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Assessment of science laboratory resources and teachers' laboratory skills: Basis for a training program

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ABSTRACT

This study developed a training program for science teachers using a developmental research design guided by the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). A quantitative approach was applied to assess laboratory resources, evaluate teachers' laboratory competencies, and inform program design. Findings showed that most participants were female, aged 26–35, and held at least a bachelor's degree in General or Biological Science. Laboratory resources and their use were generally rated as average, with notable shortages in chemicals, reagents, and physical science equipment. Teachers demonstrated moderate to high proficiency in laboratory skills and safety practices, though some areas required improvement. Based on these needs, a training program was designed, validated by experts, and implemented, showing effectiveness in addressing identified gaps. The study highlights the importance of continuous professional development through targeted training and workshops to enhance laboratory competence and ensure safe and effective science teaching.

1. Introduction

Science and technology are pivotal to national development, playing a crucial role in driving modernization and economic progress (Mormina, 2019). In the Philippines, this significance is formally recognized in the Constitution and reaffirmed in recent national priorities. For instance, the 2022 Presidential State of the Nation Address (SONA) underscored the need to strengthen STEM (Science, Technology, Engineering, and Mathematics) education as a strategic move to boost the country's global competitiveness.

In response, the Philippine science curriculum has undergone reforms to improve scientific literacy and encourage students to pursue STEM-related careers (Jimenez and Errabo, 2024). These reforms are aligned with national educational policies such as the K to 12 Enhanced Basic Education Act (R.A. 10533) and DepEd Order No. 21, s. 2019, both of which advocate for learner-centered, inclusive, and research-based instructional approaches. Despite these efforts, however, science education in the country continues to encounter persistent challenges.

The COVID-19 pandemic further highlighted gaps in the education system, particularly around science instruction. Global studies emphasize the urgent need for comprehensive teacher training programs that address digital competency, laboratory safety, and adaptable teaching methods (Rivera and Tanghal, 2021). OECD (2021) recommended post-pandemic science teacher training to include blended learning models, effective digital resource use, and hands-on safety practices. Similarly, Lacerenza et al. (2017) stressed the value of well-designed training programs in fostering adaptability and resilience among science teachers, especially in remote or hybrid settings. UNESCO (2021) echoed this by urging countries to reimagine teacher professional development to ensure learning continuity and resilience in science education, particularly in resource-limited settings. Meanwhile, Trust and Whalen (2020) emphasized the importance of preparing teachers for digital and remote laboratory instruction, noting that many lacked the competencies to maintain practical science learning during the pandemic. These global insights point to the importance of integrating international best practices into the Philippine

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context. These global insights underscore issues that are particularly salient in the Philippines, where one of the most pressing issues is the country's consistent underperformance in international assessments such as PISA and TIMSS. These outcomes have been partly attributed to the scarcity of functional laboratory facilities and instructional materials. Many Filipino students struggle to understand scientific concepts due to a lack of hands-on learning experiences. Science studies have shown that science instruction is directly influenced by the availability of laboratory resources and teacher readiness. Effective science teaching relies heavily on access to laboratory equipment, teacher content mastery, and curriculum alignment (Pareek, 2019). Public schools do not have sufficient or functional science laboratories, which limits opportunities for experimentation and reduces student engagement in STEM subjects (de Borja and Espinosa, 2025; Jimenez and Errabo, 2024).

Compounding this problem is the limited laboratory competence among science teachers. The implementation of the K to 12 curriculum's Spiral Progression Approach has introduced additional challenges, as it requires teachers to teach across multiple science disciplines. This has resulted in difficulties with content mastery and effective lesson planning (Orbe et al., 2018). Teachers often struggle to deliver laboratory activities in subject areas outside their specialization, further reducing the quality of instruction. Despite these issues, there remains a lack of focused research and interventions aimed at improving science teachers' laboratory skills. Given this context, the present study aims to address the dual concerns of laboratory resource adequacy and teacher competency within the Schools Division of Cabanatuan City. Specifically, it seeks to assess the availability and utilization of science laboratory resources as a basis for determining readiness for laboratory-based instruction. In parallel, it evaluates the laboratory skills of science teachers to inform the development of a targeted training program designed to enhance laboratory teaching practices. To achieve these objectives, the study aimed to answer the following research questions:

1. What is the demographic profile of the respondents in terms of age, gender, highest educational attainment, major of specialization, and years of service?
2. What is the status of science laboratory resources in terms of availability and utilization, including physical features and facilities, chemicals and reagents, and laboratory equipment?
3. What is the level of teachers' laboratory skills across domains such as safety and hazardous materials handling, general science laboratory skills, chemistry, physics, biology, and science process skills?
4. How was the training program designed and developed to improve laboratory-based instruction?
5. How was the training program evaluated in terms of general objectives, course duration and modality, content, teaching presence, cognitive presence, and social presence?
6. What are the respondents' perceptions of the implemented training program, specifically in terms of facilitator effectiveness, content relevance, support mechanisms, and overall satisfaction?

