

Lived Experiences of STEM Graduates in College Biology Laboratory Courses: Challenges and Coping Strategies

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Abstract. Laboratory learning plays a crucial role in science education by bridging theoretical knowledge and practical application. However, limited qualitative studies have explored the lived experiences of STEM graduates transitioning to college biology laboratories, particularly in the Philippine context. This study aimed to explore the lived experiences of STEM graduates in college biology laboratory courses, identify the challenges they encountered, examine their coping strategies, and develop a Science Laboratory Action Plan to improve laboratory learning. A qualitative phenomenological research design was employed involving fourteen (14) purposively selected nursing students who graduated from the STEM strand. Data were gathered through semi-structured interviews and analyzed using Braun and Clarke's thematic analysis with NVivo-assisted coding. The findings revealed that participants experienced a significant transition to a more advanced laboratory environment characterized by unfamiliar equipment, complex procedures, and higher academic expectations. Although their STEM background provided foundational knowledge, it was insufficient to fully prepare them for college laboratory demands. Participants commonly experienced difficulties in using laboratory equipment, following procedures, and adapting to limited hands-on experience. They coped through peer collaboration, instructor guidance, self-directed learning, and repeated practice, which strengthened their confidence and laboratory competence. The findings informed the proposed Project LAB (Learning Advancement in Biology) to enhance laboratory instruction, student preparedness, and overall laboratory learning experiences.

Keywords: biology laboratory; challenges; coping strategies; laboratory learning; lived experiences

Introduction

College biology labs are an important part of how students learn. Lectures usually cover scientific ideas more abstractly, but labs let students apply what they learn by working directly with materials and conducting experiments. For many, moving from theory to practice is exciting because it helps them understand better and feel more confident. However, some students, especially those with little lab experience or limited resources, may find labs stressful and start to doubt themselves.

Studies show that biology labs are often one of the hardest parts of science education. Hofstein and Lunetta (2020) explain that labs are more than just places to learn; they are spaces where students build scientific knowledge through real-world applications. Without enough hands-on practice, students can struggle to learn lab skills and think like scientists. This can make labs feel less empowering and more overwhelming, leading students to worry about making mistakes and doubt their abilities.

Despite coming from STEM or related strands, students possess varying levels of readiness for laboratory work. The transition from classroom-based learning in high school to hands-on laboratory work in college can be difficult, even in well-equipped institutions. In schools with limited resources, these challenges become more pronounced. Mendez and Senining (2023) found that the laboratory learning environment significantly influences students' practices, with material resources being the strongest factor. This highlights how the availability or lack of equipment directly affects students' ability to perform tasks effectively.

This study focuses on how college students navigate biology laboratory courses under conditions of limited resources and high academic demands. It examines their preparation, engagement, and understanding during laboratory sessions, as well as their emotional responses and coping mechanisms. Rather than focusing solely on academic performance, the study aims to capture students' lived experiences as they navigate challenges and adapt through persistence and self-discipline. By giving voice to students' experiences, this research seeks to provide context-specific insights into the realities of laboratory learning in the Philippines. While previous studies, such as those by Hofstein and Lunetta (2004) and Abrahams and Millar (2008), have emphasized the importance of laboratory work in science education, there remains a lack

of research focusing on students' personal experiences, particularly in local contexts. Most existing studies examine general laboratory conditions rather than students' challenges, emotions, and coping strategies.

Addressing this gap, the present study contributes to the growing body of knowledge by exploring the lived experiences of STEM graduates in college biology laboratories. It aims to shed light on the difficulties they encounter and the adaptive strategies they employ, ultimately providing insights that may inform improvements in laboratory instruction and support systems.

