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RESEARCH ARTICLE

Hurdling obstructions on instructional management of science teachers in schools with challenging laboratory resources

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ABSTRACT

Lacking the resources for hands-on scientific experimentation could impact both students' educational experiences and their long-term proficiency. Without access to laboratories, students miss out on crucial opportunities to engage in practical applications of theoretical concepts, hindering their ability to comprehend scientific principles fully. The purpose of this exploratory study was to analyze the experiences of science teachers (n=20) from last-mile schools in the Philippines. Narratives from science teachers were the primary data in this study being collected through one-on-one interview. Thematic analysis revealed that the science teachers were challenged by insufficient resources available in their laboratories while others conduct experiments only in their classrooms while having class. Adapting to their concerns, teachers were able to maintain their instructional competence through hands-on demonstrations, visual and audio-visual presentations, interactive activities, and printout instruction. For science teachers, addressing these challenges requires concerted efforts from policymakers, educational institutions, and stakeholders to ensure equitable access to resources and professional development opportunities for teachers. The study emphasized the need for sustainable solutions to bridge the gap between resource-rich and resource-poor schools, ultimately enhancing students' educational experiences and long-term proficiency in science.

Keywords: hands-on learning; instructional strategies; laboratory deficiencies; science teaching

1. Introduction

Science, defined as the systematic study of the natural world and the principles governing its behavior, plays an indispensable role in the advancement and prosperity of nations worldwide[1]. Central to the cultivation of scientific literacy and critical thinking skills among students is the provision of robust laboratory instruction[2,3]. Laboratories serve as dynamic learning environments wherein theoretical concepts are brought to life through hands-on experimentation, facilitating a deeper understanding of scientific principles and phenomena[4]. Effective laboratory instruction not only reinforces classroom teachings but also fosters essential skills such as problem-solving, data analysis, and experimental design, which are fundamental for success in scientific disciplines[5].

The Department of Education (DepEd) field offices conducted an assessment and determined that there

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are approximately 9,225 schools located in remote areas across the country, or locally described as "last-mile schools"[6]. Several distant schools in the Philippines still experience a shortage of teaching resources, and teachers consistently face difficulties in providing high-quality basic education[7]. It was also evident that the last-mile schools in the Philippines experienced the consequences of digital divide facing several instructional problems like unavailability of devices, challenges in learning, limited means of communication for evaluation, and inadequate knowledge of parents[8].

Science teachers in last-mile schools encounter difficulties in giving students a high-quality science education because of the lack of facilities and resources. The lack of laboratory equipment and facilities, which are necessary for practical learning and hands-on experimentation, is one of the biggest challenges they face. Hence, the purpose of this study was to explore different challenges that science teachers from last-mile schools faced and determine their adaptive strategies.

In the Philippines, studies revealed that the state of science laboratory in the country is remarkably concerning. For instance, in their study done in the public secondary schools in Lanao del Sur, Hadji Abas and Marasigan[9] identified various challenges related to laboratory equipment, such as malfunctioning tools and insufficient laboratory facilities. Reviewing the literatures, no study was conducted regarding the state of science laboratories and science instruction among last-mile schools in the country.

Internationally, multiple studies have provided insights into the conditions of laboratories in various global schools and universities. An et al.[10] stressed the need of equipping general chemistry laboratories with the essential tools for students to acquire practical laboratory abilities, as laboratories are an integral part of student's identity. However, Bogusevschi et al.[11] contended that due to financial constraints and challenging upkeep requirements, public schools are susceptible to a shortage of resources and equipment for their laboratories. In some worse cases, some schools completely lack laboratory furniture, such as cabinets, shelves, tables, sinks, etc., while other high schools have improperly set up furniture, which hinders effective education and instruction in science[12].

Noroña[13] proposed that a crucial element in achieving scientific literacy among secondary pupils is by means of developing proficiency in integrated scientific methods and skills. Insufficient familiarity with laboratory equipment among learners has been found to result in subpar performance on examinations[14-16]. Insufficient exposure to laboratory practices and equipment has been associated with subpar outcomes, indicating a potential gap in students' ability to effectively apply scientific concepts and methodologies. Consequently, addressing this deficiency becomes imperative for educators and policymakers aiming to enhance scientific literacy and academic achievement among students.