2. Literature review

Over the years, the Philippine education system has undergone several reforms aimed at improving quality and access. From the pre-colonial period to the present K–12 curriculum, these reforms have sought to align the national education agenda with global standards. Grgić and Jutzi (2024) emphasized that the revision of the educational system and curriculum is crucial for enhancing the country's human capital and achieving higher educational outcomes. Key reform milestones include the Education for All (EFA) Plan of 2015, the National Elementary School Curriculum (NESC), the Revised Basic Education Curriculum (RBEC), the 2002 Basic Education Curriculum (BEC), and the Enhanced Basic Education Act of 2013 or Republic Act No. 10533. These reforms were largely informed by results from national and international assessments such as the Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA).

One of the most significant reforms is the K–12 curriculum, which extended the basic education cycle and sought to improve learners' competencies in science, mathematics, and communication. According to Dizon et al. (2019), the K–12 curriculum was designed to equip Filipino students with skills aligned with 21st-century demands and enhance their global competitiveness. The K–12 reform addresses critical gaps in the previous educational structure and strengthens the foundation for long-term national development.

In the realm of science education, hands-on learning through laboratory work is considered essential for conceptual understanding and scientific literacy. Numerous studies underscore the importance of laboratory experiences in improving students' academic performance and engagement. Pinar et al. (2025) emphasized that science laboratories provide students with experiential learning opportunities that enhance conceptual clarity, critical thinking, and problem-solving skills. Similarly, Luneta (2012) noted that meaningful laboratory work fosters a deeper understanding of scientific phenomena and supports the development of procedural skills, including observation, data collection, and analysis.

The American Chemical Society adds that laboratory experiences promote collaboration, develop practical skills in using scientific equipment, and improve students' capacity to work through ambiguity—skills vital to success in scientific careers. However, in the Philippine context, many schools struggle with inadequate laboratory facilities. de Borja and Espinosa (2025) reported widespread shortages of laboratory rooms, equipment, and safety materials, particularly in Regions III, IV-A, X, XI, and XII. These limitations hinder the effective implementation of inquiry-based instruction and laboratory experiments.

Teachers' laboratory competencies also present a concern. Although many science teachers in the Philippines demonstrate strong content knowledge in general science and biology, they often lack hands-on experience in physics and chemistry laboratory work (Orbe et al., 2018). This disparity stems in part from the spiral progression approach adopted in the K–12 curriculum, which requires teachers to teach across multiple science disciplines regardless of their specialization. As a result, many feel underprepared to conduct experiments outside their core areas of expertise.

The lack of adequate training in laboratory skills further exacerbates these challenges. Bancual and Ricafort (2019) identified limited access to seminars and workshops as a major barrier to effective science instruction, ranking it as the fourth most pressing concern among teachers. Jimenez and Errabo (2024) found that unfamiliarity with laboratory equipment contributed to teacher reluctance in utilizing available tools, negatively impacting the quality of instruction. Similarly, Noroña (2021) advocated for mass training initiatives focused on laboratory pedagogy and equipment use to improve instructional delivery. Hipolito and De Leon (2021) also reported that many mobile science teachers lacked opportunities for professional development, particularly in hands-on science teaching.

Professional development programs targeting laboratory instruction have been widely recommended in international literature. According to the Asian Development Bank in 2021, developing 21st-century skills among students requires sophisticated forms of teaching that can only be achieved through continuous teacher training. Luneta (2012) emphasized that teacher professional development should cover content knowledge, pedagogical content knowledge, and procedural skills—elements essential for effective laboratory instruction. In Southeast Asia, it is outlined that teaching competence frameworks are used to guide the design of capacity-building programs for educators, including science teachers.

Given these challenges, the Department of Education (DepEd) should give priority to improving science laboratory infrastructure and providing continuous training programs to develop teachers' laboratory competencies. The existing gap between curriculum expectations and actual laboratory practice reflects a systemic problem. Addressing this issue requires clear policy interventions, sufficient allocation of resources, and sustained professional development to ensure that science instruction is effective, practical, and aligned with curriculum goals across schools.

3. Methods

Descriptive developmental research plays a vital role in informing the design of training programs across various disciplines by systematically observing, documenting, and analyzing behaviors, skills, and attributes over time. In this study, a developmental research design was employed to provide an empirical foundation for the creation of instructional and non-instructional products and tools. This approach allowed for a structured process of identifying needs, designing interventions, and evaluating their effectiveness within an educational context (Hipolito and De Leon, 2021). This study employed the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model as a framework for developing the training program. Each phase is described as follows:

- Analysis: A checklist questionnaire was used to determine the status of laboratory resources and science teachers' laboratory skills. The data served as the basis for identifying training needs.
- Design: Based on the analysis results, specific training objectives were formulated. The content structure, delivery methods, and schedule of the training were also planned during this phase.
- Development: A complete training program matrix was developed, focusing on areas where teachers showed low proficiency. This included detailed module content, hands-on activities, and instructional strategies.
- Implementation: The training program titled "Upskilling and Reskilling Science Teachers: A Training Program on Science Laboratory Skills" was delivered through structured workshops. Teachers participated in various activities such as lectures, demonstrations, group tasks, and self-assessments.
- Evaluation: The effectiveness of the training program was assessed through participant feedback, which covered facilitator effectiveness, content relevance, support mechanisms, and overall satisfaction. Evaluation tools used Likert-scale instruments to quantify responses.

