for 74% of the total cohort, while male and LGBTQIA++ participants comprised 21% and 5%, respectively. This means that the composition of the participants is predominantly female, reflecting broader gender trends observed in science education programs where female representation often exceeds that of their male and non-binary counterparts.

Year Level. The table revealed that most of the respondents are in their second year of study, representing 52% of the population, followed by the third-year cohort at 28%, and the first-year students comprising the remaining 20% of the surveyed science education population.

Prior laboratory engagement. The data shows that most students have taken part in 6 to 10 laboratory sessions, indicating a moderate level of hands-on experience during their undergraduate training. While this provides a basic foundation, the fact that no students have completed more than 15 sessions suggests that more intensive practical training is needed to help students better apply their classroom learning to real laboratory tasks.

Level of Science Education Students' Knowledge Towards Science Laboratory

This section shows how well the students understand laboratory safety and their ability to identify and use the different tools and equipment needed for science experiments.

***Table 2**: Level of Knowledge Towards Laboratory Safety Protocols and Hazard Mitigation Among Science Education Students*

Score	Frequency	Percentage	Verbal Description
9 – 10	21	25	Outstanding
8	20	24	Very Satisfactory
7	12	14	Satisfactory
6	8	9	Slightly Satisfactory
0 - 5	24	28	Did Not Meet Expectation
Mean Score	**7.06**	**SD 1.86**	**Slightly Satisfactory**

The table presents the results about the level of science education students' knowledge regarding laboratory safety protocols and hazard identification, which yielded a mean score of 7.06, categorized as "Satisfactory" . Majority of the respondents did not meet the expectation evident from their scores 5 and lower. However, 25% were still outstanding and 24% are very statisfactory. This outcome indicates a notable disparity in proficiency, suggesting that while a segment of the student population demonstrates high readiness, a significant portion lacks the fundamental grasp of safety protocols required to navigate complex experimental environments securely (Lekhu, 2023). Such a variation in competency underscores the critical necessity for standardized safety interventions to bridge these knowledge gaps and prevent potential accidents in high-stakes laboratory settings (Sumile & Malinao, 2025).

Level of Knowledge towards Identification of Essential Laboratory Equipment Among Science Education Students

This section presents the results of the students' ability to identify standard laboratory apparatus.

Table 3: Level of Knowledge Towards Glassware and Volumetric Tools

Score	Frequency	Percentage	Verbal Description
5	26	31	Outstanding
4	24	28	Very Satisfactory
3	24	28	Satisfactory
2	11	13	Slightly Satisfactory
0 - 1	0	0	Did Not Meet Expectation
Mean Score	**3.76**	**SD = 1.025**	**Slightly Satisfactory**

The table presents the students' proficiency in identifying standard laboratory glassware and volumetric tools, yielding a mean score of 3.76. This result indicates a "Slightly Satisfactory" level of competency. Moreover, most of the respondents were outstanding evident from the highest percentage of students achieving perfect scores; followed by 28% who are very satisfactory and satisfactory. Despite this, while most students recognize common apparatus, some struggle with the correct names and how to use specialized measuring tools. These findings suggest that while students have a basic familiarity with routine materials, their ability to correctly handle technical equipment remains inconsistent (Restiana & Djukri, 2021).

Table 4: Level of Knowledge Towards Measuring and Analytical Instruments

Score	Frequency	Percentage	Verbal Description
5	9	11	Outstanding
4	39	46	Very Satisfactory
3	27	32	Satisfactory
2	10	12	Slightly Satisfactory
0 - 1	0	0	Did Not Meet Expectation
Mean Score	**3.51**	**SD 0.89**	**Satisfactory**

The table presens the nts' capacity to accurately identify and utilize precision instruments, resulting in a mean score of 3.51, which falls under the "Satisfactory" level. Although the majority of respondents performed well—with 46% rated as very satisfactory and 32% as satisfactory—in identifying basic measuring tools, they continue to struggle with the practical application of more complex analytical equipment, which is essential for accurate results (Paredes, 2025). These findings align with other research suggesting that laboratory safety and technical competence are closely linked to the quality of instructional resources and the complexity of laboratory procedures (Oktariani et al., 2022).

