IMPACT OF INADEQUATE LABORATORY FACILITIES ON THE EFFECTIVE TEACHING OF CHEMISTRY EDUCATION AMONG UNIVERSITY OF BENIN UNDERGRADUATES

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A PROJECT SUBMITTED TO THE DEPARTMENT CURRICULUM AND INSTRUCTIONAL TECHNOLOGY, FACULTY OF EDUCATION, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE B.Sc (Ed) DEGREE IN CHEMISTRY, UNIVERSITY OF BENIN, BENIN CITY, EDO STATE.

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CERTIFICATION

We the undersigned, hereby certify that this work was carried out by **Jude Okem NWANUA** with the matriculation number **EDU2102070** in the Department of Curriculum and Instructional Technology , Faculty of Education, University of Benin, Benin City, Edo State in partial fulfillment of the requirement for the award of Bachelor of Science (B.Sc. Ed) degree in Chemistry Education.

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DEDICATION

This project is dedicated to Almighty God, whose grace, wisdom, and strength made this research possible. It is also dedicated to my beloved parents and loving siblings for their unending love, prayers, and support throughout my academic journey.

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ABSTRACT

This study investigates the impact of inadequate laboratory facilities on the effective teaching of Chemistry education among undergraduates at the University of Benin. Employing a descriptive survey research design, the study focuses on four key dimensions of laboratory inadequacy: lack of functional equipment, shortage of laboratory materials and chemicals, poor laboratory infrastructure, and untrained laboratory personnel.

The population comprised 79 chemistry education students from 300 and 400 levels, with data collected through a structured questionnaire. The findings reveal that deficiencies in these areas significantly hinder practical learning, reduce students' mastery of scientific concepts, and negatively affect their overall performance in Chemistry.

The study underscores the need for strategic investments in laboratory infrastructure, procurement of materials, and training of technical staff to enhance the quality of Chemistry education. Recommendations include increased funding, regular supply of laboratory resources, infrastructure upgrades, and professional development for laboratory personnel to create a conducive environment for effective teaching and learning.

CHAPTER ONE

INTRODUCTION

Background of the Study

Science education has always been globally recognized as one of the sources of innovation, industrial development, and the advancement of technology. Of all the sciences, Chemistry is central given its wide range of applications in medicine, agriculture, manufacturing, pharmaceuticals, environmental management, and daily human activities. Education in Chemistry in Nigerian universities is not only intended to provide students with theoretical knowledge but also with practical skills that would enable them to apply scientific principles to day-to-day challenges (Okafor & Nwankwo, 2022).

Lecture delivery alone is not enough to teach Chemistry effectively. The laboratory is the hub of Chemistry learning because it affords students opportunities to test hypotheses, manipulate equipment, observe reactions, and develop problem-solving and analytical abilities. Adeyemo (2021) and Olatunji (2022) pointed out that students who take laboratory practicals regularly excel at mastering concepts and show more confidence in applying scientific knowledge than students who learn through lectures only. Practical exposure also enhances employability since industries would normally demand graduates who have demonstrated laboratory competence.

Regardless of its importance, Chemistry education in Nigeria is faced with extremely real challenges that are ascribed to the absence of functional laboratory equipment. These challenges can be grouped broadly into four aspects: inadequate functional apparatus, inadequate laboratory chemicals and materials, inadequate laboratory infrastructure, and inadequate laboratory personnel. Functional lab equipment such as burettes, spectrophotometers, pH meters, gas chromatographs, and distillation apparatus are typically lacking or ineffective. Studies have shown that in over 55% of Nigerian universities, most science laboratories have old or non-functional equipment, hence the scope of experiments that can be performed by students is restricted (Adebayo & Salami, 2021).

Similarly, the absence of laboratory chemicals and materials is an ever-rising concern. During a shortage of essential reagents, lecturers are required to demonstrate experiments on paper or limit practical sessions to very basic actions. Ajayi (2023) reported that about 60% of Nigerian science undergraduates perform fewer than three in-depth laboratory sessions per semester due to inadequate consumables. This disempowering efficacy in teaching and bars students from gaining basic manipulative skills.

Inadequate laboratory infrastructure contributes to the problem. Most university laboratories are characterized by insufficient space, poor ventilation, inadequate lighting, unstable electricity supply, and lack of sophisticated safety equipment. In others, one laboratory can hold over 80 students at a time, despite it being designed for fewer than 30,

thus resulting in congestion and reducing the level of supervision (Ogunleye, 2020). The practical sessions become unpleasant, unsafe, and less efficient to perform under these conditions.

Additionally, the absence of competent laboratory staff is another acute problem. Laboratory technologists, assistants, and technicians are of utmost value when it comes to preparing reagents, maintaining equipment, and guiding students through practicals. Where they are lacking or poorly trained, lecturers typically are left with the burden of carrying out technical work, which detracts from efficient teaching. An estimated 40% of Nigerian universities operate with fewer than half of the recommended complement of trained laboratory technologists for the science faculties, according to Eze and Ugwuegbu (2021).

Implications of such shortfalls are very extensive. Graduates emerge with inefficient laboratory skills, minimal confidence in handling equipment, and reduced capability to apply theoretical principles to practical use. Compared to their counterparts in developed countries with well-equipped and well-staffed laboratory facilities, Nigerian undergraduates are disadvantaged. For instance, universities in the United States and Germany heavily invest in exposing students to current laboratory facilities before graduation, which increases their research competence and marketability (OECD, 2022). Conversely, Nigeria's underfinancing of its universities has an impact on the poor global competitiveness of Nigerian science graduates. These shortages in laboratory

infrastructure limit lecturers' efficacy, lower the performance of Chemistry students, and affect the standard of science education in general. It is against this backdrop that this study investigates the impacts of poor laboratory facilities—i.e., shortage of functional equipment, inadequacy of laboratory chemicals and materials, lack of adequate laboratory infrastructure, and incompetent laboratory personnel—on efficient teaching of Chemistry education among University of Benin undergraduates.