Research Questions

The study problem that the researcher examined concerned the lived experiences of STEM graduates in the laboratory subjects of their college courses. Specifically, this sought answers to the following sub-problems:

1. What are the lived experiences of STEM graduate respondents in their college biology laboratory courses?
2. What challenges do the respondents encounter in their biology laboratory courses?
3. In what ways do the respondents cope with the difficulties they encounter in their biology laboratory classes?
4. Based on the findings of the study, what Science Laboratory Action Plan would help improve the laboratory learning experiences of the future STEM students?

Scope and Delimitation of the Study

This study is limited to students' self-reported experiences and does not include numerical measures such as grades, test scores, or formal assessments of laboratory facilities. It also does not cover non-biology laboratory courses or the perspectives of teachers and administrators, as the primary goal is to capture firsthand experiences of learners directly engaged in laboratory activities. Including other groups may shift the focus away from the students' personal narratives, which are central to this research. The study is limited only to the exploration of experiences and does not establish causal relationships. The results of the study are presented in thematic tables and a thematic map to provide a clear, organized presentation of the findings.

Literature Review

Students' Biology Laboratory Experiences

Biology laboratory learning plays a vital role in science education by enabling students to connect theoretical concepts with practical application. Beyond developing scientific knowledge and technical skills, laboratory experiences also influence students' confidence, emotional engagement, and sense of belonging in science. Across different educational settings, studies consistently report that repeated exposure to hands-on laboratory activities enhances students' self-efficacy while helping them become more engaged and motivated in learning (Adams & McCullough, 2023; Robinson & Turner, 2023). However, laboratory experiences are often accompanied by mixed emotions, as students may simultaneously feel excitement, curiosity, and anxiety when working with unfamiliar equipment, procedures, and scientific tasks.

Previous studies also emphasize that the quality of students' laboratory experiences is strongly influenced by their prior preparation. Students with limited laboratory exposure before entering college often report feelings of fear, uncertainty, and stress, particularly in institutions with inadequate laboratory resources (Garcia et al., 2022; Nesbit & Thomas, 2022; Roxas & Jaramillo, 2022). In contrast, students who enter college with prior hands-on experience demonstrate greater confidence, stronger engagement, and a higher willingness to participate in laboratory activities (Martinez-Cortes et al., 2022; Hernandez et al., 2024). These experiences are particularly important in biology-related programs such as Nursing, where laboratory learning serves as a foundation for future clinical practice. Consequently, students often perceive biology laboratories as high-pressure learning environments because mistakes may affect both their academic performance and professional preparedness (Betz et al., 2021; Peterson & King, 2024).

Students' Challenges in Biology Laboratory Learning

Despite the recognized benefits of biology laboratory learning, students commonly encounter challenges that affect their learning experiences. Existing literature identifies limited laboratory exposure, unfamiliar equipment, insufficient instructional guidance, time constraints, and inadequate resources as recurring barriers to meaningful laboratory participation. These factors often hinder students' ability to connect theoretical knowledge with practical applications and reduce their confidence in performing laboratory procedures.

Research further indicates that students' initial laboratory experiences are frequently characterized by confusion and uncertainty, especially when they struggle to relate laboratory activities to concepts

discussed in lectures (Finne et al., 2022). Early laboratory experiences are often viewed as procedural tasks rather than meaningful opportunities for scientific inquiry (Keen & Sevian, 2021; Jimenez & August, 2025). However, as students gain more exposure, many begin to appreciate laboratory activities as valuable opportunities for developing conceptual understanding through observation and experimentation (Hernandez, Patel, & Kim, 2024; Lopez & Tan, 2022). Collectively, these findings suggest that students' laboratory experiences are shaped by the interaction of prior preparation, instructional support, and the overall laboratory learning environment, all of which influence their confidence, engagement, and adjustment to laboratory learning (Nicol et al., 2022; Katz et al., 2023).

Students' Coping Strategies in Biology Laboratory Learning

To adapt to the demands of biology laboratory learning, students employ various coping strategies that enable them to overcome challenges and improve their laboratory experiences. The literature consistently highlights peer collaboration, instructor support, and self-directed learning as the most common strategies used by students to manage laboratory-related difficulties.