Table 5: Level of Knowledge Towards Heating and Thermal Equipment

Score	Frequency	Percentage	Verbal Description
5	11	13	Outstanding
4	39	46	Very Satisfactory
3	26	31	Satisfactory
2	9	11	Slightly Satisfactory
0 - 1	0	0	Did Not Meet Expectation
Mean Score	**3.61**	**SD = 0.85**	**Satisfactory**

The table presents the proficiency of students in identifying and operating heating apparatus, resulting in a mean score of 3.61, which is categorized as "Satisfactory." Also, most of the respondents have very satisfactory and satisfactory level with 46% and 31%. Heating tools such as Bunsen burners are critical for laboratory experiments, and proper mastery of their operation remains essential for maintaining safety and preventing accidents (Alda et al., 2025). However, the identified gaps in understanding specific apparatus underscore the need for targeted instructional materials to address disparities in technical literacy (Hendrawan et al., 2021).

Table 5: *Level of Knowledge Towards Support and Handling Equipment*

Score	Frequency	Percentage	Verbal Description
5	29	34	Outstanding
4	26	31	Very Satisfactory
3	21	25	Satisfactory
2	9	11	Slightly Satisfactory
0 - 1	0	0	Did Not Meet Expectation
Mean Score	**3.88**	**SD = 0.98**	**Satisfactory**

The table presents the students' ability to recognize and utilize support equipment such as stands, clamps, and tongs, achieving a mean score of 3.88 , indicating a "Satisfactory" level of competency in managing foundational laboratory infrastructure. Moreover, it also revealed that majority of the students, 34%, are outstanding. Additionally, the 31% student respondents were very satisfactory amd 25% re satisfactory. Despite this generally positive performance, persistent challenges in equipment handling continue to impede the overall development of practical laboratory competencies (Nwune et al., 2023).

Table 6: *Level of Knowledge Towards Biological and Optical Tools*

Score	Frequency	Percentage	Verbal Description
5	5	6	Outstanding
4	28	33	Very Satisfactory
3	38	45	Satisfactory
2	14	16	Slightly Satisfactory
0 - 1	0	0	Did Not Meet Expectation
Mean Score	**3.28**	**SD = 0.81**	**Satisfactory**

The table presents students' proficiency in identifying specialized biological and optical instruments, yielding a mean score of 3.28, which is categorized as "Satisfactory." Additionally, most of the students reported satisfactory performance, with 45% falling into this category and 33% were very satisfactory; however, the lower frequency of "outstanding" marks compared to other equipment types suggests that students encounter greater difficulty mastering the intricacies of optical magnification and biological sample preparation. Such limitations in technical aptitude suggest that procedural complexities and insufficient hands-on practice may hinder students from achieving full proficiency in advanced laboratory experimentation (Kolil et al., 2023).

Table 7: *Overall Level of Knowledge towards Identification of Essential Laboratory Equipment*

Score	Frequency	Percentage	Verbal Description
24 – 25	1	1	Outstanding
21 – 23	13	15	Very Satisfactory

18 – 20	36	42	Satisfactory
15 – 17	25	29	Slightly Satisfactory
0 – 14	10	12	Did Not Meet Expectation
Mean Score	**18.09**	**SD = 2.69**	**Satisfactory**

The table presents the overall level of knowledge among respondents regarding the identification of essential laboratory apparatus, reflecting an aggregate mean score of 18.09 which indicated satisfactory. Majority of the respondents demonstrated a baseline understanding of laboratory requirements, yet 42% of the cohort failed to reach a level above "satisfactory," indicating significant gaps in comprehensive equipment literacy. These deficiencies suggest that traditional instructional methods may be insufficient for ensuring technical proficiency, necessitating the development of specialized learning resources to bridge the gap between theoretical knowledge and practical application (Gaelo, 2024).