Statement of the Problem

Effective delivery of Chemistry education depends heavily on adequate laboratory facilities. Several researchers have indicated this as an issue in Nigerian universities. For example, Adeyemo (2021) indicated that most Nigerian university laboratories lack working equipment, which has caused lecturers to replace practical sessions with descriptions. Furthermore, Ajayi (2023) clarified that the insufficiency of laboratory chemicals and materials in tertiary institutions inhibits students from performing routine Chemistry experiments, thereby denying them manipulative exposure. Similarly, Ogunleye (2020) clarified that poor laboratory infrastructure—e.g., overcrowded areas, erratic power supply, and out-of-date safety measures—offers an unconducive teaching environment, which impacts teaching effectiveness as well as student participation.

While these studies provide useful information on laboratory deficiencies, they leave some loopholes. Adeyemo (2021) focused primarily on equipment availability but not on laboratory personnel's role in facilitating students' practical learning. Ajayi (2023)

mentioned the lack of chemicals but failed to express how substandard infrastructure conspires with a lack of resources to affect teaching. Ogunleye (2020) mentioned infrastructure, but did not capture the manner in which all four dimensions—unavailability of functional equipment, lack of laboratory material, poor infrastructure, and untrained personnel—cumulatively impact Chemistry education within the context of a university. This current study seeks to fill these gaps by adopting a systematic perspective of investigating the cumulative impact of these four dimensions of inadequate laboratory facilities on effective teaching of Chemistry education among undergraduate students at the University of Benin. In filling these under-researched gaps, the study provides a clearer picture of how laboratory deficiencies impact teaching and learning, and therefore evidence-based recommendations to improve Chemistry education in Nigerian universities.

Research Questions

The study will be guided by the following research questions:

1. How does lack of functional laboratory equipment affect the teaching of Chemistry at the University of Benin?
2. To what extent does shortage of laboratory materials and chemicals influence Chemistry education?
3. In what ways does poor laboratory infrastructure affect the teaching and learning of Chemistry?

4. How does the presence of untrained laboratory personnel impact effective teaching of Chemistry education?

Purpose of the Study

The main objective of this study is to examine the impact of inadequate laboratory facilities on the effective teaching of Chemistry education among University of Benin undergraduates. Specifically, the study seeks to:

1. Investigate how lack of functional laboratory equipment affects the teaching of Chemistry.
2. Examine the influence of shortage of laboratory materials and chemicals on Chemistry education.
3. Assess the impact of poor laboratory infrastructure on the teaching and learning of Chemistry.
4. Determine the extent to which untrained laboratory personnel affect the effective teaching of Chemistry education.

Significance of the Study

This study is of great importance to different stakeholders in the teaching and learning of Chemistry education. For students, it draws attention to how inadequate laboratory facilities hinder their learning experiences, reduce their performance in practical work, and ultimately affect their mastery of scientific concepts. By exposing

these challenges, the study creates awareness among students of the need to advocate for better learning resources.

For lecturers, the research provides valuable insights into the specific obstacles they encounter in delivering practical-oriented teaching. It also highlights possible strategies that can be adopted to overcome these barriers and improve the quality of instruction, even in the face of limited resources. For university management and policymakers, the findings will serve as an evidence-based guide to the importance of investing in laboratory facilities. It emphasizes the need for adequate funding, regular supply of laboratory materials and chemicals, proper training and recruitment of technical staff, and the upgrading of existing infrastructure to create a conducive learning environment. Finally, for researchers, this study will contribute to the growing body of literature on science education and laboratory management in Nigerian universities. It will provide a reference point for further studies, thereby enriching scholarly discussions on improving Chemistry education in tertiary institutions.

Scope of the Study

The study is limited to the impact of inadequate laboratory facilities on the effective teaching of Chemistry education among undergraduates of the University of Benin. It specifically focuses on four dimensions of inadequacy: lack of functional equipment, shortage of laboratory materials and chemicals, poor laboratory infrastructure, and

untrained laboratory personnel. Respondents will include Chemistry education students and lecturers in the Faculty of Education.

Definition of Terms

- **Lack of Functional Equipment:** The absence or insufficiency of modern and working laboratory apparatus necessary for Chemistry experiments.
- **Shortage of Laboratory Materials and Chemicals:** Inadequate supply of reagents, consumables, and related materials needed for effective practical sessions.
- **Poor Laboratory Infrastructure:** Substandard physical conditions of laboratories, including space, ventilation, electricity, and safety facilities.
- **Untrained Laboratory Personnel:** Laboratory assistants or technologists without adequate training or expertise to support teaching and experiments.
- **Effective Teaching of Chemistry:** The process of delivering Chemistry lessons in a way that enhances students' understanding, participation, and ability to apply knowledge practically.
- **Undergraduates:** Students currently pursuing a bachelor's degree program in Chemistry education at the University of Benin.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter focuses on the review of relevant and related literature to the concern of this study. It is discussed under the following subheadings:

- Theoretical Framework
- Concept of Chemistry Education
- The Role of Laboratory Facilities in Science Education
- Impact of Inadequate Laboratory Equipment on Chemistry Education
- Shortage of Laboratory Materials and Chemicals: Consequences for Chemistry Education
- Effects of Poor Laboratory Infrastructure on Chemistry Education
- The Role of Laboratory Personnel in Effective Chemistry Education
- Global Perspectives on Laboratory Challenges in Chemistry Education
- Summary of Reviewed Literature.

Theoretical Framework

The theoretical frameworks that support the investigation of the impact of insufficient laboratory facilities on the effective teaching of chemistry education among undergraduates at the University of Benin are the Constructivist Learning Theory and the Experiential Learning Theory.