The Philippine government has implemented inclusive initiatives through the enhancement of infrastructure and educational resources for small and geographically isolated schools[17]. The rise in enrollment, decline in dropout rates, and increase in completion rates of the last-lime schools during the pandemic can be attributed to government initiatives aimed at addressing resource and opportunity disparities[18].

This study also recognized the role of teachers in improving the quality of education in last-mile schools, especially in the context of limited laboratory resources. Previous studies indicated that equipping teachers with the necessary training, resources, and infrastructure can empower them to deliver science education of the utmost quality[19-21]. Students can acquire these science process abilities by participating in specific science education activities. In contrast, teachers can foster a culture of scientific curiosity, critical thinking, and hurdling obstruction abilities in their students by addressing learning, instructional, and laboratory deficits.

Despite the evident importance of laboratory facilities and equipment in enhancing science education, there is a notable gap in research regarding the state of science laboratories in last-mile schools in the Philippines. The study intends to investigate the adaptive techniques utilized by scientific instructors to overcome problems in laboratory instruction, particularly in resource-constrained situations, while recognizing the crucial role of teachers in enhancing the quality of education. The study aimed to provide policymakers and educators with valuable insights into effective teaching methods and interventions. Its goal is to improve the delivery of science education in last-mile schools, ultimately promoting scientific literacy and critical thinking skills among students in the country.

2. Literature review

2.1. Student's scientific skills

Developing students' abilities to actively participate in and critically analyze scientific investigation is widely recognized as a primary objective of science education in numerous global standards and policy papers[22]. Scientific inquiry capabilities encompass the knowledge and skills required to develop scientific questions and hypotheses, design and execute scientific experiments, and evaluate and interpret results. An effective strategy for developing students' scientific inquiry competencies is to integrate their active participation in inquiry-based activities with explicit instruction that provides detailed explanations and elaboration of the conceptual knowledge[23-25].

To effectively design a significant scientific inquiry, students must possess knowledge of dependent and independent variables, the control-of-variables technique[26], and the influence of repeated measurements on the reliability of gathered data. Scientific inquiry competences can be characterized as the procedural understanding, skills, and mindsets required to actively participate in and think critically about scientific investigation[24,27,28].

Engaging students directly in inquiry activities is commonly believed to enhance the development of their scientific inquiry competencies[29,30]. Giamellaro[31] describes context-based scientific education as an instructional approach that focuses on teaching science by using the local environment and building on students' personal experiences. Expanding students' understanding using locally accessible materials is a reasonably straightforward task, as students are already familiar with these resources, rendering science more engaging and relevant to their lives and the country[32].

2.2. Obstructions in science instruction

Most faculty members in higher education strongly depend on having access to laboratories and engaging in direct physical touch with human participants to properly teach laboratory skills and carry out meaningful research[33]. Furthermore, it is widely acknowledged that lab-based experiential learning is a teaching practice that has a high impact on student learning outcomes[34,35]. The implementation of active learning strategies and student engagement techniques in educational settings has been found to have a positive impact on students' development of inquiry skills, critical thinking abilities, and problem-solving capabilities[36].

However, effective implementation of hands-on experiments is severely hindered by limited resources, including laboratory equipment, materials, and trained teachers[37]. Several studies also argued that the lack of material resources is a contributing factor to inadequate teaching and ineffective instruction. According to Chingos and West[38], the quality of learning resources, such as textbooks, has a crucial role in enhancing instructional effectiveness. In contrast, the effectiveness of teaching and learning does not depend on the physical structures of the buildings, but rather on the quality of the processes that occur within them[39].

This literature inspired the preliminary analysis of challenges experienced by science teachers in last-mile schools having to deal with limited laboratory resources. The researchers sought to ascertain the specific obstacles faced by science educators in dealing with laboratory deficiencies and to elucidate the strategies they employ to enhance instructional quality notwithstanding these challenges.