Table 8: *Level of Knowledge Towards Proper Handling of Laboratory Apparatus Among Science Education Students*

Score	Frequency	Percentage	Verbal Description
9 – 10	10	12	Outstanding
8	10	12	Very Satisfactory
7	28	33	Satisfactory
6	15	18	Slightly Satisfactory
0 - 5	22	26	Did Not Meet Expectation
Mean Score	**6.35**	**SD = 1.64**	**Slightly Satisfactory**

The table presents the students' perceived proficiency in the physical manipulation of laboratory apparatus, resulting in a mean score of 6.35, which is categorized as "Slightly Satisfactory." Furthermore, while 33% of respondents rated their skills as satisfactory, 26% failed to meet expectations, revealing a clear gap in their hands-on and procedural abilities (Anane, 2023). This trend mirrors reports that students often lack foundational science process skills, highlighting the need for more effective practical training (Apeadido et al., 2024).

Table 9: *Level of Knowledge Towards Execution of Fundamental Experimental Procedures Among science Education Students*

Score	Frequency	Percentage	Verbal Description
9 – 10	5	6	Outstanding
8	20	24	Very Satisfactory
7	16	19	Satisfactory
6	11	13	Slightly Satisfactory
0 - 5	33	39	Did Not Meet Expectation
Mean Score	**6.31**	**SD = 1.67**	**Slightly Satisfactory**

The table presents the students' assessment of their ability to execute fundamental experimental procedures, yielding a mean score of 6.31 which is interpreted as "Slightly Satisfactory." Also, a significant proportion of the cohort, at 39%, failed to meet the minimum expectations for these technical tasks, indicating that a substantial segment of learners struggles with the complexities of experimental execution. This difficulty in performing experiments shows a clear need for more hands-on training, which is often made worse by the ongoing shortage of working equipment and necessary supplies (Mafugu, 2022; Rivera & Deleon, 2026). As a result, not being able to practice regularly in the lab prevents students from building important science skills, such as observing, inferring, and experimenting (Mohanty et al., 2025).

Table 10: Overall Level of Laboratory Knowledge Among the Science Education Students

Score	Frequency	Percentage	Verbal Description
51 - 55	0	0	Outstanding
45 – 50	5	6	Very Satisfactory
39 - 44	37	44	Satisfactory
33 - 38	32	38	Slightly Satisfactory
0 -32	11	13	Did Not Meet Expectation
Mean Score	**39**	**SD = 8.84**	**Satisfactory**

The table presents the overall laboratory knowledge level of respondents, revealing an aggregate mean score of 39.0, which indicates a satisfactory level of preparedness. Moreover, most of the respondents fall into the "satisfactory" or "slightly satisfactory" brackets, underscoring that many future teachers often lack the deep understanding and hands-on experience needed to effectively lead science labs (Khoza, 2024). This ongoing lack of practical training reflects the widely held view that many teachers begin their careers with limited scientific skills. Consequently, fixing these training gaps is essential to ensure that future teachers can move beyond basic familiarity and achieve the skill level needed to lead effective, hands-on science lessons (Torres & Sandemetrio, 2024).

Attitudes of the Pre-service Teachers Towards Science Laboratory Work

This section only include the results regarding the pre-service interest, motivation, and their confidence in facilitating inquiry-based laboratory experiences.

***Table 11**: Attitudes of the Pre-service Teachers Towards Science Laboratory Work in terms of Interests and Motivation*

Interest and Motivation	**Mean**	**Verbal Description**	**Rank**
1. I feel a sense of excitement and curiosity when I am about to perform a new laboratory experiment.	3.68	Strongly Agree	7
2. I believe that laboratory activities are the most engaging part of the science curriculum.	3.72	Strongly Agree	4.5
3. I am highly motivated to master laboratory techniques because I see them as essential for my future teaching career.	3.75	Strongly Agree	3
4. I enjoy the challenge of troubleshooting when an experiment does not yield the expected results	3.24	Agree	10
5. I would participate in additional laboratory workshops even if they were not required for my degree.	3.25	Agree	9
6. I feel a sense of accomplishment and "joy" when I successfully complete a complex laboratory procedure.	3.76	Strongly Agree	2
7. I am eager to learn how to operate modern and digital laboratory instruments.	3.79	Strongly Agree	1
8. I prefer learning science through hands-on laboratory work rather than purely theoretical lectures.	3.71	Strongly Agree	6
9. I am motivated to investigate scientific phenomena independently using laboratory resources.	3.49	Strongly Agree	8
10. I believe that a strong foundation in lab skills will make me a more confident and effective science teacher.	3.72	Strongly Agree	4.5
Overall	3.61	Strongly Agree	