Collaborative learning allows students to exchange ideas, clarify procedures, divide laboratory tasks, and build confidence through shared experiences (McAlpin et al., 2023; Davis et al., 2024). Likewise, instructor support plays a significant role in reducing students' anxiety and strengthening their motivation. Clear demonstrations, timely feedback, and a supportive learning environment encourage students to ask questions, participate actively, and view mistakes as opportunities for learning rather than failure (Wineinger et al., 2022; Harrison & Carr, 2023). In addition, students increasingly engage in self-directed preparation by reviewing laboratory manuals, studying experimental procedures independently, and utilizing available learning resources before laboratory sessions. Together, these coping strategies promote resilience, improve laboratory competence, and enhance students' overall biology laboratory experiences.

Although previous studies have extensively examined laboratory learning, laboratory challenges, and coping strategies, most have focused on students' academic performance, laboratory readiness, or the effectiveness of laboratory instruction. Comparatively fewer studies have explored the lived experiences of STEM graduates as they transition into college biology laboratory learning, particularly within the Philippine context. Moreover, existing research tends to examine laboratory experiences, challenges, and coping strategies separately rather than understanding how these experiences collectively shape students' adaptation to biology laboratory learning. This study addresses this gap by exploring the lived experiences of STEM graduates in college biology laboratory courses through a phenomenological approach, providing a deeper understanding of how they experience, interpret, and cope with the realities of laboratory learning.

Methodology

Research Design

This study employed a qualitative phenomenological research design using semi-structured interviews to explore the lived experiences of STEM graduates in college biology laboratory courses. Phenomenology was deemed appropriate because it seeks to understand how individuals perceive, interpret, and make meaning of their experiences with a particular phenomenon. In this study, the phenomenon refers to the transition of STEM graduates into biology laboratory learning within their Nursing program. Participants were selected based on their direct experience with the phenomenon under investigation. Specifically, they had to be graduates of the STEM strand within the previous two years, currently enrolled in a Nursing program, have completed college biology laboratory courses, and be willing to share their experiences. These criteria ensured that participants possessed relevant and recent laboratory experiences, enabling them to provide rich and meaningful descriptions of the challenges they encountered and the strategies they used to cope with them. Individual semi-structured interviews lasting approximately 30 to 60 minutes were conducted either through Google Meet or face-to-face, depending on participants' availability and preference. With participants' consent, all interviews were audio-recorded. Ethical standards were observed by ensuring voluntary participation, maintaining anonymity and confidentiality, securely storing all research data, and informing participants of their right to withdraw from the study at any stage without penalty. The interview transcripts were analyzed using the six-phase thematic analysis framework of Braun and Clarke (2006), which involved familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. NVivo software was utilized to facilitate systematic coding, organization, and retrieval of qualitative data. The identified themes were presented through thematic tables and a thematic map to illustrate the relationships among participants lived through experiences.

Sampling Design

The study employed purposive sampling; a non-probability sampling technique commonly used in phenomenological research to identify participants who have firsthand experience with the phenomenon being investigated. This approach allowed the researcher to obtain rich, detailed, and information-rich accounts relevant to the study objectives. Fourteen Nursing students who graduated from the STEM strand within the previous two years participated in the study. Participants met the following inclusion criteria: 1) Completed the STEM strand during senior high school; 2). Currently enrolled in a Nursing program and had completed college biology laboratory courses; and 3). Voluntarily agreed to participate in the study. The sample size was considered appropriate because phenomenological studies typically involve 5 to 25 participants, allowing for in-depth exploration of lived experiences (Creswell & Poth, 2018). Data collection continued until data saturation was achieved, indicating that no new themes or significant insights emerged from subsequent interviews.

