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Availability and Usage of Laboratory Equipment for Chemistry Learning in Onitsha North Local Government Area

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CONTENT

ABSTRACT

Background: Practical activities in Chemistry are vital for students' scientific skills, but the lack of laboratory equipment in Nigerian secondary schools hinders effective teaching and learning. **Objective:** This study investigated the availability and use of laboratory equipment for Chemistry learning in public secondary schools in Onitsha North, Anambra State, focusing on equipment availability and its usage during lessons. **Methods**: A descriptive survey research design was adopted. The sample consisted of 200 Chemistry students selected from 10 randomly chosen public secondary schools in the study area. Data were collected using a validated questionnaire with a reliability coefficient 0.72, determined using Cronbach's alpha. Data analysis was conducted using mean and standard deviation to answer three research questions**. Results:** The study revealed that laboratory equipment is not adequately available, and that the available laboratory equipment is poorly utilized in the learning of Chemistry in the selected schools. As a result, these students encounter difficulty in learning Chemistry, and lack the ability required to acquire scientific knowledge and skills. **Conclusions:** The study concluded that the limited availability and poor utilization of laboratory equipment negatively impact Chemistry's effective teaching and learning. Without sufficient resources, students are deprived of hands-on experiences vital for understanding scientific concepts. **Contributions:** This research highlights the infrastructure challenges public secondary schools face in practical science education, emphasizing the need for policymakers and educators to prioritize laboratory equipment and create an environment that supports students' scientific skill development.

KEYWORDS

Availability, Usage, Laboratory Equipments, Learning, Chemistry

1. INTRODUCTION

Education is an investment in human capital that produces returns to the individual in the form of higher earnings and social well being, that are important in generating a rapid growth. Much of the cream of training of the human capitals of a country takes place in academic institutions such as universities, polytechnics, colleges and their

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affiliates (Schiller, 2014). Education implies the transmission of what is worthwhile to those who become committed to it. Education has been universally recognized as an indispensable instrument for the national development and advancement (Nwankwo, 2016). Nigeria's education system has always had its objectives, principles, and ethics that govern all operations, especially in the conduct of examinations.

Examination is one major way of finding out the level of achievement of learners of all categories and determine how effective the teaching and learning have taken place. Education is unequivocally a great contributor to a nation's socio-economic development. According to Gupta & Gupta (2014), it is the most powerful tool for change and must therefore train the minds of the educated to cope with the change. Ode & Omokaro (2018) pointed out that higher education institutions are charged with the formation of human capital through teaching, building knowledge through research and knowledge development, dissemination, and use of knowledge by interacting with the learners. This simply means that education is a tool used in passing or inculcating knowledge or information to the learners. It can be used in all areas of discipline with science knowledge inclusive.

Science is a discipline that investigates nature, analyzes societal problems, and provides technological needs of the society. Scientists ask questions and conduct investigations about the natural world (Gupta, 2014). Science education is a field of science that is concerned with the sharing of science contents, some social science through education pedagogy, in order to provide expectations for the development of understanding part of the scientific community (Lockheed, 2011). Scientific methodology includes the following: objective observation, measurement, and data (possibly, although not necessarily, using mathematics as a tool), evidence (Nbina, 2013). Science as a discipline is divided into three main areas: Biology, Chemistry, and Physics.

Chemistry is the scientific study of the interaction of chemical substances that constitute atoms (Mahadevi & Sastry, 2013). It is an integral part of the science curriculum both at the senior secondary school level as well as higher institutions. Chemistry as one of the science subjects is indispensable to technological advancement (Wan & Bi, 2020). It has helped in the development of modern technology through the application of its principles to modern invention. To this end, the United Nations Educational Scientific and Cultural Organization (UNESCO) and the International Union of pure and Applied Chemistry (IUPAC) have participated in numerous international meetings to promote inexpensive experimental based teaching in chemistry.

Teaching and learning take place in the classroom. It involves the teacher in charge of teaching and students who are the learners. Teaching involves a careful organization of human and material resources. The students are the human resources, while the classroom and other learning facilities constitute the non-material resources. Uka (2010), opines that the concept of classroom management involves the bringing together in a careful manner of those things which help to create good teaching and learning conditions in the classroom. Teaching and learning of Chemistry requires a teacher with special knowledge and experience, this is because Chemistry is one of the core science subjects that is more concerned with the systematic process of making enquiry about the living and nonliving things in the environment (Sola & Ojo, 2014). It requires a lot from the teacher to properly understand the subject matter and use experience to improvise some instructional resources where necessary. For this very reason, Lockheed (2011), opined that there is need for science teachers to thoroughly understand all the contents of the subject matter in teaching and learning science subject like Chemistry and appreciate the importance of available resources in making teaching real to the learner. He further stated that instructional resources are critical ingredients in learning and that the curriculum could not be easily implemented without them.

