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Chemistry Laboratory Engagement: STEM Students' Perceptions, Confidence, and Career Aspirations

Paul John D. Tiangco

pjdtiangco@nu-fairview.edu.ph

National University, Philippines https://orcid.org/0009-0002-7199-0913

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Abstract

The growing demand for STEM professionals underscores the importance of effective laboratory-based instruction in senior high school science education. This descriptive–correlational study investigated the perceptions, confidence, and motivations of 465 Grade 12 STEM students from NU Fairview, Inc. toward face-to-face chemistry laboratory activities, with particular emphasis on the role of gender and academic specialization. Data was collected through a structured survey instrument and analyzed using descriptive statistics and inferential statistics. Findings indicate that students generally perceive chemistry laboratory work as an essential and engaging component of learning. Positive engagement was strongly associated with hands-on experimentation, peer collaboration, instructor support, and the perceived relevance of laboratory tasks to real-life and future careers. While students reported high confidence in basic laboratory procedures and safety practices, comparatively lower confidence was observed in higher-order skills such as problem-solving, data analysis, and interpretation of results. Statistical analysis revealed no significant differences in perceptions, confidence, or motivation when grouped by gender, suggesting an inclusive laboratory learning environment. However, academic specialization significantly influenced students' levels of engagement and self-assessed performance, particularly in laboratory tasks aligned with their chosen STEM track, such as Allied Health or Engineering. The study recommends strengthening instructional strategies that emphasize analytical thinking and data interpretation, improving time management during laboratory sessions, and contextualizing experiments to align with students' academic specializations. These findings provide practical insights for educators aiming to enhance chemistry laboratory pedagogy and better prepare students for future STEM pathways.

Introduction

In the Philippines, the demand for professionals in science, technology, engineering, and mathematics (STEM) continues to rise, reflecting both national development goals and global workforce needs. To help meet this demand, educators are working to strengthen science education by providing meaningful learning experiences, particularly in the laboratory setting. Chemistry laboratory activities are seen not only as instructional tools but also as powerful platforms for developing critical thinking, problem-solving abilities, and a deeper understanding of scientific concepts. As the world becomes more technologically advanced, the importance of preparing students through active, inquiry-based learning has never been greater.

Hands-on laboratory work plays a vital role in shaping how students perceive and engage with science. Yet, despite its significance, limited studies have deeply examined how students' perceptions of chemistry lab experiences influence their interest and participation in face-to-face settings. Finne et al. (2022), for instance, studied the impact of shifting from laboratory instruction to online theoretical tasks during the COVID-19 lockdown. Their findings revealed that students struggled with the absence of physical lab work, which hindered their understanding of how scientific knowledge is produced. However, the study did not explore students' perceptions upon returning to in-person laboratory environments.

Similarly, Antonio (2018) highlighted that science teaching has long been rooted in experimentation and laboratory-based activities. While this affirms the instructional value of labs, there remains a gap in research examining students' attitudes toward hands-on chemistry lab work in the post-pandemic educational landscape. This is particularly relevant, as recent shifts in modality may have altered students' views and emotional responses toward science learning.

In a more recent study, Ramirez (2023) explored Grade 12 STEM students' experiences in a blended chemistry laboratory setup. The study emphasized the benefits and challenges of transitioning between online and physical settings. Although informative, it fell short of investigating how these shifts shaped students' behavioral engagement, such as their motivation, participation, and focus during in-person lab activities.

Furthermore, while previous works (e.g., Reid & Shah, 2007; Bernhard, 2018; Bretz, 2019; Pacifico & Prudente, 2021) acknowledge the value of laboratory instruction in building scientific inquiry skills and cognitive competencies, few studies have explicitly linked these experiences to students' future career aspirations in STEM. There is a pressing need to understand how early, meaningful lab work can influence students' decisions to pursue science-related professions.

Given these gaps, this study aims to explore the perceptions, attitudes, behavioral engagement, and career motivations of STEM students in the context of face-to-face chemistry laboratory work. By taking this approach, the research aims to support the creation of more responsive and inspiring STEM education programs aligned with contemporary learner needs.