The table presents the results of the pre-service teachers' interest and motivation levels, yielding an overall mean of 3.61, which indicates that these students maintain a high level of enthusiasm for laboratory-based learning. This positive attitude aligns with research showing that pre-service teachers are highly motivated to use inquiry-based teaching methods (Park et al., 2021). The table also revealed that pre-service teachers strongly agreed that they are eager learning to operate modern digital instruments, evident from the highest mean of 3.79.

Moreover, respondents also strongly agreed that they felt a sense of accomplishment when completing a complex laboratory procedure (m= 3.76), and highly motivated to master laboratory techniques (m= 3.75) suggesting that positive emotional experiences during practical work significantly foster their intentions to utilize such approaches in future instructional settings (Smit et al., 2021).

Despite the high motivation, they just agree about participating additional laboratory workshops (m= 3.25), and enjoy the challenge of troubleshooting unsuccessful experiments, suggesting a potential gap between general enthusiasm and the persistence required for inquiry-based problem solving (Iglesias et al., 2023). This gap shows that even though students are excited, they often lack the basic skills needed to define problems or form hypotheses when experiments fail. This is a common challenge seen in new science teachers (Anam et al., 2023).

Table 12: *Attitudes of the Pre-service Teachers Towards Science Laboratory Work in terms of Science Laboratory Confidence*

Science Laboratory Confidence	Mean	Verbal Description	Rank
1. I feel a sense of nervousness or "lab anxiety" when I am assigned to handle chemicals.	2.85	Agree	9
2. I am afraid of making a mistake that might cause an accident or damage expensive equipment.	3.41	Strongly Agree	5
3. I'm feeling positive to complete laboratory procedures within the strictly allotted class time.	3.28	Strongly Agree	7
4. I feel overwhelmed by the number of steps and technical details required in laboratory manuals.	2.84	Agree	10
5. I am afraid that my lack of technical skills will lead to incorrect experimental results.	3.11	Agree	8
6. I feel anxious about my ability to respond correctly in case of a laboratory emergency or chemical spill.	3.85	Strongly Agree	1
7. I find the operation of digital or advanced analytical instruments to be intimidating and difficult to learn.	3.69	Strongly Agree	4
8. I often feel that I need constant supervision from an instructor to perform an experiment safely.	3.76	Strongly Agree	2
9. I worry about my future responsibility of managing a laboratory and ensuring the safety of my own students.	3.36	Strongly Agree	6
10. I find scientific calculations and data analysis to be the most difficult part of the laboratory experience.	3.75	Strongly Agree	3
Overall	3.39	Strongly Agree	

The table presents the results of the pre-service teachers' self-reported confidence levels in the laboratory, yielding an overall mean of 3.39, which highlights a clear contrast between their high enthusiasm for teaching and their significant worry about technical skills and managing safety (Rohandi, 2022). This matches research findings where teachers express strong interest in inquiry-based teaching but also report major anxiety about the challenges of putting it into practice (Mohammed & Amponsah, 2021).

Moreover, the data revealed that respondents felt anxious about their proficiency in managing laboratory emergencies, as reflected by the highest mean score of 3.85, indicating that safety concerns are a primary barrier to their professional self-efficacy. Furthermore, they also strongly agreed that they still need supervision during their experimental procedures (m=3.76), and find calculations and analysis difficult. This suggests that a lack of confidence in technical skills may make it difficult for these teachers to guide students through independent experiments without extra help (Heinrich et al., 2024). These concerns are worsened by their limited experience in planning and analyzing experiments, which prevents them from building a strong belief in their own abilities (Beudels et al., 2021).