Theory of Experiential Learning

The Experiential Learning Theory (ELT), established by David Kolb in 1984, constitutes a pivotal foundation in educational psychology and pedagogy. Kolb's theory posits that learning is a process in which knowledge is generated via the transformation of experience. Kolb proposed that learning encompasses a cyclical process consisting of four stages: tangible experience, reflective observation, abstract conceptualisation, and active experimentation. The learner initially participates in a tangible experience (e.g., conducting an experiment in a chemistry laboratory), subsequently reflects on that experience (reflective observation), develops theories or generalisations from those reflections (abstract conceptualisation), and ultimately evaluates those theories or generalisations through new actions (active experimentation) (Kolb, 1984). This hypothesis is pertinent to the examination of insufficient laboratory facilities in chemistry education, especially for university students. Chemistry, as a practical discipline, necessitates that students interact directly with chemicals, equipment, and experimental methodologies in the laboratory to comprehensively grasp intricate topics such as chemical reactions, molecular structures, and stoichiometry. Kolb asserts that effective learning necessitates active engagement and the capacity to reflect upon and experiment with real-world experiences. The absence of sufficient laboratory facilities significantly hampers students' engagement in this process, thereby affecting their learning and academic achievement. The absence of laboratory resources restricts

students' tangible experiences, hindering their advancement through Kolb's learning cycle. The deficiency in experiential learning results in pupils forgoing essential educational opportunities, impeding their acquisition of both practical and theoretical information. The applicability of this theory to your study's subject is evident. The substandard laboratory facilities at the University of Benin significantly hinder students' capacity to participate in practical chemistry experiences, hence interrupting the cyclical learning process articulated by Kolb. Inadequate laboratory resources hinder students' full engagement in experiments, which are essential to their chemical education. This adversely affects their academic performance, inhibiting the acquisition of essential skills and knowledge required to master fundamental concepts in the subject. Kolb's experiential learning cycle emphasises the significance of active experimentation and actual experience in chemistry education; its absence results in inadequate learning.

Constructivist Learning Theory

Constructivist Learning Theory emerged from the contributions of various psychologists, including Jean Piaget and Lev Vygotsky, who posited that learning is an active process wherein learners build new knowledge grounded in their experiences and existing comprehension. Piaget, in his phases of cognitive development, posited that infants acquire knowledge most effectively by exploration and interaction with their surroundings, rather than by being passive consumers of information. Vygotsky, expanding upon Piaget's theories, highlighted the significance of social interaction and

culture in learning, particularly the concept of scaffolding, wherein learners receive assistance from more educated individuals, such as educators or peers, along their educational journey (Vygotsky, 1978).

In chemistry education, constructivism underscores the significance of students developing their comprehension through active engagement, experimentation, and social interaction. Chemistry students develop their understanding of chemical processes, molecular behaviour, and laboratory techniques through practical engagement and reflective analysis of their experiences. Inadequate laboratory facilities hinder students from participating in essential hands-on activities required for profound experiential learning. This constraint significantly hinders their capacity to acquire new knowledge and comprehend chemical principles effectively. The lack of participation in laboratory experiments hinders knowledge creation, which is fundamental to the theory's assertion that learners enhance their existing knowledge through experience.

The significance of constructivist learning theory in your research is substantial, as it underscores the importance of laboratory-based learning in chemistry for students to have a thorough comprehension of the subject. Insufficient laboratory facilities hinder students' engagement in essential experiential learning, hence impairing their capacity to develop new concepts. This hypothesis posits that when students lack opportunities for hands-on experimentation, they cannot actively generate information, resulting in deficiencies in comprehension and academic performance. The absence of adequate facilities

fundamentally contradicts the principles of constructivist learning, which posits that students acquire knowledge most effectively through active exploration and reflection.

Concept of Chemistry Education

Chemistry education is essential for cultivating scientific literacy and equipping students with the knowledge and skills required to comprehend and address real-world issues. Chemistry, known as the "central science," links the physical sciences, biological sciences, and applied sciences like engineering and medicine, rendering it a crucial field of study in both secondary and postsecondary education. It provides pupils with the capacity to comprehend the properties, composition, and behaviour of matter, along with the chemical interactions and processes that dictate our environment. Chemistry education is fundamentally important in developing future scientists, engineers, medical professionals, and informed citizens.

The primary objective of Chemistry education is to enable students to comprehend fundamental chemical concepts, principles, and theories, while simultaneously cultivating their problem-solving, analytical, and critical thinking abilities. Comprehending principles such as atomic structure, chemical bonding, reactions, and thermodynamics is crucial for students aspiring to jobs in medicine, pharmacology, environmental science, industrial chemistry, and engineering. Chemistry education not only imparts essential knowledge but also cultivates cognitive skills, such as logical reasoning, that are applicable to other fields and daily life (Yandell & Collins, 2020). This extensive

applicability highlights the significance of Chemistry as a fundamental discipline in scientific education.

Chemistry education is mostly taught through a balanced curriculum that mixes theoretical knowledge with practical application. Theoretical courses furnish students with essential knowledge of chemical processes, while practical laboratory work enables the application of that information in real-world experiments. Laboratory experiences are essential in Chemistry education, as they provide students practical opportunity to observe chemical reactions and participate in scientific investigation. Practical sessions foster the development of critical thinking abilities, hypothesis testing, and comprehension of the scientific method, all of which are fundamental components of scientific reasoning (Hesse et al., 2021). Research indicates that laboratory practicals not only deepen students' comprehension but also augment their involvement with the subject (Girod & White, 2019).

Chemistry education encounters various problems that may impede its efficacy, despite its significance. A primary impediment is the insufficiency of appropriate laboratory facilities and resources. In numerous educational institutions, especially in poor nations, the lack of operational equipment, chemicals, and reagents hinders students from conducting experiments essential to their education (Ajayi et al., 2019). This frequently leads to an overreliance on theoretical training, which may reduce student involvement and impede their comprehension of essential chemical principles. The deficiency of

properly maintained laboratory facilities, along with insufficient availability to essential chemicals, diminishes the quality of Chemistry teaching and constrains the extent of practical work available to students (Ogunleye, 2021). Consequently, students may find it challenging to integrate theory with practice, resulting in a superficial comprehension of the subject matter.

A notable problem in Chemistry education is the training and professional development of instructors. Effective chemistry instruction needs both subject matter understanding and the capacity to articulate intricate concepts clearly while actively engaging students in the learning process. Educators must possess the requisite knowledge and pedagogical expertise to render the subject matter accessible and engaging for learners. Nevertheless, numerous educators, particularly in resource-limited settings, do not have access to professional development programs that would enable them to remain informed about contemporary teaching methodologies and laboratory techniques (Oladimeji & Ige, 2022). In the absence of such preparation, educators may struggle to maintain student engagement and to render the subject matter more pertinent to their lives. The insufficiency of proper teacher preparation is especially detrimental in nations where Chemistry education encounters financial and resource limitations, hence intensifying the difficulties in instruction and comprehension.