2.3. Instructional factors for quality learning

Teachers must employ suitable pedagogical approaches to facilitate the acquisition of essential skills by students, including critical and creative thinking, innovation, and problem-solving abilities for real-life situations[40,41]. Effective teaching should prioritize the learner, be engaging, efficient, and foster the development of new information and creative thinking[42]. Research has demonstrated that the implementation of guided peer discussion and collaborative teaching leads to successful learning outcomes in the classroom[43,44]. In some cases, receiving support from a teacher helps students feel a sense of belonging in the classroom, which enhances their emotional learning including their attitude towards the subject and their teacher[45]. This enhances their efficient acquisition of knowledge, dynamic investigation of the educational setting, and involvement in social relationships with their peers[46].

This study recognized the role of adaptive teaching strategies in developing effective instructional processes in the classroom. Although a large volume of studies was conducted regarding the importance of teaching strategies, there was scarcity in analyzing the experiences of science teachers among last-mile schools in the country. This study analyzed how science teachers deal with limited resources they have and how they adapt to them to continuously deliver quality education.

2.4. The current study

This study acknowledged how adaptive teaching strategies foster effective instructional processes within the classroom setting. Despite the extensive body of research emphasizing the importance of teaching strategies, there was a notable gap in the literature regarding the experiences of science teachers in last-mile schools within the country. Through a qualitative analysis informed by interviews, the study shed light on the adaptive strategies and pedagogical adjustments employed by science teachers to address the challenges associated with limited laboratory resources.

Below are the specific objectives of the study.

1. Describe the state of science laboratory used for teaching among last-mile schools.
2. Determine several instructional managements to address the deficiencies.
3. Determine potential administrative efforts to address the deficiencies.

3. Methods

3.1. Research design

This study was a qualitative exploratory study that described the experiences of science teachers in dealing with limited instructional resources in school science laboratories. Specifically, this study described their challenges, their adaptive strategies, and possible administrative support. The primary data in this study was the narratives from selected science teachers in the Philippines.

A qualitative exploratory study is a research approach aimed at gaining a deeper understanding of a phenomenon or topic of interest, particularly when there is limited existing knowledge or understanding. Qualitative exploratory studies often employ flexible and open-ended research designs, allowing researchers to adapt their methods and approaches based on emerging insights and findings[47-49]. These studies typically

involve collecting rich and detailed data through techniques such as interviews, observations, focus groups, or document analysis.

3.2. Participants and sampling technique

The participants of this study were science teachers in last-mile schools in the Philippines. The selection process involved purposive sampling[50,51], contacting potential participants through online initial survey. This survey gathered data from potential participants including their place, sex, age, years in service, educational attainment, and short narratives of their instructional problems. The participants were then selected based on these characteristics; finally, there were 20 science teachers from remote schools who participated in the one-on-one interview.

3.3. Instrument

This study developed a comprehensive interview set questions to elicit responses from the participants. The interview guide was composed of open-ended questions describing the experiences of participants in teaching science. **Table 1** below presents the instrument of the study used for one-on-one interview.

Table 1. Instrument of the study.

Objectives	Questions
1. Describe the state of science laboratory used for teaching among last-mile schools.	Can you describe the state of your science laboratory used for teaching in your school? Elaborate its deficiencies in terms of instruction.
2. Determine several instructional managements to address the deficiencies.	What do you do in terms of instructional management to address the deficiencies? Explain the actions you took and suggestions you forwarded to the educational leaders. Given the situation with equipment and tools-deficient laboratories for instruction, what alternative teaching strategies do you employ for your students? Explain each strategy. Can you elaborate how you conduct each of these teaching strategies in terms of steps and procedures? Describe each step. Can these teaching strategies substitute for the teaching strategies with the sufficient science laboratory? Please Compare.
3. Determine potential administrative efforts to address the deficiencies.	What is the feedback or response to the actions you made and the suggestions you forwarded to the educational administration? Elaborate.

