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LABORATORY-BASED SCIENCE INSTRUCTION IN PUBLIC SCHOOLS: INSIGHTS FROM TEACHERS' EXPERIENCES AND IMPLICATIONS FOR CONTEXTUALIZED INTERVENTIONS IN BATAAN, PHILIPPINES

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ABSTRACT
This study examines the lived experiences of science teachers in public senior high schools in Bataan, Philippines, focusing on barriers to effective laboratory-based science instruction. Findings reveal seven interconnected themes: resource limitations, exposure to virtual laboratory tools, professional development and technical training needs, administrative support, teacher motivation, student engagement, and time constraints with workload issues. These challenges impede quality science instruction and reflect systemic educational planning deficiencies. The research recommends targeted interventions including increased funding allocation, comprehensive professional development programs, administrative empowerment strategies, and enhanced exposure to virtual laboratory platforms. The findings emphasize the critical need for supportive, adequately resourced environments that enable teachers to facilitate authentic scientific inquiry experiences for students.
KEYWORDS: *Laboratory-Based Instruction, Science Education, Teacher Experiences, Public Senior High Schools, Philippine STEM Education*

INTRODUCTION

Laboratory-based instruction serves as a fundamental component of effective science education, fostering scientific literacy, inquiry skills, and real-world problem-solving abilities (Kotsis, 2024; Huang, 2022; Hofstein, 2004). Through hands-on experimentation, learners can apply theoretical concepts, leading to deeper understanding and improved knowledge retention. Within the Philippine basic education system, science education constitutes an essential element of the Senior High School curriculum, particularly within the STEM (Science, Technology, Engineering, and Mathematics) track. Laboratory-based instruction enables students to engage directly with scientific concepts, developing critical thinking, problem-solving, and scientific inquiry skills necessary for future STEM careers (Astawan et al., 2023; Huang, 2022).

Despite its importance, the Philippine public school system faces significant barriers to delivering high-quality laboratory-based science instruction, particularly in underfunded and rural areas. In Bataan province, many public schools struggle with outdated laboratory equipment, insufficient chemicals, and limited experimental spaces. Teachers in these schools often report diminished motivation and inadequate preparation, negatively impacting science instruction quality and student learning outcomes (Mangarin & Macayana, 2024; Pacala, 2023; Perdio, 2022).

Effective science education requires substantial teacher confidence and self-efficacy, particularly regarding laboratory management and safety protocols (Rivera & Manalastas, 2025; Koç, & Çavas, 2022; Faulconer et al., 2020; Maeng et al., 2020). However, many teachers lack formal training in laboratory management, constraining their instructional effectiveness (Cabacungan & Calzada, 2025; Rivera & Manalastas, 2025; Caballes et al., 2024). International research consistently demonstrates that effective science teaching depends on resource availability, teacher confidence, and institutional support (Cudal et al., 2024; Seno & Paglinawan, 2024; UNESCO, 2021; Noble, 2016). Nevertheless, evidence remains limited regarding how Filipino science educators navigate these challenges, particularly in laboratory settings.

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This study explores the lived experiences of science teachers in Bataan, specifically examining challenges in laboratory-based science instruction. Using a phenomenological approach, the research investigates barriers teachers encounter and their self-perceptions as science educators. The study aims to provide insights and recommendations for improving STEM education quality in the Philippines. This research holds significance in providing understanding of barriers to effective laboratory-based science instruction in Philippine public senior high schools. It contributes to expanding research on STEM education in under-resourced settings and offers practical insights for science education quality improvement. The findings can inform policy development at local and national levels, ensuring public schools receive adequate laboratory resources and teacher training opportunities.

OBJECTIVES

This study explored public school science teachers' perspectives regarding laboratory-based instruction experiences, guided by the following objectives:

1. Examine challenges encountered by teachers conducting laboratory-based instruction in public senior high schools.
2. Identify institutional and personal factors influencing teacher motivation and student engagement in laboratory classes.
3. Recommend context-responsive interventions addressing identified barriers in public science instruction.

METHODOLOGY

Research Design. This study employed a qualitative research design with a phenomenological approach. Phenomenology explores and interprets individuals' lived experiences and their perceptions of these experiences (Dodgson, 2023). This approach was selected to develop deeper understanding of science teachers' experiences and challenges in laboratory-based instruction.

Participants. The study included 10 science teachers from public senior high schools in Bataan. Participants were selected using purposive sampling to ensure diversity in gender, subject specialization (Biology, Chemistry, and Physics), and teaching experience (minimum three years). This diversity facilitated representation of experiences across different contexts and teaching backgrounds.

Data Collection. Data were collected through semi-structured interviews allowing in-depth exploration of participants' experiences and self-perceptions regarding laboratory-based teaching. All interviews were recorded, transcribed, cleaned, and analyzed for emerging patterns and themes.