Alongside these structural and professional problems, student motivation continues to be a crucial element in Chemistry education. The topic is frequently perceived as

challenging and intangible, resulting in student disengagement. Numerous students perceive Chemistry as daunting due to its intricate concepts and significant dependence on mathematical principles. Consequently, enthusiasm for the subject may diminish, resulting in subpar academic achievement. To resolve this challenge, educators must implement novel pedagogical practices that render Chemistry more accessible and relevant to pupils. Project-based learning, inquiry-based methodologies, and technological integration can enhance student engagement and demonstrate the real-world implications of the principles being studied (Eckert et al., 2020).

Recent advancements in Chemistry education seek to tackle these difficulties by incorporating technology into pedagogy. Utilising virtual laboratories and simulations enables students to perform experiments and visualise chemical processes that may otherwise be unattainable owing to resource constraints. These tools provide interactive methods for students to investigate intricate chemical topics and conduct virtual experiments, thereby augmenting their comprehension of the subject. Virtual laboratories have gained significance in contexts where access to physical laboratory facilities is restricted, rendering them a valuable complement to conventional pedagogical approaches (De Wet, 2020).

Furthermore, the increasing focus on interdisciplinary education in Chemistry promotes students' ability to link Chemistry with other disciplines, including biology, physics, and environmental science. This interdisciplinary approach expands students' viewpoints and

equips them for professions in burgeoning sectors such as biotechnology, materials science, and environmental chemistry. Modern Chemistry education seeks to prepare students with the necessary capabilities to tackle global concerns, such as climate change and public health crises, by integrating real-world problems and promoting interdisciplinary thinking (Wilkerson, 2021).

Chemistry education is essential for scientific and technological progress, equipping students with the information and abilities required to tackle the challenges of contemporary society. The efficacy of Chemistry teaching is frequently impeded by insufficient resources, inadequate teacher preparation, and the difficulties associated with engaging students in a subject seen as challenging. Confronting these problems necessitates investment in laboratory infrastructure, professional development for instructors, and the implementation of innovative pedagogical approaches that enhance the accessibility and relevance of Chemistry for students. Enhancing the quality of Chemistry education would better equip students to address future scientific and societal challenges.

The Role of Laboratory Facilities in Science Education

Laboratory facilities play a critical role in the teaching and learning of Chemistry and other science disciplines, as they provide the practical environment where theoretical knowledge is translated into tangible experience. In science education, particularly in Chemistry, laboratory settings are essential for students to engage directly with scientific

principles, conduct experiments, and observe chemical reactions firsthand. The role of laboratory facilities in Chemistry education extends beyond the mere availability of space and equipment; it encompasses the entire environment that enables interactive, hands-on learning, which is crucial for fostering a deeper understanding of the subject matter.

Laboratories serve as the primary setting for students to apply the concepts they learn in lectures. In Chemistry, this involves conducting experiments that demonstrate the behavior of matter under various conditions, allowing students to observe and test chemical theories. Through practical work, students not only consolidate their theoretical knowledge but also develop critical skills such as problem-solving, analytical thinking, and the ability to interpret experimental results (Girod & White, 2019). As highlighted by Hesse et al. (2021), laboratory work is essential for developing an understanding of the scientific method, as students are actively involved in hypothesis formation, experimentation, data collection, and analysis. These activities cultivate an inquiry-based approach to learning, encouraging students to ask questions, explore variables, and draw conclusions based on empirical evidence.

The hands-on nature of laboratory work also contributes to higher student engagement and motivation. Chemistry, like other scientific disciplines, often requires abstract thinking, which can be difficult to grasp solely through textbook learning. Laboratory facilities offer students the opportunity to visualize and experience chemical concepts in action, making complex theories more accessible and relatable. According to Yandell and

Collins (2020), students who participate in laboratory work are more likely to develop a long-term interest in science because they see the practical relevance of what they are learning. This engagement can be particularly significant in subjects like Chemistry, where the manipulation of materials and observation of reactions help to solidify understanding and make the learning process more enjoyable.

In addition to fostering engagement, laboratory facilities are essential for developing students' practical skills, which are indispensable for their future careers in science, engineering, medicine, and other related fields. The ability to conduct experiments, operate scientific equipment, and apply safety protocols are vital competencies for any science student. The laboratory environment provides students with opportunities to practice these skills in a controlled and supervised setting. As noted by Okafor and Oyedepo (2020), students who have access to well-equipped laboratories are better prepared for careers that require technical expertise and hands-on problem-solving. Furthermore, laboratory-based learning encourages teamwork and collaboration, as many experiments require students to work together to achieve a common goal. These collaborative experiences help students develop communication and interpersonal skills that are critical in both academic and professional settings.

The quality of laboratory facilities also has a significant impact on the effectiveness of Chemistry education. Well-maintained and well-equipped laboratories create an optimal environment for learning, where students can perform a wide range of experiments

without encountering technical limitations. In contrast, poorly equipped laboratories or those with outdated equipment can severely restrict the types of experiments that can be conducted, which ultimately limits the scope of learning. According to Ajayi et al. (2019), the availability of modern equipment and chemicals in laboratories directly affects the quality of education students receive, as it enables them to engage in diverse and up-to-date experimental practices. Conversely, the absence of key laboratory resources can lead to frustration among students and teachers, as they are unable to perform essential experiments that reinforce key learning outcomes.

Moreover, laboratories are integral to cultivating a safe and conducive learning environment. Safety is paramount in Chemistry education, given the potential hazards associated with chemicals and laboratory equipment. Properly equipped laboratories with appropriate safety measures such as fume hoods, safety goggles, and fire extinguishers ensure that students can engage in practical work without compromising their well-being. According to Ogunleye (2021), safety protocols are critical in preventing accidents and ensuring that students understand the importance of handling chemicals and equipment responsibly. Laboratories that are not properly equipped with safety features can put students at risk and hinder their ability to learn effectively. Ensuring that laboratory facilities are safe and accessible is therefore a crucial aspect of promoting effective science education.