4. Data gathering procedure

In adherence to ethical guidelines and principles of informed consent, the researchers developed an initial survey to gather preliminary data from the participants. The data was used for sampling and selecting participants to be interviewed. Each participant was furnished with a formal letter affirming the authorization granted for the study's conduct, delineating the purpose, procedures, and implications of their involvement. Additionally, all participants were provided with detailed information regarding their rights, including the freedom to withdraw from the study at any juncture without repercussion.

Upon securing approval and informed consent from the participants, data collection sessions were specifically scheduled for the convenience of each participant. These sessions were predominantly conducted through online or phone call interview for ease of communication and facilitation. Throughout the interviews, records of participants' responses were maintained, facilitated by the utilization of a voice recorder integrated into a mobile device, supplemented by note-taking to initial themes and contextual details.

5. Data analysis

The narratives acquired from interviews with the teachers chosen to participate in the interview served as the main source of data for this study. To identify important themes about the instructional strategies of science teachers at last-mile schools with laboratory deficiencies, the transcribed interview data was categorized and classed. Each transcript was systematically coded, with responses categorized according to the specific questions posed during the interviews. This initial phase of coding enabled the researchers to organize the qualitative data into manageable units, facilitating subsequent analysis.

Thematic analysis, a widely employed qualitative research method, was then employed to systematically identify, analyze, and interpret recurring patterns or themes within the dataset[47,52]. Drawing upon the coded data, themes representing key concepts, ideas, or experiences were identified. These themes served as the foundation for further analysis, facilitating a comprehensive exploration of the data. Throughout the analysis process, rigorous scrutiny was applied to the themes and sub-themes, with continuous examination and refinement undertaken to ensure their coherence and alignment with the objectives of the study.

6. Results

6.1. State of science instruction among resource-deficit laboratories

Theme 1: Insufficient instructional materials

In the context of educational settings characterized by a dearth of instructional materials, teachers often find themselves confronted with the challenge of devising and fabricating their own teaching resources to effectively deliver curriculum content. For one teacher, she struggled in dealing with inadequacy of instructional materials in teaching and making experiments with her students. For most of them, inadequate resources were their primary concern which they feel hindered the way they teach the students.

> "The science laboratory in our school is spacious, however, the tools we are using, and the instructional materials are lacking."

> "Our school's science laboratory is facing difficulties because we don't have enough equipment, supplies, and infrastructure."

Theme 2: No laboratory access

As impossible as it sounds, some teachers also faced the problem of not having laboratories at all. One teacher highlighted a stark reality faced by certain educators—the absence of dedicated laboratory facilities within their educational institutions. This predicament underscores the significant disparities in resource allocation and infrastructure across educational settings, with some schools lacking even the most basic laboratory amenities. For teachers in such circumstances, the absence of laboratories poses considerable challenges in delivering comprehensive science education and facilitating hands-on experimentation, which are essential components of effective science instruction.

> "As of now, we don't have a science laboratory in our school. We are currently using the classroom for conducting experimental activities."

6.2. Instructional management and adaptive strategies

Theme 1: Interactive learning

For some teachers (n=12), interactive learning was an essential aspect to deal with resource-deficit laboratories in last-mile schools. Utilizing video presentations, teachers leverage multimedia resources to provide visual demonstrations of laboratory procedures and equipment, compensating for the lack of

physical materials and enabling students to grasp scientific concepts through virtual exploration. Additionally, the incorporation of interactive activities, such as puzzles or games, serves to foster student engagement and reinforce learning objectives in an enjoyable and participatory manner.

> "Video presentations wherein the students can visually learn the specific lab materials and how to use it. second is an activity but looks like a game wherein they could solve a puzzle and guess the picture."

Teachers implement inquiry-based projects and multimedia presentations to promote student-centered learning, empowering learners to take ownership of their educational journey and delve deeper into scientific inquiry.

> "This involves inquiry-based projects, and multimedia presentations to illustrate scientific principles, facilitate student-led research, and enhance understanding of complex concepts."

> "I employ alternative teaching strategies such as demonstrations, simulations, virtual labs, group discussions, and real-world applications."