The study employed a quantitative research design using a survey questionnaire to assess the availability of laboratory resources, teachers' laboratory skills, and the stages of training program development. The respondents consisted of 74 Science teachers from the Schools Division of Cabanatuan City, Philippines. Among them, 18 were teaching at the Senior High School level, while 56 were from Junior High School. A purposive sampling technique was applied, whereby participants were selected based on specific criteria to ensure their relevance, experience, and alignment with the objectives and overall scope of the study.

3.1. Data analysis

The data collected in this study were analyzed using appropriate descriptive statistical methods to address the research objectives effectively.

First, the demographic and professional profiles of the respondents, including age, gender, educational attainment, specialization, and services, were summarized using frequencies and percentages. Second, to assess the availability and utilization of science laboratory resources, means and percentages were computed. Availability was measured using a three-point Likert scale (1 = Not Available, 2 = Available but not functional, 3 = Available), while utilization was assessed through a four-point Likert scale (1 = Never, 2 = Rarely, 3 = Occasionally, 4 = Many Times.

Third, the laboratory skills of science teachers were evaluated using both mean scores and percentage distributions. The assessment covered six key domains: (1) Safety and Hazardous Material Handling, (2) General Science Laboratory Skills, (3) Chemistry Skills, (4) Physics Skills, (5) Biology Skills, and (6) Science Process Skills. A four-point Likert scale (1 = Not skilled, 2 = Slightly skilled, 3 = Skilled, 4 = Highly skilled) was used to measure proficiency levels and to identify areas requiring further development.

Fourth, the design and development of the training program were informed by the results of the laboratory skills assessment. To evaluate the perceived quality and relevance of the training program, data were analyzed using means and percentages derived from responses to a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). This evaluation focused on dimensions such as the program's general objectives, content, structure, instructional presence, cognitive engagement, and social support mechanisms.

To further strengthen the findings of this study, inferential statistical tests were conducted. A one-way ANOVA was conducted to examine the effect of years of teaching experience on laboratory skill levels.

The comprehensive use of these statistical tools enabled a systematic interpretation of the data and supported evidence-based conclusions relevant to improving science laboratory instruction and teacher training.

4. Results and discussion

4.1. Demographic profile of the respondents

Most science teachers in the Division of Cabanatuan City fall within the age brackets of 26–30 (28.38%) and 31–35 (22.97%). This age distribution suggests that many are in their mid-career phase, and some may experience challenges in adapting to new curriculum reforms. According to Anto et al. (2023), prolonged exposure to traditional curricula may lead teachers to internalize specific teaching methods and content delivery styles, making it more difficult for them to adopt new approaches required by modern curriculum frameworks. Table 1 presents the demographic profile of the science teachers' respondents.

Table 1: Demographic profile of the respondents

Classification	Frequency	Percentage (%)
Age		
21 – 25	8	10.81
26 – 30	21	28.38
31 – 35	17	22.97
36 – 40	9	12.16
41 – 45	8	10.81
46 – 50	4	5.41
51 – 55	4	5.41
56 – 60	3	4.05
Total	74	100.00
Sex		
Male	28	37.84
Female	46	62.16
Total	74	100.00
Educational attainment		
Bachelor's degree	52	70.27
Master's degree	20	27.03
Ph.D.	2	2.70
Total	74	100.00
Area of specialization		
General science	32	43.24
Physics	5	6.76
Chemistry	9	12.16
Biology	28	37.84
Total	74	100.00
Teaching experience		
1 – 3 years	15	20.27
4 – 6 years	19	25.68
7 – 9 years	24	32.43
10 – 12 years	6	8.11
16 – 18 years	2	2.70
19 – 21 years	2	2.70
22 – 25 years	6	8.11
Total	74	100.00

In terms of gender distribution, the science teaching workforce is predominantly female, comprising 62.16% of the respondents, compared to 37.84% male. Regarding educational attainment, 70.27% (52 respondents) hold a bachelor's degree, 27.03% (20 respondents) have a master's degree, and only 2.70% (2 respondents) possess a doctorate. This indicates that while most teachers meet the basic qualification requirements, relatively few have pursued graduate studies. Vural and Başaran (2021) noted that teachers often seek a master's degree for reasons such as personal development, professional growth, academic advancement, and subject mastery. However, factors such as financial limitations, time constraints, and institutional challenges can hinder the completion of graduate programs.

In terms of specialization, most respondents majored in General Science (43.24%) or Biological Science (37.84%). However, under the current curriculum, science teachers are expected to teach across four disciplines—Biology, Chemistry, Physics, and Earth Science—which may present difficulties in subject mastery, especially in Physics and Chemistry. As Orbe et al. (2018) pointed out, teachers whose undergraduate specialization is not in science must undergo re-education and professional development to deliver quality science instruction across multiple domains.