Variation Theory and Social Cognitive Theory in Understanding Chemistry Laboratory Learning

This study is grounded by two theoretical foundations—Variation Theory and Social Cognitive Theory (SCT)—to explore how senior high school STEM students perceive and engage with chemistry laboratory work, and how these experiences shape their attitudes, behaviors, and aspirations toward future careers in science. Variation Theory, developed by Ference Marton, highlights that meaningful learning happens when learners experience differences or changes in key features of a concept. These variations help students focus on what truly matters. In the chemistry laboratory setting, this could mean observing how different variables affect a reaction or how techniques yield different results. Such experiences encourage deeper understanding by helping students distinguish the core ideas from superficial ones (Kullberg, Kempe, & Marton, 2017; Orgill, 2012). In this way, the lab becomes more than a place to follow instructions—it becomes a space for critical thinking, inquiry, and discovery.

However, while understanding how students grasp scientific concepts is important, it's equally crucial to consider why they engage—or disengage—in the learning process. This is where Albert Bandura's Social Cognitive Theory (1986) becomes relevant. SCT explains how students' confidence, motivation, and career goals are shaped not only by what they know, but also by their beliefs about their abilities, their

learning environment, and the people around them. In the context of laboratory work, a student's positive or negative experiences can strongly influence whether they see themselves as future scientists or whether they feel capable of succeeding in a science-related path.

By combining these two theories, this study offers a more complete picture of laboratory learning. Variation Theory helps explain the cognitive aspects of learning—how students come to understand chemical concepts through differences in lab experiences—while Social Cognitive Theory sheds light on the personal and social aspects of learning, including confidence-building and future aspirations.

This dual framework supports the design of chemistry laboratory experiences that are not only intellectually rigorous but also personally meaningful, fostering both scientific understanding and a stronger sense of identity and purpose among future STEM professionals.

Statement of the Problem

This study aims to describe and analyze the perceptions, attitudes, and motivations of general chemistry 2 students towards laboratory work in face-to-face settings, including the factors influencing their enjoyment, confidence, and future career aspirations in science of STEM senior high school students from NU Fairview during the academic year 2023–2024. Specifically, it sought to answer the following questions:

1. What is the demographic profile of the respondents in terms of:

a. sex and;

b. specialization

2. How may the chemistry laboratory work of the respondents be described in terms of:

2.1. perceptions

2.2 Confidence

2.2.1 Attitude

2.2.2 Behavior

2.3. future career aspirations

3. Is there a significant difference in the chemistry laboratory work of the respondents when grouped according to their profile?

Methodology

This study employed a descriptive-correlational research design to explore the perceptions, confidence (attitude and behavior), and motivation of Grade 12 STEM students regarding laboratory work, as well as

to examine differences based on demographic factors such as gender and specialization. This design allowed the researchers to measure naturally occurring differences among groups without manipulating variables, providing insights into how students' attitudes, behaviors, and motivation relate to their engagement in laboratory activities and future career aspirations.

The participants consisted of 465 Grade 12 STEM students from NU Fairview, Inc., selected through purposive sampling to ensure that respondents had prior exposure to laboratory work in their general chemistry 2 subject. Students' sex (male or female) and specialization (Allied Health, Architecture, Engineering, and ICT) were recorded to investigate whether these factors influenced perceptions, confidence, and motivation.

A structured survey questionnaire was utilized to measure the main variables: perceptions of laboratory work, confidence in performing laboratory tasks (attitude and behavior), and motivation toward laboratory activities. Each variable was assessed using validated 4-point Likert-type items (4 = Very High Extent, 1 = Very Low Extent). The instrument underwent a pilot test with 30 students from a different section, yielding a Cronbach's alpha of 0.70, indicating acceptable internal consistency.

The survey was administered electronically via Microsoft Forms, ensuring convenience, accuracy, and secure data collection. Respondents were informed of the study's objectives, their voluntary participation, and their right to withdraw at any time. All responses were anonymized and stored in password-protected files, in compliance with the Data Privacy Act of 2012 (RA 10173).

Data was analyzed using SPSS. Descriptive statistics—including percentage, standard deviation, and weighted mean—were used to summarize students' perceptions, confidence, and motivation. Independent samples t-tests were conducted to determine differences between male and female respondents, while one-way ANOVA was used to identify differences across specializations. These analyses provided insights into whether demographic factors influenced students' laboratory experiences and attitudes.