Theme 2: Hands-on demonstration

In some cases, teachers were the ones who had access to the laboratory resources, and it was impractical for them to provide their students individual tools. Instead, they conduct hands-on demonstrations while making experiments while discussing. Some teachers (n=15), hands-on demonstrations serve as a practical and effective means of facilitating experiential learning and engaging students in scientific inquiry without spending too much on laboratory paraphernalia. Teachers undertake careful consideration of experimental procedures, ensuring alignment with curriculum objectives and emphasizing key concepts and techniques pertinent to the scientific inquiry.

> "During demonstrations, I meticulously prepare and perform experiments or procedures in front of the class, focusing on important concepts and techniques."

> "For demonstrations, I carefully plan and prepare the experiment, ensuring that I have all the necessary materials and safety precautions in place."

Theme 3: Virtual experiments

Some teachers (n=3) resort to virtual experiments where they were using online applications to simulate science experiments in classrooms. For them, virtual laboratories offered students the opportunity to engage in hands-on experimentation and exploration of scientific concepts through digital simulations, transcending the physical limitations of traditional laboratory settings.

> "Virtual laboratories provide students with access to digital simulations of laboratory experiments, enabling them to perform experiments remotely using computers or tablets."

> "Yes, they can [learn]…they can actually learn from it though not primarily but there is learning from it such as the different lab tools, what is it used for, and the basics of the science laboratories application."

6.3. Administrative efforts to address laboratory deficiencies

Theme 1: Comprehensive assessment

Science teachers (n=6) highlighted their commitment to conducting a comprehensive assessment of laboratory needs as a foundational step towards enhancing science education quality. Within this thematic focus, teachers demonstrate proactive engagement in identifying deficiencies in laboratory resources, compiling detailed reports outlining necessary equipment and materials, and advocating for investment in resources to address these gaps.

> "I've conducted a comprehensive assessment of the laboratory's needs, compiled a detailed report on necessary equipment and materials, and proposed investing in resources to improve science education quality, and collaborated with fellow teachers to develop alternative teaching strategies."

Theme 2: Seminars for students

Science teachers (n=4) suggested organizing special seminars dedicated to familiarizing students with the usage of different laboratory tools. By designating a specific day or event for these seminars, teachers create a structured and focused opportunity for students to gain practical experience and proficiency in handling laboratory equipment. Through interactive demonstrations and guided exercises, students are given the opportunity to explore the functionality and operation of various tools firsthand fostering understanding of scientific principles and experimental techniques.

> "I'm still waiting for their decisions; thus, they are already in the process to have special day wherein students undergo seminar pertaining to the usage of different laboratory tools as well as let them experience how to use it."

7. Discussion

The results of the study reveal critical insights into the challenges faced by science teachers in last-mile schools regarding the state of science instruction and instructional management strategies. Two primary themes emerged from the analysis—insufficient instructional materials and the absence of laboratory access.

Firstly, it was not surprising that last-mile schools in the Philippines were facing problems in access to quality science laboratories and limited resources. For instance, the study of Hadji Abas and Marasigan[9] revealed that science teachers from Lanao Del Sur, Philippines feel challenged in science instruction because of several reasons like (i) inadequacy of laboratory facilities and science equipment, (ii) defective laboratory equipment, (iii) lack of laboratory room, and (iv) inadequacy of learning materials (*e.g.,* textbook). Similar was observed among last-mile schools in the country. Participants of this study said that *"the tools we are using, and the instructional materials are lacking"* indicating teachers struggling to provide comprehensive science instruction amidst a backdrop of inadequate resources and infrastructure.

To address these challenges, teachers employed adaptive instructional strategies aimed at enhancing student engagement and facilitating meaningful learning experiences. Interactive learning emerged as a prominent theme, with educators leveraging multimedia resources, interactive activities, and inquiry-based projects to compensate for resource deficits and promote student-centered learning. Interactive learning asserts that learning is a dynamic process of creating significance, wherein learners shape, enhance, and adapt the framework of their experiences by engaging with both familiar and novel events[53-56]. For science teachers, interactive learning involves *"…inquiry-based projects, and multimedia presentations to illustrate scientific principles, facilitate student-led research, and enhance understanding of complex concepts".* Specifically, by leveraging multimedia resources, interactive activities, and inquiry-based projects, challenged science teachers empower students to take an active role in their learning journey. For instance, multimedia presentations serve as dynamic tools for illustrating scientific principles and phenomena,

providing visual and auditory stimuli to enhance students' understanding of complex science concepts. Or through inquiry-based projects, students were encouraged to explore scientific topics independently, fostering curiosity and critical thinking skills.