Furthermore, most of the respondents have been teaching for 7–9 years (32.43%), followed by 4–6 years (25.68%) and 1–3 years (20.27%). Only a small portion have been in the profession for 10–12 years or more than 22 years (each at 8.11%). This indicates that a large segment of the teaching force is relatively early in their careers. These teachers would benefit significantly from targeted training programs, workshops, and seminars to strengthen their instructional skills and enhance their proficiency in delivering innovative science lessons.

Professional development programs offer structured opportunities to build instructional capacity and enhance domain-specific expertise (Lacerenza et al., 2017). These initiatives help educators improve content knowledge, adapt to changing curricula, and strengthen instructional effectiveness in science classrooms.

4.2. Status of science laboratory resources in the schools' division of Cabanatuan City

The facilities and furniture in science laboratories, as shown in Table 2, are generally available on average. This indicates that secondary schools in the Division of Cabanatuan City have access to laboratory spaces and furnishings that support science instruction and experimentation. However, essential safety components such as emergency showers and eyewash stations are notably absent, posing potential safety risks to both students and teachers. This observation aligns with the findings of Jimenez and Errabo (2024), who reported that inadequate laboratory infrastructure and equipment are common issues in secondary schools. Specifically, because many schools lack emergency showers, the facility has never been used, reflected by a low mean score of 1.38. Overall, the mean utilization score for all physical facilities and furnishings is 3.02, suggesting that these are used only occasionally. Regarding the availability of chemicals and reagents, most items listed are either unavailable or not in working condition, as indicated by mean availability scores near 1.50. Their absence severely limits the types of experiments that can be conducted, hindering students' opportunities to engage in hands-on science learning. This gap compromises the delivery of mandated laboratory activities in the curriculum, which are crucial for conceptual understanding. Addressing the lack of chemical supplies is therefore essential to improving science education and achieving the goals outlined in the curriculum guide. The mean utilization score for chemicals and reagents is 1.57, indicating infrequent use. Most chemicals were categorized as "Never Used," except for denatured alcohol—highlighting the direct impact of availability on utilization.

Pareek (2019) supported this view, emphasizing that the quality of teaching and learning in science laboratories is closely tied to the adequacy of laboratory resources and the capacity of teachers to use them effectively. According to the instructional theory of learning interaction, laboratory environments significantly influence students' attitudes and academic performance in science.

The total availability of physical science equipment received a mean score of 2.19, suggesting that although many items are present, they are not functional. These issues may stem from equipment damage, maintenance delays, or obsolescence. Consequently, mandated experiments in Chemistry and Physics may not be implemented, likely contributing to poor student performance in those subjects. Similar findings were reported by de Borja and Espinosa (2025) in a study of public junior high schools in Calamba City. Their research emphasized the importance of real-world laboratory experiences in helping students overcome learning challenges. Noroña (2021) likewise reported that 26 out of 38 basic science laboratory resources were marked "Not Available" by participating schools in Eastern Samar. On a more positive note, biological science equipment had an average availability score of 2.60, indicating that it is generally accessible, with most items scoring between 2.50 and 2.75.

The utilization of physical science equipment correlates strongly with its availability. The overall mean utilization score was 2.30, which suggests that most items are rarely used, largely due to their non-functional condition. Maintenance issues, equipment damage, and lack of spare parts are likely causes. Another contributing factor is the limited laboratory skills of teachers. Based on the study's assessment, most secondary school science teachers in the Division of Cabanatuan City demonstrated limited proficiency in Chemistry and Physics, which can be attributed to their academic backgrounds—many having majored in General Science or Biology. Noroña (2021) found comparable results, noting that basic laboratory equipment is rarely, if ever, used during classes. This utilization of science equipment may also stem from multiple systemic factors. These include insufficient teacher training on laboratory equipment, lack of planning time to incorporate experiments into lessons, fear of equipment damage, and a limited understanding of the educational value of laboratory-based instruction. Álvarez-Siordia et al. (2025) demonstrated that effective use of physics laboratory equipment significantly improves teaching outcomes in Physics.

To address these issues, it is recommended that science teachers receive practical training in equipment use. Jimenez and Errabo (2024) suggested that empowering teachers with operational knowledge will improve laboratory utilization and safety. These persistent issues require urgent attention and action from the Department of Education (DepEd) to ensure that science teaching and learning meet quality standards

4.3. Science teacher's laboratory skills

Table 3 summarizes the laboratory skills of secondary school science teachers in the Division of Cabanatuan City across various domains. The data indicate that teachers demonstrate a good level of competence in safety skills, general science, and biology laboratory skills. However, their proficiency in chemistry and physics laboratory skills is described as slightly skilled, suggesting a limited grasp of key principles, techniques, and pedagogical practices in these disciplines.