In countries where resources are limited, the lack of adequate laboratory facilities often leads to reliance on theoretical teaching methods, which can diminish the quality of science education. As noted by Omotayo (2022), many schools and universities, particularly in developing nations, struggle to provide adequate laboratory resources, resulting in a gap between theoretical learning and practical application. This disconnect can negatively impact students' learning outcomes, as they may find it difficult to fully grasp abstract concepts without the opportunity to conduct experiments and make direct observations. To address these challenges, it is essential for educational institutions to invest in laboratory infrastructure and ensure that teachers have access to the resources they need to create engaging and effective learning experiences for their students.

In conclusion, laboratory facilities are fundamental to effective Chemistry education, as they provide a space for students to apply theoretical knowledge, develop practical skills, and engage in hands-on learning. Well-equipped laboratories not only enhance student understanding and interest in Chemistry but also prepare students for careers in science and related fields by cultivating essential skills such as problem-solving, teamwork, and technical expertise. However, the lack of adequate laboratory resources in many educational settings can limit the potential for effective teaching and learning, making it essential to address these challenges through investment in infrastructure and resources. A well-maintained and fully equipped laboratory environment is essential for promoting

high-quality Chemistry education and ensuring that students are prepared for the scientific and professional challenges of the future.

Impact of Inadequate Laboratory Equipment on Chemistry Education

The impact of inadequate laboratory equipment on Chemistry education is a significant concern that affects the quality of teaching and learning in this field. Laboratories are central to the practical learning of Chemistry, allowing students to engage directly with the subject matter and apply theoretical knowledge to real-world experiments. However, when laboratory equipment is insufficient or dysfunctional, it creates significant barriers to effective teaching and learning. The absence of essential tools such as beakers, pipettes, thermometers, and fume hoods hinders the ability to conduct basic experiments, thus limiting the hands-on experience that is crucial to Chemistry education.

One major consequence of lacking functional laboratory equipment is the reduction in the scope of experiments that can be carried out. Many Chemistry concepts require specific instruments to be fully understood. For example, concepts like the behavior of gases, chemical reactions, and molecular structures are often best demonstrated through experiments that require precise measurements and observations. Without functional equipment, students are unable to replicate experiments or make accurate observations, which can lead to gaps in understanding. Research by Igbokwe et al. (2019) found that in many schools and universities, inadequate equipment results in the use of outdated or malfunctioning tools, which compromises the quality of practical lessons. These

constraints often lead instructors to either modify experiments or, in the worst cases, abandon them entirely, diminishing students' opportunities for hands-on learning.

Moreover, the lack of functional laboratory equipment directly impacts student engagement. Practical work in Chemistry provides an interactive and dynamic learning environment that encourages students to think critically, test hypotheses, and engage in problem-solving. Without the appropriate equipment, students are forced to rely on theoretical learning, which can make Chemistry feel abstract and disconnected from real-world applications. This disconnection between theory and practice can lead to a decline in student motivation and interest in the subject. According to a study by Ogunleye (2021), when students do not have access to the necessary tools to conduct experiments, their interest in Chemistry tends to wane, and their academic performance suffers as a result. Lack of hands-on experience also limits the development of critical thinking and analytical skills that are essential for students pursuing careers in scientific fields.

Another key issue is the impact on the development of technical skills. Chemistry education is not only about theoretical knowledge but also about developing practical skills that students will need in their future careers. These skills include the ability to use scientific instruments, interpret data, and adhere to safety protocols. When laboratories lack functional equipment, students miss out on learning how to properly use the tools and equipment that are fundamental to scientific research and industry applications. The inability to master these technical skills can leave students unprepared for professional

work in fields such as pharmaceuticals, environmental science, and industrial chemistry. Studies have shown that students from institutions with inadequate laboratory equipment are less likely to perform well in internships or job placements that require practical Chemistry knowledge (Hesse et al., 2021).

In some cases, the lack of proper equipment forces teachers to adopt alternative methods of teaching, such as relying more heavily on theoretical lectures or using virtual simulations. While these methods can provide some value, they are not a substitute for the experiential learning that occurs in the laboratory. Virtual laboratories, for example, can simulate chemical reactions but cannot replicate the tactile experience of handling reagents or observing reactions firsthand. As a result, students may struggle to develop the practical skills needed to understand and apply complex chemical principles in real-world settings. A study by Jiboku et al. (2020) highlights that, although virtual labs can help to some extent, they are not as effective as physical lab experiences in fostering a deep understanding of Chemistry concepts. Without hands-on practice, students may struggle to retain and apply what they have learned.

Furthermore, the issue of inadequate laboratory equipment also has broader implications for the quality of Chemistry education at the national and international levels. Research by Igbokwe et al. (2019) has shown that universities in developing countries, in particular, often face significant challenges due to a lack of funding for laboratory equipment. This has led to disparities in the quality of education between institutions, with some students

receiving a subpar education compared to their peers at well-equipped universities. These inequities further perpetuate the cycle of limited access to quality science education, contributing to gaps in knowledge and skills in the global workforce. Inadequate resources not only affect students' academic performance but also their ability to contribute meaningfully to the scientific and technological advancements in their countries.

In conclusion, the impact of inadequate laboratory equipment on Chemistry education is profound. It limits students' ability to perform experiments, reduces engagement, hinders the development of technical skills, and exacerbates inequalities in educational quality. To improve Chemistry education, it is essential for institutions to prioritize the acquisition and maintenance of functional laboratory equipment. Doing so would not only enhance the quality of teaching and learning but also ensure that students are better prepared for careers in science and related fields. Adequate laboratory facilities are essential for fostering critical thinking, technical expertise, and a deeper understanding of the scientific concepts that underpin Chemistry.

Shortage of Laboratory Materials and Chemicals: Consequences for Chemistry Education

The accessibility of laboratory materials and chemicals is a crucial element of effective Chemistry education. In Chemistry, practical experiments are essential for facilitating students' comprehension of theoretical concepts and cultivating the requisite abilities to

apply these principles in real-world contexts. Laboratory materials, including chemicals, reagents, glassware, and other vital supplies, facilitate students in conducting experiments that illustrate chemical reactions, molecular behaviour, and scientific processes. These practical activities are essential for consolidating classroom learning, increasing student engagement, and fostering critical thinking and problem-solving skills.