For Chemistry to be studied as a scientific discipline one needs to be continuously involved in a series of guided experimentation which can only be carried out under the conditions of a well-equipped laboratory equipment. However, despite the prime position Chemistry occupies in the education system in Nigeria and the efforts made by Chemistry educators to enhance students' achievement in Chemistry, in general, it is still low (Cheval & Hart, 2014). Two of the reasons identified for this failure are laboratory inadequacy and the environment. The adequacy and use of educational resources like laboratory equipments enhance the effectiveness of teachers' lesson and understanding of abstract ideas and improve students' achievement in Chemistry. Chemistry teaching is supposed to be result-oriented and student-centered, and this can only be achieved when students are willing. The teachers are favorably disposed to use appropriate methods and resources in teaching the students (Pratt & Hackett, 2011).

Knowledge is actively constructed through the action of an individual. Clayden, Greeves, and Warren (2012), proposed that all science subjects must be underpinned by evidence. Practical work is formative as it helps the students to understand science and how scientific ideas are developed. To achieve the goals of science education, it is imperative that an attempt is made to balance emphasis on both theory and experiments. The skills normally emphasized in science practical include procedural and manipulative, observation, drawing, reporting, and interpretative skills. The purposes of practical work include: motivation of students, excitement of discovery, consolida-

tion of theory, development of manipulative skills, knowledge of standard techniques, general understanding of data handling, development of other skills like analytic, evaluative, planning, applied and mathematical and developing an understanding of how science works through concept of scientific process, collaborative working, reproducible results and fair testing. Experiments are the essence of science, and must be performed in the school Science laboratory (Yagger & Akcay, 2010).

The laboratory has been a distinctive feature in the teaching of science. Nbina (2013) defined a science laboratory as an instructional facility used by science teachers to help students learn about science and how scientists investigate the world around them. It is a place set aside for scientific inquiry. The Chemistry laboratory represents a wonderful opportunity for making the connection between the unseen microscopic world and the observable macroscopic world in which man lives. According to Ihiegbulem (2016), resource utilization during practical lessons inculcates in the students the spirit of careful observation, manipulative skills, respective thinking and creativity in the learners. Lewin (2010), reported that science facilities are only important when they are used. Similarly, Awoniyo (2019) reported that the availability of resource input into the education system has no value for achieving educational objectives if they are not actually utilized.

Omiko (2015) stressed that a laboratory is a room, or a building, or a special place equipped and set apart for practical or experimental studies to take place. He sees the laboratory as the heart of a good scientific programme which allows students in the school to have experience which are consistent with the goals of scientific literacy. This implies that science teaching and learning cannot be completely done in a secondary school where there is no equipped laboratory. Ufondu (2009), opined that the laboratory is an indispensable organ of the school if effective teaching and learning of the science subjects are to be achieved. However, whatever is done in the science laboratory is to obtain or acquire skills that would help to advance scientific knowledge which subsequently would lead to the development of the human society. Dienye & Gbamanja (2014), observed that laboratory method of teaching is an activity involving a two-way approach carried out by one or more persons through the exercise and experimental approaches both of which are useful in science teaching. The experimental approach provides an opportunity for students to seek information using experimental procedures. These procedures call for careful observations and interpretation of data. It has the qualities of questioning, investigating, and confronting the unknown.

The use of the laboratory in chemistry teaching makes the students to learn about the nature of science and technology in order to foster the knowledge of human enterprise of science and thus enhance the aesthetic and intellectual understanding of the child. Dienye & Gbamanja (2014) opined that science is known to be a way of doing certain things by the observation of natural phenomena, quantifying the observed thing, integrating such quantities, and interpreting the results in order to make useful meaning out of the exercise. The students can identify cause and effect relationships and, in this process, develop important skills. Learning scientific inquiry skills fosters a range of cognitive abilities that extend into other areas of problem-solving, equipping learners with essential life skills.