Table 2: Availability and utilization of science laboratory resources

	Facilities/furniture	Mean	Verbal description (availability)	Mean	Verbal description utilization
1	Demonstration table	2.75	Available	3.25	Occasionally
2	Storage cabinet for chemicals	2.75	Available	3.13	Occasionally
3	Display cabinet for glassware	2.75	Available	3.63	Many times
4	Highchairs	2.75	Available	3.38	Many times
5	Science laboratory table	3.00	Available	3.38	Many times3
6	Emergency shower	1.25	Not available	1.38	Never
	Overall mean	2.54	Available	3.02	Occasionally
	Chemicals/reagents				
1	Acetone	1.75	Available but not useful	1.38	Never
2	Activated carbon	1.50	Not available	1.50	Never
3	Ammonia	1.50	Not available	1.38	Never
4	Baking soda	2.13	Available but not useful	1.63	Never
5	Boric acid	1.75	Available but not useful	1.75	Never
6	Bromothymol blue	1.25	Not available	1.25	Never
7	Denatured alcohol	1.75	Available but not useful	2.00	Rarely
8	Formaldehyde	1.50	Not available	1.75	Never
9	Gentian violet	1.50	Not available	1.50	Never
10	Glucose	1.50	Not available	1.50	Never
11	HCL	2.00	Available but not useful	1.75	Never
12	Iodine solution	1.50	Not available	1.75	Never
13	Lye	1.25	Not available	1.75	Never
14	Magnesium oxide	1.50	Not available	1.75	Never
15	Magnesium ribbon	1.88	Available but not useful	1.63	Never
16	Oil vegetable	1.50	Not available	1.38	Never
17	Phenolphthalein	1.50	Not available	1.50	Never
18	Potassium permanganate	1.25	Not available	1.50	Never
19	Sulfur powder	1.50	Not available	1.38	Never
20	Yeast powder	1.50	Not available	1.63	Never
21	Zinc pellets	1.25	Not available	1.38	Never
	Overall mean	1.56	Not available	1.57	Never
	Physical science equipment				
1	Advanced electromagnetic set	1.63	Not available	1.25	Never
2	Alcohol lamp	2.75	Available	2.63	Occasionally
3	Anemometer	1.75	Available but not functional	1.63	Never
4	Archimedes principle set	1.75	Available but not functional	1.75	Never
5	Bar magnets	2.75	Available	2.38	Rarely
6	Barometer	2.38	Available	2.00	Rarely
7	Basic lens set	2.50	Available	2.50	Rarely
8	Beaker with a different volume capacity	3.00	Available	3.25	Occasionally
9	Burettes	2.25	Available but not functional	2.25	Rarely
10	Celestial globe	2.25	Available but not functional	2.50	Rarely
11	Centrifuge	1.50	Not available	1.50	Never
12	Clinical thermometer	2.50	Available	2.25	Rarely
13	Conductivity apparatus	1.75	Available but not functional	1.50	Never
14	Connecting wires with crocodile clips	2.00	Available but not functional	1.75	Never
15	Covalent and ionic bonding model	2.00	Available but not functional	1.88	Rarely
16	Cover slip	2.50	Available	3.00	Occasionally
17	Dc ammeter	2.50	Available	2.25	Rarely
18	DC string vibrator	1.50	Not available	1.75	Never
19	Dc voltmeter	2.50	Available	2.38	Rarely
20	Digital balance	2.00	Available but not functional	2.25	Rarely
21	Distillation set-up	1.63	Not available	1.25	Never
22	Dropper with aspirator glass	2.25	Available but not functional	2.13	Rarely
23	Dry cell	2.38	Available	2.38	Rarely
24	Dynamic carts	1.75	Available but not functional	1.88	Rarely
25	Electrical conductivity apparatus	2.00	Available but not functional	1.75	Never
26	Electronics kit	2.13	Available but not functional	1.88	Rarely
27	Erlenmeyer flask	2.75	Available	2.75	Occasionally
28	Evaporating dish	2.75	Available	3.00	Occasionally
29	Filter paper	2.50	Available	2.63	Occasionally
30	First aid kit	3.00	Available	3.50	Many times
31	Funnel	2.75	Available	3.38	Many times
33	Galvanometer	2.25	Available but not functional	2.38	Rarely
32	Glass tubing	1.75	Available but not functional	1.63	Never
34	Globe	2.25	Available but not functional	3.13	Occasionally
35	Graduated cylinder with different volume capacities	3.00	Available	3.50	Many times
36	Hand gloves	3.00	Available	3.50	Many times
37	Hand magnifying lens	2.75	Available	2.63	Occasionally
38	Heat conduction metals	1.75	Available but not functional	1.63	Never
39	Hydrocarbons model	1.50	Not available	1.88	Rarely
40	Hydrometer	1.88	Available but not functional	1.38	Never
41	Iron filling and sand	2.00	Available but not functional	1.25	Never
42	Iron stand with clamp	2.50	Available	2.13	Rarely
43	Laboratory goggles	2.75	Available	2.38	Rarely
44	Layers of the Earth model	2.25	Available but not functional	1.88	Rarely
45	Lever with axle	1.75	Available but not functional	1.75	Never
46	Magnetic wire#22	1.75	Available but not functional	1.88	Rarely
47	Magnetic compass	2.00	Available but not functional	2.75	Occasionally
48	Magnetic board	1.75	Available but not functional	3.00	Occasionally
49	Meterstick	2.50	Available	2.63	Occasionally
50	Microscope slide box	3.00	Available	3.50	Many times
51	Miniature light bulb	2.00	Available but not functional	3.38	Many times
52	Miniature light bulb base	2.00	Available but not functional	2.38	Rarely
53	Mirror set	2.25	Available but not functional	1.63	Never
54	Mortar and pestle	2.50	Available	3.13	Occasionally
55	Motor generator model	2.25	Available but not functional	3.50	Many times
56	Multimeter digital	1.75	Available but not functional	3.50	Many times
57	Nstic cart-rail system	1.50	Not available	2.63	Occasionally
58	Nstic set of coils	1.75	Available but not functional	1.63	Never
59	Nstic stand setup	1.50	Not available	1.88	Rarely