Results and Discussion

Table 4.1
Demographic Profile of the Respondents

	Male		Female		Total	
	N	***%***	***N***	***%***	***N***	***%***
Specialization						
Allied Health	40	8.60	169	36.34	209	44.94
Architecture	15	3.23	39	8.39	54	11.62
Engineering	97	20.86	26	5.59	123	26.45
ICT	59	12.69	20	4.30	79	16.99

The table shows a total of 211 male and 254 female respondents, indicating a higher number of female participants in the STEM field. Furthermore, most of the respondents belong to STEM sections specializing in allied health, followed by those in the engineering specialization.

Table 4.2.1
Chemistry Laboratory Work of Respondents in terms of Perceptions

Indicators	**WM**	**SD**	**VI**
a. I find chemistry laboratory work to be an essential part of my STEM education.	3.59	0.573	VHE
b. I feel that the chemistry laboratory sessions are well integrated with the theoretical concepts taught in lectures.	3.41	0.585	VHE
c. I believe that chemistry laboratory work helps me better understand scientific principles.	3.5	0.613	VHE
d. I find that the chemistry laboratory equipment and materials provided are adequate for my learning needs.	3.53	0.557	VHE
e. I think that the structure and organization of the chemistry laboratory sessions are effective.	3.41	0.613	VHE
f. I enjoy participating in chemistry laboratory work.	3.61	0.543	VHE
g. I find that chemistry laboratory work stimulates my interest in the subject matter.	3.53	0.605	VHE
Total	3.51	0.451	VHE
Note: WM – Weighted mean, VI – Verbal interpretation, 3.26–4.00 = To a Very High Extent (VHE), 2.51–3.25 To a High Extent (HE), 1.76–2.50 = To a Low Extent (LE), and 1.00–1.75 = No Extent at All (NE)			

The table demonstrates a very strong and consistently positive perception of chemistry laboratory work as part of their STEM education, as reflected by the overall weighted mean of 3.51 (SD = 0.451), interpreted as Very High Extent. All indicators received very high ratings, indicating that students view

laboratory activities not only as an essential component of their curriculum but also as an effective means of reinforcing theoretical concepts discussed during lectures. High ratings for enjoyment and interest stimulation suggest that laboratory work plays a significant role in sustaining student engagement and curiosity in chemistry. Additionally, students' perceptions of adequate laboratory equipment, effective organization, and strong integration with scientific principles highlight the supportive learning environment provided during laboratory sessions. Collectively, these findings suggest that well-structured and resource-supported laboratory instruction enhances conceptual understanding, promotes positive learning experiences, and strengthens students' appreciation of chemistry as a core discipline within STEM education.

Table 4.2.2
Chemistry Laboratory Work of Respondents in terms of Attitude

Indicators	**WM**	**SD**	**VI**
a. I feel confident in my ability to perform chemistry laboratory experiments accurately.	3.06	0.655	HE
b. I can solve problems that arise during chemistry laboratory work effectively.	3.05	0.623	HE
c. I am comfortable using the various instruments and tools in the chemistry laboratory.	3.2	0.614	HE
d. I am confident in my ability to follow chemistry laboratory protocols and safety procedures.	3.39	0.596	VHE
e. I believe I can interpret and analyze experimental data accurately.	3.08	0.668	HE
f. I feel prepared to tackle unexpected challenges during chemistry laboratory sessions.	3.12	0.671	HE
g. I feel that my chemistry laboratory skills have improved significantly since I started my STEM program.	3.34	0.608	VHE
Total	3.18	0.486	HE
Note: WM – Weighted mean, VI – Verbal interpretation, 3.26–4.00 = To a Very High Extent (VHE), 2.51–3.25 To a High Extent (HE), 1.76–2.50 = To a Low Extent (LE), and 1.00–1.75 = No Extent at All (NE)			