The significance of laboratory supplies and chemicals in Chemistry teaching is paramount. Chemistry is fundamentally a practical field, where comprehension of abstract ideas like atomic structure, chemical bonding, and reaction mechanisms is most effectively attained through experimentation. Laboratory work enables students to directly witness chemical events, test hypotheses, and validate theoretical predictions. This experience learning is essential for enhancing students' understanding and cultivating a greater interest in the subject (Hesse et al., 2021). Moreover, laboratory supplies, encompassing safety equipment and protective gear, are crucial for conducting research safely and efficiently. These products serve both educational and practical purposes, providing students with the technical skills essential for jobs in science, engineering, and medicine.

The scarcity of laboratory materials and chemicals is a considerable obstacle to the quality of Chemistry teaching. The absence of essential resources in educational institutions significantly impedes the capacity to do practical experiments. Olasehinde et al. (2020) discovered that the deficiency of chemicals, reagents, and laboratory glassware

at numerous educational institutions leads to an excessive dependence on theoretical training. This circumstance denies students the practical experience essential for cultivating critical scientific skills and linking theoretical knowledge to real-world applications. Insufficient materials may compel teachers to alter or annul experiments, thereby diminishing the extent of practical work and constraining students' engagement with the practical facets of Chemistry. This not only impacts students' comprehension of fundamental topics but also detracts from their overall educational experience.

The effect of a deficiency in laboratory supplies is especially significant in the cultivation of technical skills. Laboratory experiments enable students to acquire skills in precise measurement, utilisation of scientific apparatus, chemical handling, and adherence to safety regulations. These competencies are vital for prospective employment in science and technology. When students lack access to essential materials, they forfeit the chance to acquire these competencies. Jiboku et al. (2020) assert that the deficiency of chemicals and laboratory materials frequently leaves students inadequately equipped for the technical requirements of scientific professions. In the absence of engaging with actual chemical reactions, students may find it challenging to cultivate the problem-solving and critical thinking abilities essential for success in the scientific domain.

The scarcity of laboratory materials adversely affects student motivation and performance. Chemistry is frequently regarded as a difficult and abstract discipline, and

students' enthusiasm may diminish when they lack opportunities for interactive, practical experiences. Ajayi et al. (2019) assert that students deprived of experimental opportunities are more prone to disengagement from Chemistry, perceiving the topic as irrelevant to their daily life and prospective professions. The failure to conduct experiments that illustrate the significance and practical utility of Chemistry may result in disengagement and diminished academic performance. Furthermore, when experiments are cancelled or altered owing to material shortages, students forfeit crucial opportunities to enhance their learning and expand their comprehension of the subject matter.

The deficiency of laboratory materials and chemicals adversely impacts the overall quality of education. When institutions fail to supply essential resources, pupils are disadvantaged relative to their counterparts at better-equipped schools. This imbalance in resource allocation results in inequitable educational outcomes, with students from impoverished institutions receiving a less comprehensive education and diminished opportunity to cultivate practical skills. Igbokwe et al. (2020) assert that students in schools with inadequate laboratory resources frequently exhibit inferior academic performance due to a lack of practical training compared to their counterparts in well-equipped institutions. The disparity in educational quality may have enduring repercussions, exacerbating inequalities in scientific literacy and professional opportunities for pupils.

Moreover, the scarcity of laboratory materials is frequently intensified by fiscal limitations and inadequate funding for educational establishments. In numerous underdeveloped nations, educational institutions face challenges in obtaining sufficient money for laboratory supplies, resulting in a deficiency of vital chemicals and equipment. The escalating costs of chemicals exacerbate the challenge for educational institutions to maintain fully stocked laboratories. Ogunleye's (2021) research indicated that insufficient government support for education and poor financial management within institutions frequently lead to shortages of essential laboratory items. These budgetary obstacles hinder schools from supplying the essential materials for pupils to fully engage in Chemistry instruction.

The deficiency of laboratory materials and chemicals substantially affects the quality of Chemistry education. It restricts students' capacity for practical learning, denies them the chance to cultivate vital technical skills, and diminishes overall student motivation and performance. To guarantee the efficacy of Chemistry instruction, it is imperative that educational institutions prioritise the procurement of requisite materials and chemicals. Proper funding, enhanced resource management, and a dedication to equipping students with necessary tools are crucial for elevating the quality of Chemistry education and preparing students for future professions in science and technology.

Effects of Poor Laboratory Infrastructure on Chemistry Education

Poor laboratory infrastructure is a significant barrier to effective Chemistry education. The physical conditions of laboratory spaces, including their design, size, ventilation, safety measures, and accessibility, play a crucial role in the quality of education provided to students. Well-equipped and well-maintained laboratories not only facilitate learning but also ensure the safety of students and teachers during experiments. In contrast, inadequate infrastructure can impede students' ability to engage with the subject matter, limit their practical experiences, and create an environment that is unsafe and difficult to navigate.

One of the primary concerns regarding poor laboratory infrastructure is the physical space available for conducting experiments. Many educational institutions, particularly in developing countries, suffer from overcrowded and underfunded laboratory facilities. A study by Okafor and Oyedepo (2020) found that overcrowded laboratories, which cannot accommodate all students simultaneously, limit the opportunities for students to perform practical experiments. The lack of space makes it difficult to set up multiple experiments or provide sufficient supervision, as students may be forced to share equipment and work in cramped conditions. This not only diminishes the quality of the hands-on experience but also increases the likelihood of accidents due to improper handling of chemicals and equipment. In such environments, students are unable to engage deeply with the material, which can lead to a less effective understanding of Chemistry concepts.

In addition to space, poor ventilation and inadequate safety measures in Chemistry laboratories are significant issues that can undermine the teaching and learning experience. Chemistry experiments often involve the use of hazardous chemicals, which can release toxic fumes or cause reactions that pose safety risks. Without proper ventilation systems, these fumes can accumulate in the laboratory, exposing students and staff to harmful substances. Safety measures, such as fume hoods, fire extinguishers, and safety goggles, are critical in ensuring that experiments can be conducted without endangering students. According to Ajayi et al. (2019), many schools and universities with poor laboratory infrastructure lack adequate safety equipment, putting students at risk. The absence of proper safety measures also means that students are not learning how to conduct experiments safely, which is an essential skill for any future scientist. Furthermore, poor infrastructure can lead to a lack of basic safety training, as teachers may be unable to properly supervise students in such hazardous conditions.