60	Nstic variable power supply	2.00	Available but not functional	1.38	Never
61	Penlight	1.75	Available but not functional	1.25	Never
62	Petri dish	2.50	Available	2.88	Occasionally
63	Ph meter	2.75	Available	2.50	Rarely
64	Ph paper	2.75	Available	2.63	Occasionally
65	Pippete	2.50	Available	2.50	Rarely
66	Protractor	2.50	Available	2.88	Occasionally
67	Pulley (double and single)	1.50	Not available	1.63	Never
68	Pulley set	1.50	Not available	1.50	Never
69	Refraction tank	1.75	Available but not functional	1.63	Never
70	Resistance board	1.88	Available but not functional	1.13	Never
71	Resonance set	1.50	Not available	1.13	Never
72	Safety goggles	2.50	Available	3.50	Many times
73	Seismograph model	1.75	Available but not functional	1.88	Rarely
74	Set of coils	1.75	Available but not functional	1.63	Never
75	Set of wire connectors	2.50	Available	2.13	Rarely
76	Simple microscope	2.50	Available	2.75	Occasionally
77	Slinky coil	2.25	Available but not functional	2.50	Rarely
78	Sound signal generator kit	1.75	Available but not functional	1.75	Never
79	Spatula	2.25	Available but not functional	3.13	Occasionally
80	Spring balance	2.00	Available but not functional	2.13	Rarely
81	Stirring rod	2.75	Available	3.63	Many times
82	Student optical bench	2.00	Available but not functional	1.50	Never
83	Sun-earth moon model	2.50	Available	2.88	Occasionally
84	Test tube holder	2.50	Available	3.13	Occasionally
85	Test tube rack	2.75	Available	3.38	Many times
86	Test tube	2.75	Available	3.63	Many times
87	Thermometer	2.50	Available	3.13	Occasionally
88	Triangular prism	2.25	Available but not functional	2.75	Occasionally
89	Triple beam balance	2.75	Available	3.00	Occasionally
90	Tripod	2.50	Available	3.25	Occasionally
91	Tuning fork	2.25	Available but not functional	2.25	Rarely
92	VSPER kit (molecular geometry model)	1.50	Not available	1.63	Never
93	Weighing scale bathroom type	1.75	Available but not functional	1.63	Never
94	Wind vane	1.50	Not available	1.50	Never
95	Wire gauze	2.50	Available	3.00	Occasionally
	Overall mean	2.19	Available but not functional	2.30	Rarely
			Biological science equipment		
1	Compound microscope	2.50	Available	3.00	Occasionally
2	Human torso	2.75	Available	3.25	Occasionally
3	Dissecting pan	2.50	Available	2.38	Rarely
4	Dissecting kit	2.50	Available	2.38	Rarely
5	Simple microscope	2.75	Available	2.38	Rarely
	Overall mean	2.60	Available	2.68	Occasionally

Table 3: Summary of the assessment of teachers' science laboratory skills

Science teacher's laboratory skills	Overall mean	Verbal description	Verbal interpretation
Safety skills (safety and hazardous material handling)	3.20	Skilled	The teacher possesses proficiency/ good level of competence in general safe handling practices for science laboratory equipment and materials.
General science laboratory skills	2.82	Skilled	The teacher showcases proficiency/ good level of competence in general science laboratory skills with good knowledge of safety measures, basic equipment usage, and scientific procedures.
Chemistry laboratory skills	2.50	Slightly skilled	The teacher possesses limited skills and understanding in chemistry laboratory practices
Physics laboratory skills	2.24	Slightly skilled	The teacher possesses limited skill and understanding of physics laboratory principles and techniques
Biology laboratory skills	2.60	Skilled	The teacher possesses proficiency/ good level of competence in biological science laboratory skills
Science process skills	3.29	Highly skilled	The teacher demonstrates an excellent understanding and mastery of science process skills.

To further strengthen the findings of this study, inferential statistical analyses were performed to determine whether there were significant differences in laboratory skills-based years of teaching experience. Table 4 presents the relationship between laboratory skills of secondary teachers to their teaching experience.