Omiko (2015) highlighted that hands-on experiences promote a spirit of inquiry and help students develop the right attitudes toward using scientific tools effectively. These inquiry-based practices are instrumental in shaping critical thinking and adaptability, vital for addressing real-world challenges (Ohamobi et al., 2025). Furthermore, experiential learning fosters productivity and motivation among teachers and students alike, thereby improving overall educational outcomes (Osegbue et al., 2020). A well-implemented curriculum that emphasizes inquiry contributes to national cohesion and global competitiveness. Principals ' effective school leadership and stress management also play a significant role in sustaining inquiry-based instruction and enhancing teacher performance (Onyekazi et al., 2016).

Additionally, the integration of ICT (Manafa et al., 2018) and school-based management strategies (Ohamobi & Manafa, 2022) further supports a dynamic and inquiry-driven learning environment. Science laboratory provides students with the richest experiences which would be transferred to the society and various places of work. It helps in providing the students the opportunities to practice science. In order for the laboratory to be effective, students need to understand not only how to do the experiment, but why the experiment is worth doing, and what purpose it serves for better understanding of a concept, relation, or process, therefore, the study aimed at determining the availability and usage of laboratory equipments in the learning of Chemistry in Onitsha North Local Government Area.

Students' persistent poor achievement in Chemistry has been partly ascribed to inadequate teaching and instructtional methods adopted by teachers. It has been shown that the persistent use of traditional methods of instruction has caused the deplorable achievement of secondary school students in Chemistry. This has affected the learning and achievement in the Chemistry subject. Many students find chemistry to be a hindrance in attaining their aims and objectives. The chemistry subject is an important subject for other applied science courses. Hence, a credit

pass is required for all students that want to study science course and its related courses in higher institutions. It is therefore, necessary to properly groom the students right from the secondary school level to enable them improve their academic achievement in chemistry. Poor achievement of students in science subjects, particularly Chemistry, has taken a devastating dimension as reported by West African Examination Council. Laboratory has been identified as the heart of a good scientific tool which enable students to have experience which are consistent with the goals of scientific literacy. Chemistry practical constitutes a major part in Chemistry education, if it is not taught properly the education of the students in the other science courses will be affected negatively. Therefore, secondary schools require properly equipped and functional laboratories. When the students are taught Chemistry theoretically, without the practical aspects done in the laboratory, there will be low retention of the topic taught, resulting massive failure in Chemistry. Given this, the study was undertaken to investigate the availability and usage of laboratory equipments in the learning of Chemistry in Onitsha North Local Government Area.

The gap analysis reveals a significant discrepancy between the ideal scenario of practical science education and the actual situation in Nigerian secondary schools. While laboratory activities are crucial for developing students' scientific skills, the research shows that the availability and utilization of laboratory equipment in the selected schools are insufficient, hindering effective teaching and learning of Chemistry. This gap is particularly evident in the underuse of available equipment, which prevents students from engaging in hands-on experiments, an essential component for fostering scientific understanding. The study highlights the need for improved infrastructure and resource allocation to enable meaningful practical experiences, which are fundamental for acquiring scientific knowledge and skills. This gap between the current state and the ideal conditions calls for urgent attention from policymakers and educational stakeholders to address the deficiencies in laboratory resources and ensure that Chemistry education can reach its full potential.

This study aims to investigate the availability and utilization of laboratory equipment for Chemistry education in public secondary schools within Onitsha North Local Government Area, Anambra State, Nigeria. The research focuses on assessing the extent to which laboratory equipment is available and how frequently students use it during Chemistry lessons. By examining these factors, the study aims to highlight the challenges related to the inadequate resources and poor utilization of laboratory equipment, which hinder effective teaching and learning. The ultimate goal is to provide insights that can inform policy decisions and improve the practical learning experiences of students in Chemistry.

2. METHOD

2.1 Research Design

This study adopted a descriptive survey design, as data were gathered by administering a structured questionnaire. This aligns with the view of Ali (2006), who noted that survey design is concerned with the documentation and description of existing conditions or the presence or absence of what is being investigated. The design was considered appropriate for this study because it relies on the views and opinions of respondents and the resources available within the study area.

2.2 Research Object

The research was conducted in Onitsha North Local Government Area of Anambra State, Nigeria, focusing on public senior secondary schools. The study was implemented in the 2024/2025 academic year. This location was selected due to its relevance and accessibility for the research objectives.

The population for this study comprised all 1,888 Senior Secondary Two (SS2) Chemistry students in public senior secondary schools in Onitsha North. From this population, a sample of 200 SS2 Chemistry students was selected using the simple random sampling technique from 10 public secondary schools in the area.