However, they only agreed about their nervousness regarding chemical handling (2.85) and technical complexity required in lab manuals (m=2.84), suggesting that while they still feel nervous overall, they see specific lab tasks as manageable rather than impossible (Smit et al., 2021). This difference between their excitement and their belief in their own skills highlights the need for training that goes beyond simple, step-by-step instructions and focuses instead on collaborative research (Irwanto, 2022).

Status of the Students' Laboratory Practices

This section evaluates the current frequency and nature of laboratory activities performed by pre-service teachers, focusing on their reliance on traditional, and confirmatory protocols.

Table 13: *Status of the Students' Laboratory Practices in terms of Compliance with Safety Regulations During Experiments*

Statements	**Mean**	**Verbal Description**	**Rank**
1. I wear the complete required Personal Protective Equipment, such as lab coats, safety goggles, and gloves, for the entire duration of the experiment	3.79	Always	3.5
2. I read the laboratory manual and safety instructions thoroughly before starting any experimental procedure	3.61	Always	10
3. I dispose of chemical, biological, and glass wastes in their specific designated containers rather than using the general trash or sink	3.72	Always	5
4. I ensure that all chemical containers are clearly labeled and tightly sealed immediately after each use	3.80	Always	2
5. I maintain a clean and organized workspace, free of personal items like bags and phones, to prevent accidents	3.79	Always	3.5
6. I refrain from eating, drinking, or storing food and beverages inside the laboratory premises	3.67	Always	8
7. I wash my hands thoroughly with soap and water after handling chemicals or biological specimens and before leaving the laboratory	3.86	Always	1
8. I locate the safety equipment (e.g., eyewash stations, fire extinguishers, first aid kits) and verify they are accessible before beginning my work	3.66	Always	7
9. I report all spills, breakages, or minor injuries to the laboratory instructor or technician immediately	3.65	Always	9
10. I strictly follow the prescribed experimental procedures and avoid performing unauthorized variations or "trial" reactions	3.69	Always	6
Overall	3.72	Always	

The table presents the results of the pre-service teachers' high adherence to safety relations as evidenced by the overall mean of 3.72, which suggests that prospective educators prioritize foundational safety protocols to mitigate the risks they previously identified as major sources of anxiety (Baysen & Baysen, 2022).

Moreover, based from the data, it revealed that respondents consistently prioritize proper hygiene through washing with soap, evident from the highest mean of 3.86. Further, they also consistently ensure labelling containers (m=3.80), maintaining clean and organized workspace (m=3.79), and dispose biological, chemical, and glass wastes on designated areas (m=3.72). This consistent compliance suggests that while students possess a strong foundational understanding of standard laboratory safety protocols, their reliance on structured procedures may stem from a preference for risk aversion to manage their technical uncertainty (Luzin et al., 2024).

Though the respondents always report spills, minor injuries, and breakages to the instructor, and read laboratory manuals thoroughly, it still ogot the lowest means of 3.65 and 3.61.

Though, by adhering to these foundational safety habits, students establish a baseline of operational security that may eventually bolster their self-efficacy, even if their technical confidence in navigating open-ended inquiry remains limited (Oliveira & Bonito, 2023).

Table 14: *Status of the Students' Laboratory Practices in terms of Technical Skills in Manipulating Equipment*

Statements	Mean	Verbal Description	Rank
1. I read the volume of liquids in graduated cylinders and burettes at the bottom of the meniscus while keeping my eyes at the same level as the liquid	3.66	Always	7.5
2. I zero or "tare" digital balances and ensure triple-beam balances are properly calibrated before taking any mass measurements	3.68	Always	5
3. I use the adjustment knob exclusively when focusing a microscope.	3.65	Always	9
4. I adjust the air collar of the Bunsen burner to achieve a non-luminous blue flame before beginning a heating procedure.	3.59	Always	10
5. I clean, rinse with distilled water, and dry all laboratory glassware thoroughly before returning it to the storage cabinets.	3.73	Always	2
6. I use specific handling tools (e.g., crucible tongs, beaker tongs, or test tube holders) when moving or holding heated apparatus.	3.79	Always	1
7. I securely fasten and align all clamps, rings, and bosses on retort stands to ensure the stability of my experimental setup.	3.69	Always	4
8. I use a glass stirring rod to guide the flow of liquid when transferring mixtures into a funnel to prevent splashing or loss of sample.	3.67	Always	6
9. I select the most appropriate volumetric tool (e.g., using a volumetric pipette instead of a beaker) based on the level of precision required by the protocol.	3.66	Always	7.5
10. I inspect all glassware for "star cracks," chips, or defects before using them in experiments involving heat or vacuum pressure.	3.70	Always	3
Overall	**3.68**	**Always**	