Table 4: One-way ANOVA on laboratory skills based on years of teaching experience

Source of variation	Sum of squares	df	Mean square	F	p-value
Between groups	1.236	3	0.412	3.57	0.018*
Within groups	7.415	64	0.116		
Total	8.651	67			

*: Significant at $p < 0.05$; Groupings: 1–3 years, 4–6 years, 7–9 years, and 10+ years

The one-way ANOVA results indicate a statistically significant difference in laboratory skills based on years of teaching experience ($F = 3.57$, $p = 0.018$). This implies that teaching experience influences laboratory skill proficiency, with mid-career teachers (e.g., 7–9 years) often exhibiting higher performance compared to newer or much more experienced counterparts. This pattern suggests that sustained classroom exposure contributes to skill refinement, while newer teachers may still be developing confidence, and more senior teachers may benefit from refresher training on updated laboratory practice. This finding aligns with global research indicating that professional development is most impactful when delivered during the mid-career stage, and that ongoing training is essential for maintaining high levels of laboratory competence (Lacerenza et al., 2017; UNESCO, 2021).

While these teachers may possess a basic understanding of experimental procedures and safety protocols, they often lack the depth of knowledge required to effectively facilitate student learning in chemistry and physics labs.

This observation aligns with the findings of Noroña (2021), who reported that biology majors commonly struggle with teaching physics concepts. Similarly, de Borja and Espinosa (2025) found that the implementation of the K to 12 curriculum with its spiral progression approach raised concerns about field specialization. Teachers with subject-specific backgrounds, particularly in biology, expressed difficulty in conducting experiments in physics and chemistry, a challenge also faced by science educators with different areas of specialization. These results, while informative, must be viewed considering contextual limitations, such as sample size, localized focus, and availability of resources. Future research should aim to validate these findings across other divisions and educational contexts. To address this gap, there is a pressing need for targeted training and capacity-building programs aimed at enhancing teachers' competence in underdeveloped laboratory domains. The education sector should take the lead in organizing comprehensive professional development initiatives that focus on the effective use of laboratory resources and the integration of related pedagogical strategies. These programs would not only improve teaching performance but also provide students with enriched, hands-on scientific learning experiences.

Meanwhile, teachers showed high proficiency in science process skills, reflecting strong mastery in observation, hypothesis formulation, experimentation, data analysis, and interpretation. This high level of competence is vital in fostering an effective and engaging science learning environment, enhancing students' scientific literacy, preparing them for STEM careers, and cultivating a genuine passion for scientific inquiry.

4.4. Design and development of the training program for science teachers

The training program for science teachers was developed using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design model.

The results of the Analysis phase—specifically, the assessment of laboratory resource availability, utilization, and teacher competency—guided the design of the program and the creation of the activity matrix.

Titled "Upskilling and Reskilling Science Teachers: A Training Program on Science Laboratory Skills," the program aimed to provide technical assistance in the safe handling of laboratory materials and equipment, enhance teachers' familiarity with laboratory apparatus, and equip them with effective strategies for conducting engaging laboratory activities. The activity matrix focused on areas where teachers demonstrated lower proficiency, with time allocations for each module carefully planned to optimize learning outcomes. The training also integrated essential elements such as teaching presence, cognitive presence, and social presence to foster interactivity, engagement, and collaboration (Courduff et al., 2021). These elements are critical for effective delivery in both face-to-face and virtual environments. To encourage participation, the training included a variety of structured activities such as warm-up exercises, lecture discussions, open forums, health breaks, energizers, insight-sharing sessions, hands-on experiments, group work, and self-assessments. Before implementation, the training design and activity matrix were reviewed and approved by educational authorities to ensure alignment with the program's objectives. The training workshop was then delivered according to the approved schedule. Table 5 presents the various activities incorporated into the training program to enhance the participants' engagement.

Table 5: Training program activities classified by primary objective and intended learning outcomes

Category	Activity name	Key objective and impact
I. Program initiation and engagement	Warm-up	Facilitates participant comfort and engagement, introduces new concepts, and energizes the group through icebreakers and interactive exercises at the beginning of a training workshop.
	Energizer	Rejuvenates participants, boosts energy levels, and refocuses attention during long training sessions via short, interactive exercises that break monotony.
Ii. Interactive learning and discussion	Open forum	Promotes active participation, allows for idea sharing and question-asking, clarifies understanding of topics, and fosters collaborative learning among participants.
	Lecture discussion	A valuable teaching method that encourages active learning, develops critical thinking skills, and enhances participant engagement through interactive discussions led by an instructor.
	Sharing insights	Cultivates collaboration, learning, and growth within the training program workshop by encouraging participants to contribute, acknowledging diverse perspectives, and fostering a dynamic, interactive learning environment where collective knowledge is built.
Iii. Practical and experiential application	Hands-on activity	Provides participants with practical and experiential learning opportunities, facilitating an immersive and impactful learning experience for acquiring practical skills, deepening understanding, and effectively applying knowledge.
	Group experiment	Enhances learning, promotes collaboration, develops practical skills, and creates a dynamic and engaging learning environment by grouping participants to perform experiments together.
Iv. Well-being and evaluation	Health break	Essential breaks during the training workshop are designed to improve participant focus, engagement, and retention; additionally, they reduce stress and anxiety, and promote positive social interaction, contributing to a supportive learning environment.
	Evaluate	Encourages participants to undertake self-evaluation post-training to assess their acquired skills, facilitating personal reflection on learning outcomes and areas for further development.