2.3 Data Collection

The primary instrument for data collection was a structured questionnaire, which consisted of three sections: Section A gathered personal and demographic data of the respondents. Section B focused on the availability of laboratory equipment for effective Chemistry learning. Responses were rated on a four-point scale: Highly Available (HA) = 4, Moderately Available (MA) = 3, Sparingly Available (SA) = 2, Not Available (NA) = 1. Section C addressed the utilization of laboratory equipment in Chemistry instruction. The questionnaire was subjected to face validation by two experts: one from the Department of Chemistry and one from the Department of Psychology at Nwafor Orizu

College of Education, Nsugbe. The instrument's reliability was determined using Cronbach's alpha, which yielded a reliability coefficient of 0.72. This was considered adequate for the study.

2.4 Data Analysis

Data collected were analyzed using mean and standard deviation to answer the research questions. These statistical tools were chosen to summarize responses and determine the extent of agreement among participants regarding the availability and use of laboratory equipment.

2.5 Research Procedures

The researchers personally visited each of the selected public secondary schools to distribute and collect the questionnaires. To ensure complete data return and avoid loss of responses, the completed questionnaires were collected on the spot immediately after they were filled out by the students.

3. RESULT AND DISCUSSION

3.1 Result

a) Research Question 1: To what extent are Chemistry laboratory equipments available in the learning of Chemistry in Secondary Schools?

Table I. Mean Scores of the Respondents on the Extent of Chemistry Laboratory Equipments that are available in the Learning of Chemistry in Secondary Schools

S/N	Items for availability of laboratory equipment	*mea*	S.D	Decision
1	Chemistry laboratory	2.71	0.67	H.A
2	Electricity supply of standing generator	2.00	1.02	N.A
3	Water supply	1.94	0.64	N.A
4	Library books/journals periodical	2.51	1.02	H.A
5	Non-consumables in the laboratory			
	a. Tripod stand and retort stand	2.56	0.86	H.A
	b. Test tubes and beakers	2.62	0.87	H.A
	c. Graduated/measuring cylinder	2.81	1.39	H.A
	d. Chart and models	2.61	0.85	H.A
	e. Weighing balance and Bunsen burners.	1.80	0.60	N.A
	f. Burettes and pipettes	1.60	0.53	N.A
6	Consumable (chemicals)			
	a. NaOH, KOH, NH_4OH	2.94	1.48	H.A
	b. HCl, H_2SO_4, HNO_3	2.73	0.91	H.A
	c. $CuSO_4$, $FeSO_4$, $BaCl_2$	1.89	0.59	N.A
	d. $AgNO_3$, $Ca(OH)_2$ etc.	2.10	1.15	N.A
	e. Indicators	2.00	0.66	N.A
7	Visual and audio visuals	1.90	0.89	N.A
8	Computer and its peripherals	1.83	0.87	N.A
9	E-laboratory	1.01	0.90	N.A
	Grand mean	2.15	1.47	N.A

Table 1 revealed that the laboratory equipment available for learning Chemistry in Secondary Schools is generally low, with a mean of 2.15 and a standard deviation of 1.47. The table also revealed that the laboratory equipments available for the learning of Chemistry in most Secondary Schools are items 1,2,3,4,5,6(a), (b), (c), (d), (e), 7, 8 and 9 while items 2,3,5(e),(g),6(e),(d),(e),7,8 and 9 are not available in majority of Secondary Schools.

b) Research Question 2: To what Extent do Chemistry Students utilize laboratory equipment in the learning of Chemistry in Secondary Schools?

Table 2. Mean Scores of the Respondents on the Extent to which Chemistry Students utilize Laboratory Equipment in the learning of Chemistry in Secondary Schools.

S/N	Items for utilization of laboratory equipment	*mean*	S.D	Decision
1	Chemistry laboratory	3.81	0.93	A.U