Research Locale

The study was conducted in Lucena City, Quezon Province, Philippines, an urbanized city with higher education institutions offering Nursing programs that include college biology laboratory courses. The locale was selected because it provides access to Nursing students who completed the STEM strand and have undergone laboratory-based instruction relevant to the phenomenon being investigated. The selected institution offers laboratory facilities where students perform biology-related experiments, utilize laboratory equipment, and develop practical scientific skills as part of their curriculum. Conducting the study in this setting enabled the researcher to gather rich descriptions of participants' lived experiences within an authentic biology laboratory learning environment.

Research Participants

The participants consisted of 14 Nursing students who met the established inclusion criteria and were selected through purposive sampling. They were chosen because they had directly experienced the transition from the STEM strand to college biology laboratory courses, making them capable of providing detailed descriptions of their laboratory experiences. Following the recommendation of Creswell and Poth (2018), the number of participants was sufficient for phenomenological research, as the emphasis is placed on obtaining depth and richness of information rather than statistical representation.

Research Instrument

The primary research instrument was a researcher-developed semi-structured interview guide consisting of ten open-ended questions designed to elicit participants' lived experiences in college biology laboratory courses. The interview questions focused on participants' laboratory experiences, perceived challenges, coping strategies, and reflections on laboratory learning. To establish content validity, the interview guide was reviewed by three experts with backgrounds in qualitative research and science education. Their recommendations regarding clarity, relevance, sequencing, and alignment with the research objectives were incorporated before the conduct of the study. Prior to the actual data collection, the interview guide underwent pilot testing with participants who possessed characteristics similar to the target respondents but were not included in the final study. Feedback from the pilot interviews was used to improve question wording, clarity, and flow. During data collection, follow-up probing questions were employed whenever necessary to obtain deeper and more comprehensive responses.

Data Gathering Procedure

Before data collection, approval was obtained from the appropriate school authorities, and informed consent was secured from all participants. Individual semi-structured interviews were conducted either face-to-face or through Google Meet over a two-week period, depending on participants' availability. Each interview lasted approximately 30–60 minutes and was guided by the validated interview protocol. With participants' permission, all interviews were audio-recorded and supplemented with field notes. The recordings were transcribed verbatim and translated into English when necessary. To ensure the accuracy and credibility of the transcripts, an English language expert reviewed the translations, while member checking was conducted by allowing participants to verify the accuracy of their responses. The finalized transcripts were imported into NVivo for coding and thematic analysis following Braun and Clarke's (2006) six-step framework. Throughout the research process, participants' identities were protected through the use of pseudonyms, all electronic files were securely stored in password-protected devices, and the collected data were used solely for academic and research purposes.

Results and Discussions

Research Question 1: What are the lived experiences of STEM graduate respondents in their college biology laboratory courses?

Table 1. The lived experiences of STEM graduate respondents in their college biology laboratory courses

Exemplar	Subthemes	Theme
"And when I entered college, all the laboratories here were fully equipped with different equipment, like microscopes, the basic ones. So, the inability to experience that during senior high school was definitely a new thing for me when I actually experienced it here in college". – I1	Exposure to complete laboratory facilities; Availability of scientific equipment; First exposure to hands-on laboratory activities	Experiencing the Transition to a More Advanced Laboratory Environment
"Based on my experience during my first year, it was not easy. Not everything was covered during high school; however, I would say that some lecture topics were familiar to me because I had already learned about them before". –I2	Familiarity with biology concepts; Prior STEM academic preparation; Background knowledge in science subjects	Applying STEM Academic Background in Laboratory Learning
"Before the class started, we were oriented on the equipment that we would use, and we reviewed the procedures in the laboratory." – I7	Laboratory orientation and safety procedures; Instructor guidance in laboratory activities; Familiarization with laboratory equipment	Receiving Guidance and Orientation in Laboratory Learning
"Our first experiment in Biochem was to observe an onion cell. We dissected the onion and used a scalpel, then we used a microscope" – I13	Conducting microscopic observations; Performing basic biological experiments; Connecting theoretical knowledge with laboratory practice	Engaging in Hands-on Biological Laboratory Activities