Data Analysis. Data analysis employed thematic analysis, involving identification and examination of patterns within qualitative data (Kushnir, 2025; Braun & Clarke, 2006). The analysis process included:

1. Familiarization with data through multiple transcript readings
2. Coding significant excerpts related to research questions
3. Grouping related codes into broader themes
4. Refining themes to accurately capture teachers' experiences

Ethical Considerations. All participants provided informed consent. They were assured of voluntary participation, confidentiality of identities and responses, and the right to withdraw from the study without consequence at any time.

RESULTS AND DISCUSSION

Resource Limitations in Laboratory-Based Instruction. A primary challenge identified by teachers was the limited availability of resources necessary for effective laboratory-based science teaching. Participants consistently emphasized the scarcity of functional laboratory equipment, chemicals, and consumable supplies, noting that many schools lacked modern and essential materials. This situation significantly hindered their ability to conduct proper hands-on experiments, impacting the overall quality of science education. These observations align with findings by Calo and De Vera (2025), who reported similar resource constraints as significant barriers in public science instruction across the Philippines.

One teacher highlighted the severity of the issue, stating, "*We barely have enough materials for one group (in laboratory activities), let alone an entire class*." Consequently, teachers frequently resorted to improvisation, using alternative or makeshift materials to demonstrate scientific concepts. While improvisation can partially address immediate needs, educators recognized that it falls short of providing students with authentic laboratory experiences. As another teacher explained, even when improvising materials, "*...it's not the same as conducting experiments with proper materials.*"

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These resource limitations observed in Bataan's public senior high schools are reflective of broader global trends, as numerous international studies have documented resource scarcity as a universal barrier to effective science education (Tindan & Rahaman, 2025; Del Mario & Tran, 2024; Chuene & Teane, 2024; UNESCO, 2017). To address this, strategic investment and targeted support are crucial for equipping schools with adequate laboratory resources, ultimately fostering richer and more meaningful science learning experiences.
Need for Proper Exposure to Virtual Laboratory Tools. While participants acknowledged digital simulations' potential, most reported limited familiarity, or training in using them effectively. "*We hear about virtual labs, but we don't really know how to use them properly yet*," one teacher explained. Although virtual labs can address resource shortages and enhance student engagement, they require teacher scaffolding and curriculum integration for effectiveness (DOST-SEI, 2024; Makransky et al., 2019; Heradio et al., 2016; De Jong et al., 2014).

The reported lack of exposure to widely available virtual lab tools limits teachers' ability to meaningfully integrate these platforms. Research demonstrates that virtual simulations are most effective when guided by teachers who can structure learning experiences and support student inquiry (Makransky et al., 2019; Zacharia & Olympiou, 2019). Consequently, providing targeted training and practice opportunities is essential to ensure these tools enhance rather than hinder laboratory instruction.

Table 1. Summary of Findings, Themes, and Proposed Context-based Interventions

Theme	Key Findings	Proposed Interventions
Resource Limitations	Scarcity of functional lab equipment, forcing reliance on improvisation	Increased funding for laboratory materials and consumables
Inadequate Professional Development	Minimal training on lab safety, management, and modern pedagogical approaches	Regular professional development focused on laboratory management and safety
Safety Concerns and Student Discipline	Behavioral issues and safety risks due to lack of proper supervision and equipment	Clear safety protocols and adequate supervisory frameworks
Time Constraints and Heavy Workload	Excessive administrative paperwork and extracurricular duties reducing time for labs	Streamlined administrative procedures and dedicated lab scheduling
Administrative Support	Higher teacher motivation and instructional quality are observed in settings with strong administrative support.	Enhanced administrative engagement and resource prioritization
Need for Exposure to Virtual Laboratory Tools	Teachers unfamiliar with virtual labs, needing structured training for effective use	Comprehensive training programs to effectively integrate virtual labs

Lack of Professional Development and Technical Training. Teachers indicated insufficient in-service training in laboratory management, safety protocols, experiment design, and modern pedagogical strategies. Many primarily relied on college-era knowledge, often outdated or insufficient, resulting in self-doubt and limited innovation.

One teacher stated, "*I feel unprepared to lead complex experiments because I haven't received proper training in managing lab activities and ensuring safety*." This finding corresponds with reports that Philippine teacher training programs frequently neglect practical aspects of laboratory resource management, resulting in underutilized and poorly maintained science laboratories (EDCOM-II, 2025; Mangarin & Macayana, 2024;).

Inadequate professional development contributes to teachers' low confidence and hesitance in conducting high-risk experiments (GPE, 2024; UPCIDS, 2019). According to Darling-Hammond et al. (2017), well-structured professional development programs focused on laboratory management significantly enhance teachers' confidence and competency in managing high-risk activities and ensuring student safety. Similar findings emphasize that comprehensive professional development directly influences teacher efficacy and student outcomes by providing sustained, content-focused, and collaborative learning opportunities (Kraft et al., 2018; Yoon et al., 2017; Wei et al., 2009).

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The Philippine Department of Education should implement targeted professional development programs specifically addressing laboratory management, experiment design, and safety protocols. These programs could be delivered through workshops and training sessions in collaboration with universities and science institutions.

Administrative Support in Laboratory Instruction. Teachers reporting strong administrative support expressed higher motivation and confidence levels in their teaching. Participants cited resource allocation, feedback, and ongoing professional development as key factors improving laboratory instruction.