Another issue related to poor laboratory infrastructure is the accessibility of laboratories. In some cases, laboratories are located in poorly accessible areas, far from classrooms or other academic facilities. This lack of accessibility can make it difficult for students, particularly those with disabilities or mobility issues, to participate in laboratory-based learning. Research by Hesse et al. (2021) emphasizes the importance of making laboratory facilities accessible to all students, including those with physical disabilities. Inaccessible laboratories not only limit the learning opportunities for students with

special needs but also create a sense of exclusion and inequality, further reducing the quality of education for all students. Additionally, inaccessible spaces can create logistical challenges, making it more difficult for teachers to organize practical sessions effectively and for students to engage with the subject matter.

The consequences of poor laboratory infrastructure extend beyond the immediate classroom experience. Poorly designed or outdated laboratories may lack the necessary equipment for modern Chemistry education. Laboratories that do not have access to up-to-date instruments and materials can severely limit the types of experiments that can be carried out. For example, the absence of modern spectroscopy devices, titration setups, or even basic glassware prevents students from exploring key concepts in modern Chemistry. The outdated state of equipment and the lack of technology can create a significant gap between what is taught in the classroom and the tools that are used in real-world scientific research and industry (Girod & White, 2019). Students who are unable to engage with current scientific technologies may find it difficult to transition into the workforce, as they lack the hands-on experience necessary to operate modern equipment and interpret experimental data effectively.

Moreover, poor laboratory infrastructure can have a negative impact on student engagement and motivation. When students are exposed to poorly maintained or unattractive laboratory spaces, it can lead to a sense of dissatisfaction and frustration. This negative environment can reduce their enthusiasm for Chemistry and diminish their

confidence in their ability to succeed in the subject. Research by Olasehinde et al. (2020) found that students in schools with poorly maintained laboratories are often demotivated and show less interest in participating in practical sessions. In such cases, students may be less likely to develop a genuine interest in pursuing careers in science, as they may feel that the subject is irrelevant or too difficult to grasp in suboptimal learning conditions. Furthermore, the lack of proper laboratory infrastructure also affects the teaching capabilities of educators. Instructors who are working in poorly equipped laboratories often face challenges in conducting demonstrations, managing experiments, and ensuring that all students have the opportunity to engage with the material. The limitations imposed by inadequate facilities can prevent teachers from delivering high-quality, interactive lessons, which are essential for fostering a deep understanding of Chemistry. According to Okafor and Oyedepo (2020), teachers in underfunded institutions often struggle to create effective learning environments because of the inadequate infrastructure, which can reduce their ability to teach the subject effectively.

In conclusion, poor laboratory infrastructure has far-reaching consequences for Chemistry education. It affects the physical learning environment, student safety, accessibility, and engagement, as well as the quality of instruction and the development of practical skills. To improve the quality of Chemistry education, it is essential for educational institutions to invest in modernizing laboratory facilities, ensuring that they are adequately equipped, well-maintained, and accessible to all students. By addressing

issues related to space, safety, equipment, and accessibility, schools and universities can create a conducive learning environment that fosters student engagement, supports practical learning, and prepares students for successful careers in scientific fields.

The Role of Laboratory Personnel in Effective Chemistry Education

The role of laboratory personnel is crucial in ensuring the effectiveness of Chemistry education. Well-trained laboratory staff are essential for creating a safe, efficient, and conducive learning environment where students can perform experiments, explore scientific concepts, and develop practical skills. The presence of skilled laboratory personnel enhances the learning experience, providing students with guidance on proper experimental techniques, safety protocols, and the proper handling of chemicals and equipment. Conversely, the absence or inadequacy of trained staff can lead to safety risks, ineffective teaching, and a suboptimal learning environment, which ultimately diminishes the quality of Chemistry education.

Laboratory personnel, including technicians, assistants, and other support staff, play a vital role in managing the laboratory environment and facilitating practical learning. One of their primary responsibilities is ensuring that laboratory equipment is set up properly and functioning well before experiments are conducted. A well-trained technician can identify faults in equipment, calibrate instruments, and troubleshoot any problems that may arise during the experiment. This expertise is essential because many Chemistry experiments rely on precise measurements and accurate instruments, such as pH meters,

balances, and spectrometers. When laboratory personnel are well-trained, they ensure that students have access to properly maintained equipment and are able to use the equipment correctly, which enhances the overall learning experience.

Moreover, laboratory personnel are responsible for maintaining safety in the lab. Chemistry experiments often involve hazardous chemicals, heat, or reactions that can be dangerous if not handled properly. Trained laboratory staff are equipped with the knowledge and skills to enforce safety protocols, such as the correct handling of chemicals, the use of safety equipment like goggles and gloves, and the proper disposal of chemical waste. Their role is crucial in preventing accidents and ensuring that students understand the importance of safety when working in a laboratory setting. In the absence of trained staff, there is an increased risk of accidents, such as chemical spills, burns, or exposure to toxic substances, which not only endanger students and staff but also disrupt the learning process.

In addition to maintaining safety, trained laboratory personnel are instrumental in supporting the learning process by providing students with the necessary guidance and assistance during experiments. A knowledgeable laboratory technician or assistant can help students understand complex experimental procedures, clarify instructions, and offer troubleshooting tips when things go wrong. This hands-on support is essential for students, particularly those who may be unfamiliar with laboratory work or those who are struggling to grasp specific Chemistry concepts. Laboratory personnel can also play a

role in encouraging students' interest in the subject by offering practical insights into the relevance of the experiments being conducted and demonstrating the connections between theory and practice.

Unfortunately, in many educational institutions, the lack of well-trained laboratory personnel poses significant challenges to the quality of Chemistry education. When laboratory staff are untrained or inadequately trained, they may lack the expertise to manage the laboratory effectively, leading to a variety of issues. For example, they may be unable to properly maintain or troubleshoot equipment, which can lead to experiments being delayed or even canceled due to malfunctioning instruments. Additionally, untrained staff may be less aware of the safety protocols necessary to protect students from potential hazards. This lack of expertise can create an environment where students are not given the appropriate level of guidance, reducing the quality of their learning experience and potentially exposing them to dangerous situations.