The findings indicate that the participant's lived experiences were characterized by a transition from the relatively limited laboratory exposure they received during senior high school to a more structured and resource-rich college biology laboratory environment. This transition required students to adapt not only to unfamiliar laboratory equipment and procedures but also to increased academic expectations. Although participants acknowledged that their STEM background provided a foundation in biological concepts, they emphasized that theoretical knowledge alone was insufficient to prepare them for the practical demands of laboratory learning. Their experiences demonstrate that meaningful laboratory learning occurs when conceptual understanding is reinforced through authentic, hands-on activities.

The themes also highlight the importance of laboratory orientation and instructor guidance in facilitating students' adjustment. Orientation sessions reduced uncertainty by familiarizing students with laboratory equipment, safety protocols, and experimental procedures before actual laboratory work. Likewise, engaging in laboratory activities enabled students to bridge the gap between classroom knowledge and practical application, supporting experiential learning principles that emphasize learning through direct experience.

These findings support previous studies showing that hands-on laboratory experiences improve students' conceptual understanding, scientific reasoning, and engagement (Theobald et al., 2020; Singh & Rao, 2023). Similarly, Trujillo and Tanner (2016) argued that active participation allows students to construct knowledge more effectively than passive instruction alone. Beyond confirming previous literature, the present findings reveal that students perceive the transition itself as a critical developmental stage that shapes their confidence and readiness for succeeding laboratory experiences.

Research Question 2: What challenges do the respondents encounter in their biology laboratory courses?

Table 2. challenges do the respondents encounter in their biology laboratory courses

Exemplar	Subthemes	Theme
"We weren't really able to use laboratory equipment. And we were only taught how to use them. But we were not able to actually utilize those lectures to apply them in the laboratory" – I1.	Limited hands-on experience in senior high school; No sufficient laboratory work; Difficulty in handling laboratory tools; Not much experience using microscopes and other laboratory instruments. Fear of mishaps during the laboratory work; nervousness in handling chemicals;	Encountering Difficulties Due to Limited Prior Laboratory Exposure
"One difficulty was the fear of breaking the glassware, since most laboratory equipment is fragile; I was not yet very familiar with handling the equipment" – I9	Lack of confidence in using laboratory equipment; Concerns about lab safety measures. Not enough time for laboratory work	Experiencing Fear and Uncertainty in Handling Laboratory Materials
"Instead of enjoying it, or taking time to appreciate what we're doing, what we understand is the pressure of finishing it right away" – I6	Trouble in finishing experiments; Pressure to complete laboratory tasks; Laboratory procedures hastened. Shortage of laboratory equipment;	Facing Time Constraints During Laboratory Sessions
"We encountered challenges because our lab is a group-based lab, which always happens that our group is the last to complete the lab because of limited resources." -I12	Broken or out-of-stock apparatus; Equipment sharing among groups; Laboratory work delays. Not enough detailed instructions.	Experiencing Limitations in Laboratory Resources
"We are not taught the procedure and what will happen." - I11	Small-scale demonstration of processes. Only expected students to have prior knowledge; less instructional help.	Experiencing Limited Instructional Guidance in Laboratory Activities

The findings reveal that students' laboratory difficulties extended beyond technical skills and reflected broader issues related to preparation, confidence, instructional support, and resource availability. Participants' fear of handling fragile equipment and unfamiliar chemicals suggests that limited prior laboratory exposure contributes to laboratory anxiety and hesitation during practical activities. Likewise, insufficient instructional guidance and limited laboratory resources reduced opportunities for meaningful engagement, resulting in uncertainty and delayed task completion.