The table presents the respondents' consistent proficiency in technical laboratory manipulations, with an overall mean of 3.68, suggesting that students have successfully internalized the technical mechanics required for routine science experiments. This consistent adherence to procedures shows that while students are comfortable with routine tasks, they may need more experience with independent, open-ended practices that require active problem-solving (Dalere & Calzada, 2025).

Further, the respondents always clean, rinse and dry all glassware and inspect them thoroughly evident from the highest means of 3.79 and 3.70, which indicates a strong grasp of post-experimental maintenance that safeguards equipment integrity and minimizes cross-contamination risks (Sukri et al., 2023). Also, they consistently securely fasten clamps and align experimental apparatus on retort stands, a practice that reflects a high level of caution necessary to prevent accidents during complex procedures (Mendez, 2023).

Conversely, the lowest mean scores recorded for Bunsen burner adjustment (m=3.59) and microscope focus (m=3.65) suggest that while students are proficient in maintenance, they may still encounter difficulties with precision-dependent mechanical calibrations (Idris et al., 2022), (Chheun & Kong, 2023).

Table 15: Significant Difference on the Level of Knowledge Towards Science Laboratory Among Science Education Students When Grouped According to Profile Variables

	Gender		Year Level		Prior Lab Engagement	
	Sig	Decision	Sig	Decision	Sig	Decision
Laboratory Safety Protocols and Hazard Mitigation	.371	Accept Ho Not Significant	.955	Accept Ho Not Significant	.230	Accept Ho Not Significant
Identification of Essential Laboratory Equipment	.145	Accept Ho Not Significant	.201	Accept Ho Not Significant	.883	Accept Ho Not Significant
Proper Handling of Laboratory Apparatus	.368	Accept Ho Not Significant	.290	Accept Ho Not Significant	.136	Accept Ho Not Significant
Execution of Fundamental Experimental Procedures	.019	Reject Ho Significant	.742	Accept Ho Not Significant	.875	Accept Ho Not Significant

This table presents the statistical analysis of how demographic and experiential factors influence the students' knowledge across four key domains of laboratory competence.

Laboratory Safety Protocols and Hazard Mitigation. Based from the table, the results revealed that there are no significant differences in knowledge levels based on gender (p= .371), year level (p= .955), or prior lab engagement (p= .742), suggesting a uniform baseline of safety awareness across the student population. This uniformity implies that regardless of prior academic background or demographic profile, students generally receive consistent foundational training in managing laboratory risks (Madamba et al., 2025).

Identification of Essential Laboratory Equipment. Based from the table, the results revealed that no significant differences across the analyzed demographic variables, gender (p= .145), year level (p= .201), or prior experience (p= .883), indicating that all students possess a comparable level of familiarity with standard instrumentation regardless of their academic stage or previous exposure to laboratory environments.

Proper Handling of Laboratory Apparatus. Based from the table, the data indicate no significant differences across profiles of gender (p= .368), year level (p= .290), or prior experience (p= .136), reinforcing that mechanical proficiency in apparatus management is consistently acquired throughout the curriculum (Reah, 2023).

Execution of Fundamental Experimental Procedures. The analysis indicates a significant difference regarding gender (p=.019), suggesting that male and female students may exhibit distinct competencies in performing core experimental tasks, which warrants differentiated instructional approach. Although students showed differences in performance based on gender, factors like academic year or previous lab experience had no effect. This suggests that these performance gaps might be caused by environmental or social influences rather than innate ability (Sebastian, 2025). Such findings diverge from other studies reporting no significant gender disparity in the acquisition of basic science process skills or experimental performance.