The Table presents the respondents' attitudes toward chemistry laboratory work in terms of confidence and perceived competence, with an overall weighted mean of 3.18 (SD = 0.486), indicating a High Extent of positive attitude toward their laboratory skills. This finding suggests that students generally feel capable and prepared to participate in chemistry laboratory activities as part of their STEM education. The highest confidence levels were observed in following laboratory protocols and safety procedures (WM = 3.39, SD = 0.596) and in the perceived improvement of laboratory skills since entering the STEM program (WM = 3.34, SD = 0.608), both interpreted as Very High Extent, implying that regular laboratory exposure and structured instructional support have effectively strengthened students' procedural competence and laboratory self-efficacy. In contrast, indicators related to solving problems that arise

during experiments (WM = 3.05, SD = 0.623) and interpreting and analyzing experimental data (WM = 3.08, SD = 0.668) obtained comparatively lower, though still High Extent, ratings. This pattern indicates that while students are confident in executing standard laboratory procedures, they may encounter challenges in tasks requiring higher-order analytical reasoning and independent decision-making, highlighting the need for instructional approaches that more deliberately emphasize problem-solving and data interpretation within laboratory activities.

Table 4.2.3
Chemistry Laboratory Work of Respondents in terms of Behavior

Indicators	**WM**	**SD**	**VI**
a. I feel that the complexity of the experiments affects my enjoyment of chemistry laboratory work.	3.3	0.633	VHE
b. I am more motivated when I receive support and guidance from laboratory instructors.	3.38	0.612	VHE
c. I enjoy chemistry laboratory work more when I collaborate with my peers.	3.48	0.598	VHE
d. I feel motivated when the experiments are relevant to real-world applications.	3.37	0.602	VHE
e. I find the feedback I receive on my laboratory work constructive and helpful.	3.3	0.64	VHE
f. I feel that the time allocated for laboratory sessions is sufficient to complete the experiments.	3.01	0.828	HE
g. I feel that the laboratory environment and ambiance positively influence my motivation.	3.26	0.639	VHE
Total	3.3	0.471	VHE

Note: WM – Weighted mean, VI – Verbal interpretation, 3.26–4.00 = To a Very High Extent (VHE), 2.51–3.25 To a High Extent (HE), 1.76–2.50 = To a Low Extent (LE), and 1.00–1.75 = No Extent at All (NE)

The table illustrates students' behavioral responses toward chemistry laboratory work in terms of motivation, engagement, and learning environment, with an overall weighted mean of 3.30 (SD = 0.471), indicating a Very High Extent of positive behavior during laboratory sessions. Students reported the highest levels of motivation when collaborating with peers (WM = 3.48, SD = 0.598), receiving guidance from instructors (WM = 3.38, SD = 0.612), and engaging in experiments with clear real-world relevance (WM = 3.37, SD = 0.602), highlighting the role of social interaction, instructional support, and contextualized learning in fostering active participation. These behavioral factors appear to reinforce students' confidence in the laboratory, as supportive and collaborative environments encourage students to attempt tasks, address challenges, and apply learned skills more effectively. Although most indicators were rated to a Very High Extent, the adequacy of time allotted for laboratory sessions received a comparatively lower rating (WM = 3.01, SD = 0.828), suggesting that time constraints may limit opportunities for deeper engagement and reflection, which are essential for strengthening confidence in

problem-solving and analytical tasks. Overall, the findings suggest that positive laboratory behaviors, particularly collaboration and instructor support, are closely linked to students' confidence and active engagement, while improved time management may further enhance both learning outcomes and self-efficacy in chemistry laboratory work.

Table 4.2.4
Chemistry Laboratory Work of Respondents in terms of Future Career Orientations

Indicators	**WM**	**SD**	**VI**
a. I feel that my experience in chemistry laboratory work has positively influenced my career aspirations in STEM.	3.26	0.704	VHE
b. I see chemistry laboratory skills as crucial for my future career in science or engineering.	3.17	0.757	HE
c. I feel that chemistry laboratory work has helped me clarify my specific career goals within STEM.	3.16	0.736	HE
d. I believe that my chemistry laboratory experience will make me more competitive in the job market.	3.12	0.73	HE
e. I feel that my interest in pursuing a research-oriented career has increased because of chemistry laboratory work.	2.98	0.805	HE
f. I feel that my chemistry laboratory experience has made me consider pursuing further studies in my field course.	3.08	0.735	HE
g. I feel that my chemistry laboratory experience is preparing me well for my future career.	3.19	0.712	HE
Total	3.14	0.62	HE
Note: WM – Weighted mean, VI – Verbal interpretation, 3.26–4.00 = To a Very High Extent (VHE), 2.51–3.25 To a High Extent (HE), 1.76–2.50 = To a Low Extent (LE), and 1.00–1.75 = No Extent at All (NE)			