The pressure created by limited laboratory time and equipment sharing further affected students' ability to fully understand experimental procedures. Rather than focusing on scientific inquiry, participants often became preoccupied with completing activities within time constraints. This finding suggests that laboratory learning may become task-oriented rather than concept-oriented when instructional and institutional support is inadequate.

These results are consistent with Seery (2020), who emphasized that structured demonstrations and guided laboratory instruction enhance procedural competence and confidence. Likewise, Velasco et al. (2021) reported that instructor-led demonstrations significantly improve students' experimental accuracy and conceptual understanding. The present study extends these findings by illustrating how multiple challenges—including inadequate preparation, insufficient resources, and limited instructional guidance—interact to shape students' overall laboratory experiences rather than existing as isolated barriers.

Research Question 3: In what ways do the respondents cope with the difficulties they encounter in their biology laboratory classes?

Table 3. The ways the respondents cope with the difficulties they encounter in their biology laboratory classes

Exemplar	Subthemes	Theme
"I closely watched the demonstrations so that I know what I really need to do" -I1.	Observing lab demos. Learning from visual cues and following the instructor's actions closely.	Learning Through Instructor Demonstrations
"I tried to find the right circle, maybe they know something that I don't know, and I know something that they don't know, so we just share information, and we can help each other." - I6.	Peer collaboration during experiments; Group cooperation in laboratory tasks; Sharing ideas and strategies with classmates; Supporting each other in completing procedures	Collaborative Peer Learning in the Laboratory
"When there's something unfamiliar, I search on the internet on how to do it. So, when it comes to our lab schedule, I'm somehow prepared" - I13	Reviewing laboratory manuals; Self-study of experimental procedures; Independent preparation before laboratory sessions; Learning laboratory concepts outside the classroom.	Engaging in Self-Directed Laboratory Preparation
"Since we work as a group, proper communication with groupmates is important. With the guidance of our professor, the process becomes easier" - I9.	Seeking assistance from instructors, consulting classmates for clarification, asking questions during laboratory sessions, and requesting guidance on experimental procedures.	Seeking Academic Support for Laboratory Understanding
"As for student preparation, based on my experience, it's better not to cram or ignore activities." - I9.	Maintaining composure during challenges; Learning from laboratory errors; Developing patience during experimentation; Building confidence through repeated practice	Developing Resilience Through Laboratory Experience

Despite the challenges they encountered, participants demonstrated resilience by adopting various coping strategies that enabled them to continue learning effectively. Students relied on instructor demonstrations to clarify procedures, collaborated with peers to exchange knowledge and solve problems, independently reviewed laboratory materials before laboratory sessions, and actively sought guidance from instructors whenever necessary. These strategies illustrate that successful laboratory learning depends not only on individual ability but also on the availability of academic and social support.

The findings further suggest that coping strategies gradually transformed students from passive learners into more confident and independent participants in laboratory activities. Through repeated practice, preparation, and collaborative learning, participants developed greater confidence in handling laboratory equipment and performing scientific procedures. This progression reflects experiential learning, where repeated engagement with authentic tasks enhances both competence and self-confidence.

These findings are consistent with previous studies highlighting the importance of collaborative learning and instructor support in laboratory education (McAlpin et al., 2023; Davis et al., 2024). Similarly, Wineinger et al. (2022) and Harrison and Carr (2023) found that supportive instructor-student relationships encourage students to participate actively, ask questions, and develop confidence during laboratory activities. The present study further demonstrates that resilience develops through the combined influence of peer collaboration, instructor guidance, and self-directed preparation rather than through any single strategy alone.

Research Question 4: Based on the findings of the study, what Science Laboratory Action Plan would help improve the laboratory learning experiences of the future STEM students?

The proposed PROJECT LAB: Laboratory Advancement for Biology Learning was developed directly from the themes that emerged across the study. Rather than serving as a general recommendation, the action plan provides targeted interventions that address the specific experiences, challenges, and coping strategies identified by the participants.