Table 16: Significant Difference on the Attitudes of the Science Education Students Towards Science Laboratory Work when grouped according to Profile Variables

	Gender		Year Level		Prior Lab Engagement	
	Sig	Decision	Sig	Decision	Sig	Decision
Interest and Motivation	.251	Accept Ho Not Significant	.708	Accept Ho Not Significant	.354	Accept Ho Not Significant
Science Lab Confidence	.018	Reject Ho Significant	.198	Accept Ho Not Significant	.081	Accept Ho Not Significant

This table presents the statistical analysis of how demographic and experiential factors influence the students' attitudes towards science laboratory work, specifically across the dimensions of interest, motivation, and confidence.

Interest and Motivation. The data indicate no significant differences across gender (p= .251), year level (p= .708), or prior experience (p= .354), suggesting that students maintain a uniform level of enthusiasm toward laboratory engagement regardless of their personal or academic background. That while students are comfortable with routine tasks, they may need more experience with independent, open-ended practices that require active problem-solving (Dalere & Calzada, 2025).

Science Lab Confidence. The table presents a significant difference in confidence levels when students are grouped by gender (p= .018), indicating that male, female, and LGBTQIA++ students perceive their self-efficacy in laboratory environments differently, potentially due to disparate socialized comfort levels with specific task types (Ecevit & Kıngır, 2022; Paul, 2025). Such gendered discrepancies in self-efficacy align with observations that restricted participation in specific laboratory roles can limit students' overall engagement and perceived motivation within STEM disciplines (Fernández et al., 2023). Moreover, based from the data, there are no significant differences in year level (p = .198) or prior lab engagement (p= .081), suggesting that confidence in these settings is more heavily influenced by individual identity and socialization than by the duration of one's academic training or previous laboratory exposure (Ouahabi et al., 2025).

Table 17: *Significant Difference on the Status of the Science Education Students' Laboratory Practices when grouped according to Profile Variables*

	Gender		Year Level		Prior Lab Engagement	
	Sig	**Decision**	**Sig**	**Decision**	**Sig**	**Decision**
Compliance with Safety Regulations During Experiments	.248	Accept Ho Not Significant	.509	Accept Ho Not Significant	.175	Accept Ho Not Significant
Technical Skills in Manipulating Equipment	.373	Accept Ho Not Significant	.827	Accept Ho Not Significant	.085	Accept Ho Not Significant

The table presents the statistical analysis of how demographic variables—specifically gender, year level and previous laboratory experience—impact the execution of routine laboratory practices.

Compliance with Safety Regulations During Experiments. The data revealed that there are no statistically significant differences in adherence to safety protocols across the studied demographic groups, indicating that safety training works well for everyone, no matter their gender (p= .248), year level (p= .509), or past lab engagement (p= .175). This consistency suggests that basic training acts as an equalizer, helping to bridge gaps created by different student backgrounds or confidence levels (Paul et al., 2024).

Technical Skills in Manipulating Equipment. The data indicate that proficiency in apparatus manipulation remains consistent across gender, year level, and prior experience, suggesting that students generally reach a consistent level of basic technical skill through current laboratory curricula (Fatmawati et al., 2024). This indicates that these basic skills are already solid, allowing teachers to shift focus from simple equipment training to more advanced, hands-on projects that promote a deeper understanding of experiments (Sawant et al., 2018).

Table 18: *Significant Relationship between the Students' Laboratory Knowledge, Attitudes, and Practices towards Science Laboratory*

		Knowledge	Attitudes	Practices
Knowledge	Pearson Correlation	1	.184	.221*
	Sig. (2-tailed)		.092	.042
	N	85	85	85
Attitudes	Pearson Correlation	.184	1	.704**

	Sig. (2-tailed)	.092		.000
	N	85	85	85
Practices	Pearson Correlation	.221*	.704**	1
	Sig. (2-tailed)	.042	.000	
	N	85	85	85