The table indicates a generally positive perception, with an overall weighted mean of 3.14 (SD = 0.62), interpreted as High Extent. The highest-rated item (WM = 3.26, SD = 0.704, VHE) reflects students' recognition that laboratory experiences have positively influenced their career aspirations in STEM, suggesting that hands-on engagement helps them connect current learning to long-term professional goals. Other indicators, including the perceived importance of laboratory skills for future science or engineering careers (WM = 3.17), the clarification of specific STEM career goals (WM = 3.16), and preparation for competitiveness in the job market (WM = 3.12), all fall within the High Extent range, highlighting students' acknowledgment of the practical and strategic value of laboratory experiences in shaping employability and professional readiness. Additionally, items related to fostering interest in research-oriented careers (WM = 2.98) and motivating further studies (WM = 3.08) suggest that while laboratory work encourages broader STEM career engagement, there remains room to enhance students' enthusiasm for research pathways. Overall, these findings indicate that chemistry laboratory experiences not only reinforce technical competence and confidence but also serve as an influential factor in students' career planning, goal setting, and aspirations within STEM fields, emphasizing the

need for more targeted support, mentorship, and exposure to research-oriented opportunities to fully cultivate students' career readiness and professional interests.

Table 4.3
Test of Difference on Chemistry Laboratory Works

	Sex	**Specialization**
	P-Value	***P-Value***
a. Perceptions	0.310	0.013
b. Attitude	0.322	0.018
c. Behavior	0.777	0.006
d. Future career aspirations	0.369	0.000
Note: The P-value in sex is computed using independent t-test, P-value in specialization is computed using one-way ANOVA, level of significance is 0.05.		

H_o1

There is no significant difference in the chemistry laboratory work of the respondents when grouped according to their sex.

H_o2

There is no significant difference in the chemistry laboratory work of the respondents when grouped according to their specialization.

The table indicates that the calculated p-value for the chemistry laboratory work of the respondents, when grouped by sex, did not show statistically significant differences in the chemistry laboratory work between male and female respondents. Therefore, the hypothesis 1 is accepted when grouped according to sex. On the other hand, there is a statistically significant difference in the chemistry laboratory work of the respondents when grouped according to their specialization. In other words, the specialization of the respondents has a significant impact on their performance in the chemistry laboratory work.

Conclusion and Recommendation

This study provides empirical evidence supporting the pedagogical value of face-to-face chemistry laboratory instruction in senior high school STEM education. Overall, students demonstrated positive perceptions of laboratory work as a critical instructional component that enhances conceptual understanding and facilitates the application of theoretical knowledge. While confidence in procedural and technical laboratory skills was consistently high, the findings indicate comparatively lower confidence in higher-order competencies, particularly problem-solving, data analysis, and interpretation

of results. These competencies are central to scientific reasoning and warrant deliberate instructional emphasis within laboratory settings.

Student motivation toward laboratory participation was strongly associated with collaborative learning environments, instructor facilitation, and the perceived relevance of experiments to real-world and career contexts. Although students generally recognized the role of laboratory experiences in supporting STEM career aspirations, the results suggest that existing laboratory practices may not fully capitalize on their potential to stimulate sustained interest in research-oriented pathways. Furthermore, while gender did not significantly influence students' perceptions or confidence, differences observed across STEM specializations highlight the importance of discipline-relevant laboratory contexts in shaping engagement and perceived performance.

Based on these findings, several evidence-based recommendations are proposed. First, laboratory curricula should integrate structured opportunities for problem-solving and data interpretation to strengthen analytical and scientific reasoning skills. Second, appropriate time allocation and pacing of laboratory activities should be reviewed to maximize student engagement and depth of learning. Third, institutions are encouraged to provide early and authentic research exposure through inquiry-based projects, mentorship, and research-linked laboratory experiences. Fourth, laboratory activities should be contextualized to align with students' STEM specializations to enhance relevance and learning outcomes. Finally, sustained efforts to maintain gender-inclusive laboratory environments remain essential to ensuring equitable participation and long-term STEM engagement.

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