Hands-on demonstrations were also utilized as a practical means of facilitating experiential learning and engaging students in scientific inquiry, particularly when providing individual tools was impractical. Moreover, some teachers resorted to virtual experiments, utilizing online applications to simulate laboratory experiments and transcend the physical limitations of traditional laboratory settings. Hands-on activities were common practice even in teaching other subjects like computer science[57], language[58-60], and mathematics[61,62]. In teaching computer science, students participate in practical tasks focused on protocol examination, network troubleshooting, and security issues related to protocols. This, according to Malik and Zhu[57], incorporating hands-on activities with instructional videos positively influenced students' evaluation of course learning objectives and was more effective in improving student's learning compared to quizzes and exams. Hands-on learning was evident in this study as science teachers in resource-deficit laboratories explained that they *"prepare and perform experiments or procedures in front of the class, focusing on important concepts and techniques"* while ensuring that *"…all the necessary materials and safety precautions in place"*.

Administrative efforts to address laboratory deficiencies were also evident, with teachers undertaking comprehensive assessments of laboratory needs and advocating for investment in resources to improve science education quality. Additionally, the organization of special seminars dedicated to familiarizing students with the usage of different laboratory tools was proposed, providing structured opportunities for hands-on learning and practical skill development.

The study sheds light on the challenges encountered by science teachers in last-mile schools, particularly concerning inadequate instructional materials and the absence of laboratory access. This situation is not unique to last-mile schools in the Philippines. Teachers often struggle to provide comprehensive science instruction due to the lack of essential tools and materials, hindering their ability to engage students effectively. In response to these challenges, teachers have implemented adaptive instructional strategies, with interactive learning, demonstrations, and virtual laboratories. Administrative efforts to address laboratory deficiencies include comprehensive assessments of needs and advocacy for investment in resources, alongside proposals for special seminars aimed at familiarizing students with laboratory tools and promoting practical skill development.

This study provided an initial understanding on the challenges that science teachers from laboratory-deficit last-mile schools experienced with science instruction, as well as preliminary contexts on the strategies they develop to address their problems. However, narrative analysis was not enough to contextualize the phenomenon of deficit instructional processes and adaptive teaching. This study opened new questions about how several teaching strategies influence the performance of students in science in resource-deficit laboratories. Such analysis requires in-depth data about the performance of students, perceptions of teachers, organizational strategies etc., to provide a more comprehensive analysis.

8. Conclusion

The findings of this study illuminated the significant challenges confronting science teachers in last-mile schools, particularly regarding the insufficiency of instructional materials and the absence of laboratory access. These challenges were not unique to last-mile schools in the Philippines but reflect broader issues faced by educators worldwide. Despite the persistent constraints, teachers demonstrated resilience and

adaptability by employing innovative instructional strategies to enhance student engagement and foster meaningful learning experiences. Interactive learning, hands-on demonstrations, and virtual experiments emerged as effective means of compensating for resource deficits and promoting student-centered learning in the absence of traditional laboratory settings.

Administrative efforts to address laboratory deficiencies have been observed, with teachers undertaking comprehensive assessments of needs and advocating for investment in resources to improve science education quality. Special seminars aimed at familiarizing students with laboratory tools and promoting practical skill development have also been proposed.

However, while this study provided valuable insights into the challenges and adaptive strategies of science teachers in last-mile schools, it also underscored the need for further research to deepen our understanding of the complex dynamics at play. Future studies should explore the impact of various teaching strategies on student performance in resource-deficit laboratories, incorporating perspectives from students, teachers, and educational administrators to provide a more comprehensive analysis of the phenomenon.

Conflict of interest

The authors declare no conflict of interest.

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