The transition to an advanced laboratory environment highlighted the need for structured laboratory orientation; therefore, the Laboratory Orientation Program was designed to familiarize incoming students with laboratory equipment, procedures, and safety practices before actual laboratory work. Likewise, the challenges associated with limited prior exposure, lack of confidence, and insufficient instructional support led to the inclusion of Hands-on Practice Sessions and Instructor-Guided Demonstrations, allowing students to develop procedural competence in a supportive environment.

The coping strategies identified in the study also informed the collaborative and self-directed components of PROJECT LAB. Peer Collaboration Activities encourage cooperative learning and knowledge sharing, while supplementary learning materials, including laboratory manuals, instructional videos, and virtual laboratory resources, promote independent preparation before laboratory sessions. Together, these components address both the academic and psychological needs of students by enhancing laboratory readiness, reducing anxiety, and strengthening confidence.

Overall, the alignment between the study findings and PROJECT LAB demonstrates that the proposed action plan is evidence-based and responsive to the lived experiences of STEM graduates. By directly translating participants' experiences into practical interventions, PROJECT LAB has the potential to improve laboratory preparedness, strengthen students' scientific competencies, and promote more meaningful and engaging biology laboratory learning experiences.

Ethical Considerations

Ethical principles were observed throughout the study to protect the rights, dignity, and welfare of the participants. Prior to data collection, informed consent was obtained after explaining the study's purpose, procedures, and voluntary nature. Participants were informed of their right to withdraw at any time without consequence. Confidentiality was maintained by using pseudonyms, and all interview recordings, transcripts, and related files were securely stored and accessed only by the researcher. Data were used exclusively for academic purposes, and participants' privacy and anonymity were preserved throughout the research process.

Conclusion

This phenomenological study provides a deeper understanding of the lived experiences of STEM graduates as they transition into college biology laboratory courses within Nursing education. The findings reveal that while a STEM background provides foundational scientific knowledge, it does not fully prepare students for the practical, technical, and emotional demands of college laboratory learning. Participants described a transition characterized by unfamiliar laboratory equipment, increased academic expectations, and the need to adapt to more complex laboratory procedures. The study further demonstrates that students overcome these challenges through instructor guidance, peer collaboration, self-directed preparation, and repeated laboratory practice. These experiences highlight that successful laboratory learning depends not only on prior academic preparation but also on supportive learning environments that foster confidence, skill development, and meaningful engagement. A significant contribution of this study is the development of PROJECT LAB: Laboratory Advancement for Biology Learning, an evidence-based action plan derived directly from the participants' lived experiences. By translating students' experiences into practical interventions, the study contributes to improving laboratory orientation, instructional support, and hands-on learning opportunities. These findings provide valuable insights for enhancing biology laboratory instruction and supporting the successful transition of future STEM graduates into college laboratory learning.

Recommendations

Based on the findings of this study, higher education institutions, particularly Nursing and science departments, are encouraged to implement PROJECT LAB: Laboratory Advancement for Biology Learning to better prepare students for college biology laboratory courses through structured laboratory orientation, hands-on practice sessions, instructor-guided demonstrations, peer collaboration activities, and supplementary learning resources. Faculty members are encouraged to strengthen laboratory instruction by providing clear demonstrations, continuous guidance, and constructive feedback to enhance students' confidence and practical competencies, while curriculum developers and academic administrators may review and strengthen laboratory curricula to improve the alignment between senior high school STEM preparation and the expectations of college biology laboratory courses. Students are likewise encouraged to actively prepare for laboratory sessions by reviewing laboratory procedures, engaging in collaborative learning, seeking guidance from instructors, and participating actively during laboratory activities to further develop their scientific knowledge and practical skills. Finally, future researchers are encouraged to replicate this study in different higher education institutions and science-related programs and to evaluate the

effectiveness of PROJECT LAB in improving students' laboratory readiness, confidence, and overall biology laboratory learning experiences.

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