4.5. Evaluations of the design and development of the training program

Table 6 presents a summary of the respondents' evaluation of the training program's design and development. The evaluation covered key components such as content, objectives, course modality and duration, teaching presence, social presence, and cognitive presence. Based on the computed overall mean scores, it can be concluded that respondents strongly agreed with the quality and relevance of the training program. They found the program's general objectives to be clearly defined and well-aligned with the intended learning outcomes. Respondents expressed satisfaction with the training's duration and delivery modality, noting that both were appropriate given the scope and complexity of the content. Additionally, the training materials were described as clear, concise, and easy to understand.

The training design was also rated highly effective in establishing a strong teaching presence. Learning objectives were clearly communicated, interactive discussions were encouraged, and meaningful learning experiences were provided. These elements contributed to a collaborative and supportive learning environment where participants were actively engaged and had numerous opportunities for peer interaction.

Overall, the training program was perceived as very effective in achieving its intended goals. While the program was developed for and evaluated within a specific local context, its design principles—grounded in instructional presence, relevance, and interactivity are adaptable and can inform similar teacher development initiatives in other educational settings. This model can serve as a reference for institutions in other regions, particularly those in developing countries seeking to improve science education through structured and responsive laboratory skills training.

4.6. Evaluation of the implemented training program

Table 7 presents a summary of the participants' evaluation of the training program that was implemented. The results indicate that the science teacher participants highly enjoyed the training program, as evident from the high overall mean scores in the categories of Facilitator Assessment, Training Content Assessment, Training Support Assessment, and Overall Satisfaction. The findings suggest that the participants perceived the training program to be well-facilitated, informative, well-supported, and, overall, extremely valuable, informative, and engaging. These results, while informative, must be viewed in light of contextual limitations, such as sample size, localized focus, and availability of resources. Future research should aim to validate these findings across other divisions and educational contexts.

Table 6: Summary of the evaluation of training program design and development

Quality of design and the development	Overall mean	Verbal description	Verbal interpretation
General objectives	4.95	Excellent	The training design's general objectives are well-defined, clear, and directly aligned with the desired learning outcomes.
Course duration and modality	4.95	Excellent	The training time is very appropriate for the scope and complexity of the topic, the in-person modality, and the scheduling flexibility.
Contents	4.88	Excellent	The content of the training design is highly effective in conveying information to participants through verbal interpretation.
Teaching presence	4.93	Excellent	The training design effectively establishes a strong teaching presence by clearly communicating learning objectives, providing meaningful experience, and actively engaging in interactive discussions.
Cognitive presence	4.95	Excellent	This training design demonstrates exceptional cognitive presence.
Social presence	4.44	Excellent	The training design's social presence is exceptionally engaging and interactive.

Table 7: Summary of the evaluation in the implemented training program

Evaluation of the implemented training program	Overall mean	Verbal description	Verbal interpretation
Facilitator assessment	4.98	Very satisfied	The participants show a high level of satisfaction with the facilitator's performance during the training.
Training content assessment	4.95	Very satisfied	The participants expressed a high level of satisfaction with the training content.
Training support assessment	5.00	Very satisfied	The participants expressed a high level of satisfaction with the training support provided.
Overall satisfaction	5.00	Very satisfied	Participants expressed a high level of satisfaction with the training, indicating that they found it extremely valuable, informative, and engaging.

5. Conclusion

This study examined the current state of science laboratory instruction in the Schools Division of Cabanatuan City, Philippines, focusing on teacher demographics, resource availability and utilization, laboratory competencies, and the design and evaluation of a targeted training program. Most teachers were female, young, and held bachelor's degrees with specializations in General or Biological Science.

Although physical laboratory facilities were generally adequate, essential safety equipment, including emergency showers, was largely absent. Equipment for biological sciences was more functional and regularly used, whereas physical science instruments and chemicals were limited in supply and often remained unused because of their low availability.

Teachers demonstrated strong skills in safety procedures, science process skills, and biological laboratory work but showed limited competence in physics and chemistry, indicating a pressing need for subject-specific training.

To address these gaps, a training program was developed using the ADDIE model, incorporating clear objectives, relevant content, and elements that fostered teaching, cognitive, and social presence. Evaluations from experts and participants affirmed the program's effectiveness in addressing teacher needs and enhancing instructional capacity.

While localized in scope, the findings reflect challenges common to many low-resource educational systems, particularly in Southeast Asia. Thus, the training framework developed through this research offers a replicable model for improving laboratory-based science education in similarly under-resourced contexts worldwide.

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Compliance with ethical standards

Ethical considerations

This study was conducted in compliance with ethical standards. All participants provided informed consent prior to participation, and their privacy and confidentiality were protected throughout the study.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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