The table presents the correlation analysis between laboratory knowledge, attitudes, and practices among science education students. Based from the table, it revealed that a significant positive relationship exists between students' laboratory attitudes and their practical application of skills (r=.704, p<.001), underscoring that a positive psychological orientation toward scientific work is a critical driver of actual laboratory performance. However, there is no statistically significant correlation between knowledge and attitudes ($r = .184, p = .092$), suggesting that theoretical mastery does not automatically foster a favorable disposition toward practical science work (Atud et al., 2025). Furthermore, the observed weak correlation between knowledge and practice ($r = .221, p = .042$) highlights that while technical information is necessary, it is insufficient to ensure proficiency without the mediation of student-centered learning strategies (Maghanoy & Codilla, 2025).

Conclusions

Based on the results, the study concludes the following;

1. Most of the Science Education students respondents were female, who are in there second year college, and have 6 - 10 laboratory engagements for the past semester.

2. While students demonstrate a satisfactory ability to identify essential laboratory equipment, their proficiency in safety protocols, apparatus handling, and procedural execution remains only slightly satisfactory. This overall performance highlights a critical need for developmental instructional materials focused on bridging the gap between theoretical tool recognition and practical technical mastery in the laboratory.

3. Pre-service teachers demonstrate high interest and motivation toward laboratory work, particularly in their eagerness to utilize modern digital tools. However, a significant contrast exists as their self-reported confidence remains lower due to persistent anxieties surrounding technical skill mastery and the management of laboratory safety.

4. Pre-service teachers demonstrate high adherence to safety regulations and technical manipulation routines, characterized by a strong emphasis on personal hygiene and post-experimental equipment maintenance. This consistent proficiency indicates that students have successfully internalized the fundamental mechanics of experimental science, which effectively helps mitigate risks and addresses previously identified laboratory anxieties

5. The statistical analysis reveals that profile variables such as gender, year level, and prior experience do not significantly influence students' knowledge regarding safety protocols, equipment identification, or apparatus handling. However, a significant difference exists in the execution of fundamental experimental procedures based on gender indicating that male and female students possess distinct levels of competency when performing core practical tasks.

6. The statistical analysis reveals that profile variables such as gender, year level, and prior experience do not significantly influence students' knowledge regarding safety protocols, equipment identification, or apparatus handling. However, a significant difference exists in the execution of fundamental experimental procedures based on gender, indicating that male and female students possess distinct levels of competency when performing core practical tasks.

7. The study demonstrates that students' interest and motivation toward laboratory work remain uniform across all demographic profiles, with no significant differences observed in gender, year level, or prior experience. There is a significant difference in laboratory confidence exists based on gender identity, suggesting that self-efficacy is more heavily influenced by individual socialization and identity than by academic seniority or previous lab engagement

8. The data indicate that proficiency in apparatus manipulation remains consistent across gender,

year level, and prior experience, suggesting that students generally reach a consistent level of basic technical skill through current laboratory curricula

9. `Positive laboratory attitudes—including interest, motivation, and confidence—are key drivers of successful technical manipulation and safety compliance. Furthermore, the weak correlation between theoretical knowledge and practical proficiency suggests that conceptual mastery alone does not ensure the operational fluency required for complex experimentation. So, it needs intervention to enhance it.

Recommendation

1. Implement targeted instructional interventions that shift focus from rote theoretical recognition to scaffolded, context-based laboratory experiences to bridge the observed gap between conceptual knowledge and operational performance.

2. Since a positive psychological orientation is the strongest driver of performance the science department should move beyond traditional lecturing to host interactive workshops focused on high-interest, real-world applications. These sessions should prioritize building Interest and Motivation through discovery-based learning, which has been shown to be more effective than theoretical mastery alone in fostering a favorable disposition toward practical work

3. The college, specifically the science department, could conduct a seminar or workshop about safety knowledge and technical skills training at the start of every school year. So, regardless of their experience or year level, maintain the same basic level of technical skill and safety knowledge.

4. Develop a manual or laboratory guide, software or concrete product, that integrates theoretical concepts with practical procedures, specifically designed to increase student engagement and alleviate common anxieties regarding experimental execution.

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