2	Electricity supply of standing generator	1.60	0.53	N.U
3	Water supply	1.94	0.64	N.U
4	Library books/journals periodical	1.60	0.53	N.U
5	Non-consumables in the laboratory			
	a. Tripod stand and retort stand	1.67	0.87	N.U
	b. Test tubes and beakers	2.69	1.07	A.U
	c. Graduated/measuring cylinder	2.05	1.01	N.U
	d. Chart and models	1.88	1.12	N.U
	e. Weighing balance and Bunsen burners	1.74	0.84	N.U
	f. Flasks (volumetric round button etc).	2.03	1.16	N.U
	g. Burettes and Pipettes	2.07	1.87	N.U
6	Consumable (Chemicals)			
	a. NaOH, KOH, NH_4OH	2.67	1.86	A.U
	b. HCl, H_2SO_4, HNO_3	3.00	1.59	A.U
	c. $CuSO_4$, $FeSO_4$, $BaCl_2$	1.67	0.82	N.U
	d. $AgNO_3$, $Ca(OH)_2$ etc.	0.95	0.84	N.U
	e. Indicators	1.24	0.40	N.U
7	Visual and audio visuals	2.05	1.01	N.U
8	Computer and its peripherals	2.02	0.99	N.U
9	E-laboratory	2.01	0.60	N.U
	Grand mean	1.89	1.38	N.U

Table 2 showed that items 1, 5(b), (g), 6(a), and (b) rated high, and above 2.50, meaning that they are primarily used in the learning of Chemistry. Items 2,3,4,5(a), (c), (d), (e), 7, 8, and 9 rated below 2.50, and are not adequately utilized during the learning of Chemistry. The table also showed that the overall usage of Laboratory equipment in the learning of Chemistry-by-Chemistry Students had a mean of 1.89 with a standard deviation of 1.38.

c) Research Question 3: Is there any difference in the availability and utilization of laboratory equipment in Secondary Schools?

Table 3: Mean difference and standard deviation of the available laboratory equipment and the extent of utilization in Secondary Schools in the learning of Chemistry.

Items	Mean	SD	Diff.
Availability of Lab. Equipments.	2.15	1.47	
Usage of Lab. Equipments.	1.89	1.38	0.26

Table 3 indicates a mean difference of 0.26. There is a slight difference between the available laboratory equipment and the extent of its usage. This showed that the available laboratory equipment is not adequately utilized in the learning of Chemistry in most Secondary Schools.

3.2. Discussion

The results in tables 1 and 2 revealed that there is laboratory equipment for the learning of Chemistry in Secondary Schools, but these laboratory equipments are inadequately and poorly equipped in schools. The findings of this study align with those obtained by Achimugu (2017), who stated that most of the laboratory equipment and materials were available. However, we are poorly utilised in the teaching and learning of Chemistry. These findings are also in consonance with the findings of Eya & Elechi (2011), who found that most senior secondary science teachers do not make use of the few available materials, such as consumables and audio-visual instructional materials, in teaching science subjects. Gopal (2010) opined that learning materials help teachers to overcome physical difficulties of presenting subject matter to Chemistry students. With learning materials, the barriers of communication and distance will be broken, making the learning of Chemistry easier for the students.

This study revealed that laboratory equipment in schools in the Onitsha North Local Government Area is severely limited. Many essential laboratory tools, which should be used to support Chemistry learning, are either unavailable or in poor condition (Bender et al., 2022). This restricts students' ability to conduct practical experiments, which are fundamental in understanding key Chemistry concepts. As a result, although Chemistry theories are taught

in classrooms, students cannot apply this knowledge through hands-on experiments that would deepen their understanding.

The lack of available equipment directly impacts student learning (Kamba et al., 2019). Practical experiments, which could reinforce theoretical concepts, are missing from the curriculum because students do not have the opportunity to engage in them (Hung et al., 2011). This results in a shallow understanding of fundamental Chemistry principles, as students cannot witness or experience firsthand the phenomena they are studying in textbooks.

In addition to limited availability, the study shows that the present laboratory equipment is often underutilized. Some schools fail to use available resources due to time constraints, a lack of trained teachers, or insufficient human resources to properly manage the equipment. Even though some tools are available, their usage is minimal, limiting the opportunities for students to engage in practical learning.

These limitations affect students' conceptual understanding of chemistry and hinder the development of practical skills crucial to the sciences. Chemistry practicals provide students with essential skills, such as observation, analysis, and problem-solving, which are valuable in daily life and future scientific careers (Salonen et al., 2017). Without hands-on experience using laboratory equipment, students miss the chance to develop these skills, which hinders their potential in the scientific field.

Educational resources, especially adequate laboratory equipment, are crucial for effective and comprehensive learning. With sufficient equipment and proper utilization, students can gain direct experiences that help them understand theoretical knowledge and develop their practical skills. Effective Chemistry education must integrate theory and practice, which can only be achieved if schools provide adequate laboratory facilities and encourage experimental learning (Amela et al., 2024).