One teacher noted, "*When the administration supports us, it's easier to try new things and get the resources we need.*"
Conversely, teachers feeling unsupported by school leadership struggled to innovate and often reverted to traditional, lecture-based methods due to resource and training deficiencies. This finding supports research indicating administrative support plays a pivotal role in teacher motivation and effectiveness (RSISI, 2024; Nguyen et al., 2022).

Additionally, teachers with proactive principals reported better resource access and morale, while others felt neglected. "*When the principal sees the importance of labs, you get funding, materials, even moral support. If not, you are on your own*," one participant shared. These experiences align with research emphasizing that effective school and district leaders are pivotal in advancing science teaching, supporting teacher development, and improving student outcomes (Wertheim, 2025; Leithwood et al., 2023; Adams & Hamdhiyya, 2022).

School administrators must provide active support to science teachers, particularly in resource allocation and professional development. Creating collaboration between administrators and teachers will ensure teachers feel empowered and motivated to implement innovative laboratory-based teaching methods enhancing student engagement and learning outcomes.

Teacher Motivation and Engagement. Teachers supported by school leadership reported higher motivation and engagement levels. Engaged teachers more readily adopted innovative teaching methods, including laboratory-based experiments requiring hands-on student participation.

One teacher shared, "*When I feel supported, I am more willing to go beyond the textbook and try different teaching methods*."
Conversely, Teachers feeling unsupported or overwhelmed by resource shortages express low morale and struggle to maintain student engagement in laboratory activities, with teacher engagement closely linked to student engagement and learning outcomes (Mangarin & Macayana, 2024, OECD, 2019; Darling-Hammond et al., 2017; Wang & Degol, 2016). Administrative support and resource inadequacies significantly impact teacher engagement, with strong support and adequate resources linked to higher engagement and job satisfaction (Tosun & Bozkurt Bostancı, 2024; Andleeb et al., 2024; Martinez & McAbee, 2020).

To foster a more engaged teaching workforce, school leadership must provide stronger teacher support systems. These include resource allocation, professional development, and ensuring teachers possess necessary tools for effective laboratory-based instruction. Teacher engagement should be prioritized as a key factor in improving science education student outcomes.

Low Student Engagement in Laboratory Activities. Teachers noted student engagement in laboratory activities was often hindered by resource limitations, safety concerns, and teacher confidence issues. Many students could not participate in meaningful hands-on activities due to equipment limitations or inadequate supervision.

One teacher shared, "*I feel that students miss out on a lot of learning because we don't have the tools to let them engage in experiments fully*."
This theme corresponds to the importance of student participation in science education. Active engagement in laboratory activities significantly determines student learning outcomes, as evidenced by experimental and review studies across multiple educational contexts (Putra & Prasetyo, 2024; Gericke et al., 2023; Kelkay, 2023; Sshana & Abulibdeh, 2020). Studies demonstrate that hands-on activities substantially improve students' problem-solving skills, critical thinking, and scientific inquiry abilities (Kapici & Akcay, 2021; Hasni et al., 2016). However, inadequate resources diminish the learning process by limiting engagement and hindering effective teaching and learning (Barrett et al., 2019; Yangambi, 2023; Mugizi, 2021).

Increasing student participation in laboratory activities requires improved resource availability and enhanced teacher confidence in conducting laboratory-based experiments. Schools should encourage active learning through interactive laboratory activities and provide teachers with resources needed to fully engage students.

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CONCLUSION AND RECOMMENDATIONS

This study illuminates the multifaceted challenges science teachers in Bataan's public senior high schools face when implementing laboratory-based instruction. The interconnected themes of resource limitations, insufficient virtual laboratory exposure, inadequate professional development, variable administrative support, fluctuating teacher motivation, and limited student engagement collectively impede effective science instruction.

The findings highlight the need for systemic interventions addressing both material and human resource development aspects of science education. Resource allocation must be prioritized to ensure schools have adequate laboratory equipment and materials. Simultaneously, comprehensive professional development programs should be implemented to enhance teachers' laboratory management capabilities, safety knowledge, and pedagogical skills.

Administrative support emerges as a critical factor influencing teacher motivation and effectiveness. School leaders should recognize their pivotal role in creating environments conducive to innovative science teaching by providing necessary resources, encouragement, and recognition for science educators' efforts.

Virtual laboratory tools represent an underutilized resource that could help mitigate physical resource limitations. Focused training programs introducing teachers to virtual laboratory platforms and their effective integration into science curricula would significantly enhance instructional capabilities.

Future research should explore the effectiveness of specific interventions addressing identified challenges and investigate student perspectives on laboratory-based science instruction. Additionally, longitudinal studies examining changes in teaching practices following targeted professional development would provide valuable insights for educational policy and practice.

By addressing the challenges identified in this study, stakeholders can work toward creating more supportive, well-resourced environments enabling teachers to engage students in authentic scientific inquiry experiences, ultimately improving STEM education quality in Philippine public schools.

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