To improve the quality of Chemistry education in schools in Onitsha North, there needs to be a significant improvement in the availability and utilization of laboratory equipment. The government and educational institutions should collaborate to provide necessary laboratory tools and ensure teachers are trained to use them effectively. Additionally, it is essential to introduce better maintenance and management programs for the equipment, ensuring that available resources are used efficiently and sustainably. Without these improvements, the quality of Chemistry education will face significant challenges.

4. IMPLICATIONS AND CONTRIBUTIONS

4.1 Reseach Implication

The implications of this study suggest that educational policies prioritize funding and procurement of laboratory equipment, ensuring regular maintenance for practical use. Additionally, curricula should incorporate hands-on activities involving laboratory tools to enhance students' understanding of scientific concepts. Teacher training programs should also include skills in using and integrating laboratory equipment into the learning process. The findings provide empirical evidence to guide policy formulation, budget allocation, and further research on science education infrastructure in secondary schools.

4.2 Reseach Contribution

This study provides empirical evidence on the availability and utilization of laboratory equipment in Chemistry education at public secondary schools in Onitsha North. It fills a gap in the literature regarding infrastructure challenges in science education in the region. Additionally, the findings offer data that can be used to inform policy development, allocate funding, and drive further research on improving science education infrastructure in secondary schools.

5. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

5.1 Reseach Limitations

The limitations of this study include its focus on a specific region, Onitsha North Local Government Area, which may limit the generalizability of the findings to other areas. Additionally, the study relied on self-reported student data, which may be subject to biases or inaccuracies. The sample size of 200 students, while representative, may not fully capture the experiences of all students in the region. Furthermore, the research did not account for factors such as teacher expertise in using laboratory equipment or external influences, such as government policies, that might also affect the availability and utilization of laboratory resources.

5.2 Recommendations for Future Research Directions

For future research, expanding the study to include other regions is recommended to enable a broader understanding of laboratory equipment availability and utilization in different parts of the country. Additionally, future studies could investigate the role of teacher training and expertise in effectively integrating laboratory equipment into the teaching process. Research could also explore the impact of government policies and funding on improving science education infrastructure. Furthermore, longitudinal studies could be conducted to assess the long-term effects of laboratory equipment availability on students' academic performance and scientific skill development.

6. CONCLUSION

From the findings, it can be concluded that while some laboratory equipment is available for the learning of Chemistry in secondary schools, it is not adequately supplied to meet the needs of students. These resources are often insufficient, limiting students' ability to engage in practical, hands-on learning experiences. As a result, Chemistry students rarely use the available laboratory equipment, which hinders their ability to gain a deeper understanding of scientific concepts and practical skills necessary for their academic and future careers.

To address this issue, it is recommended that secondary schools be provided with the necessary materials and laboratory equipment for effective Chemistry education. These resources are fundamental for facilitating practical activities and encouraging hands-on experiences essential for students' scientific development. The collaboration between school administrators and government bodies is key to ensuring that laboratory resources are available and maintained regularly. This joint effort will create an environment where practical experiments are integrated into the curriculum, enhancing students' understanding of Chemistry concepts. Furthermore, investing in laboratory equipment will empower teachers and students to engage in a more interactive and practical learning environment.

Moreover, it is essential for chemistry teachers to effectively utilize the available laboratory equipment and incorporate it into their lessons as part of their teaching strategies. Teachers must be adequately trained to maximize the potential of laboratory resources, enabling students to actively engage in experiments and projects that reinforce their theoretical knowledge. By equipping teachers with the skills to integrate practical activities into their instruction, students will have a more enriching learning experience. Students, in turn, should be encouraged to take an active role in laboratory activities, fostering a sense of ownership in their learning. This active participation will help students develop essential scientific skills and deepen their understanding of Chemistry. Cultivating a culture of practical learning, resource utilization, and student involvement will provide students with a comprehensive education that prepares them for future academic and professional pursuits in the sciences.

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Author Contribution Statement

The author declares that the entire research and writing process for this article was conducted independently. The author assumes full responsibility for all data associated with this research. No other individual contributed as a co-author or made any significant contribution to the content of this work.

Conflict of Interest Statement

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

Ethical Approval Statement

The authors declare that this study was conducted with due regard for research ethics, including obtaining approval from the institution. This includes respecting the autonomy of participants, maintaining confidentiality of data, and ensuring their safety and well-being, in accordance with applicable research ethics guidelines.

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