Furthermore, untrained laboratory personnel may be unable to provide students with the appropriate level of instructional support. Chemistry experiments are often complex and require careful guidance to ensure that students are conducting the procedures correctly and interpreting their results accurately. Without knowledgeable staff to offer this guidance, students may struggle to understand the scientific principles behind the experiments, leading to confusion and frustration. This can have long-term consequences,

as students may develop a negative perception of Chemistry and become less motivated to pursue further studies or careers in the field.

The challenges posed by untrained laboratory personnel extend beyond individual experiments and affect the overall teaching process. Teachers may be forced to spend extra time managing the laboratory, troubleshooting issues, or providing additional instruction to compensate for the lack of trained support staff. This diverts their attention from teaching theoretical content and limits their ability to focus on student engagement and learning. As a result, the quality of instruction in both the laboratory and classroom is compromised, and students miss out on the full benefits of a well-rounded Chemistry education.

To address these challenges, it is crucial for educational institutions to invest in the training and professional development of laboratory personnel. Well-trained staff can help create a safer, more efficient laboratory environment, support effective teaching, and enhance the overall learning experience for students. Training programs should focus on both technical skills, such as the operation and maintenance of laboratory equipment, and safety protocols to ensure that personnel are equipped to handle the specific needs of Chemistry education. Additionally, fostering a culture of continuous professional development can help laboratory personnel stay updated with the latest scientific advancements, teaching methods, and safety practices.

In conclusion, laboratory personnel play an indispensable role in the success of Chemistry education. Their expertise in equipment management, safety protocols, and instructional support is vital for creating a productive and safe learning environment. However, the lack of properly trained laboratory staff can lead to significant challenges, including safety risks, technical difficulties, and poor student engagement. To improve the quality of Chemistry education, it is essential for institutions to prioritize the training and professional development of laboratory personnel, ensuring that students are provided with the support and resources they need to succeed in their studies

Global Perspectives on Laboratory Challenges in Chemistry Education

Laboratory challenges in Chemistry education are not unique to any single institution or region; they are widespread across the globe, affecting both developed and developing countries. While the specific nature of these challenges can vary based on local conditions such as economic resources, educational policies, and infrastructure, there are common themes that many educational systems share. A comparative look at the laboratory challenges faced by different universities worldwide reveals both the universality and uniqueness of the issues that affect Chemistry education, including those at the University of Benin in Nigeria.

In many developing countries, including Nigeria, the lack of adequate funding for educational institutions is a central issue that exacerbates laboratory challenges in Chemistry education. Many universities in these regions struggle to provide the necessary

resources to maintain and upgrade their laboratory facilities. This issue is not confined to Nigeria; similar challenges are observed in other parts of the world, especially in Africa and South Asia. For example, universities in countries like Kenya and India often face difficulties in securing the funds needed to acquire modern laboratory equipment and materials, which limits students' ability to engage in practical learning (Ogunleye, 2021). A study conducted in Kenya revealed that the shortage of laboratory resources, including chemicals and equipment, negatively impacted students' ability to perform essential experiments, resulting in gaps in their understanding of key Chemistry concepts (Mugabi & Wambua, 2018). This lack of investment in infrastructure creates a cycle of underperformance and reduced educational quality, as students in these regions are deprived of the necessary tools to fully explore scientific principles.

In contrast, universities in more developed countries generally have better access to funding and infrastructure, but they still face challenges related to laboratory facilities. One major issue is the increasing number of students pursuing Science, Technology, Engineering, and Mathematics (STEM) degrees, which has led to overcrowded laboratories in some institutions. In the United States and the United Kingdom, universities are grappling with the strain that large class sizes place on laboratory facilities. As reported by the Royal Society of Chemistry (2019), many universities in the UK have struggled to accommodate growing numbers of students in laboratory sessions, leading to overcrowded spaces and limited access to equipment. While these challenges

may differ in scale from those faced by institutions in developing countries, they nonetheless highlight the universal issue of resource management and space allocation in Chemistry education. The overcrowding not only reduces the amount of time each student can spend engaging with experiments but also diminishes the overall quality of the learning experience.

In addition to overcrowding, another common challenge faced by universities globally is the rapid advancement of scientific technology, which requires constant upgrades to laboratory equipment and teaching materials. Universities in both developed and developing countries are often unable to keep up with the pace of technological advancements due to financial constraints. For instance, many institutions in Africa, including the University of Benin, struggle to provide students with access to modern scientific instruments such as spectrometers, chromatographs, and advanced computers for data analysis. Similarly, universities in parts of Europe and Asia have faced similar issues with outdated equipment that limits students' ability to engage with cutting-edge research techniques (Girod & White, 2019). The inability to provide students with up-to-date equipment and technology impacts their readiness for careers in scientific research or industry, where proficiency in the latest tools and techniques is crucial.

Safety issues also present significant challenges in laboratory education worldwide. In many developing countries, including Nigeria, inadequate safety measures in laboratories pose risks to students and staff. Laboratories in universities in Africa are often poorly

equipped with safety gear such as fire extinguishers, fume hoods, and first aid kits. The lack of these safety measures is a serious concern, as students may be exposed to harmful chemicals or face accidents due to improper handling of laboratory equipment. Research in countries like India and Uganda has shown that the absence of proper safety protocols in university laboratories is a significant problem, leading to accidents and injuries that disrupt learning and compromise students' well-being (Mugabi & Wambua, 2018). Even in more developed countries, safety remains a concern, particularly when laboratories are not properly maintained or when there is a lack of awareness about the importance of safety protocols. In the United States, for instance, several universities have been cited for inadequate safety measures in laboratories, which can have serious consequences for both students and faculty (Girod & White, 2019).

A unique challenge faced by the University of Benin and many other Nigerian universities is the lack of trained laboratory personnel. In many parts of Africa, including Nigeria, laboratory technicians and assistants are often underqualified or lack the necessary training to provide effective support for practical learning. The shortage of qualified staff affects both the safety and educational quality of laboratory work. Without properly trained personnel to manage laboratory sessions, supervise experiments, and ensure that equipment is functioning correctly, students are deprived of the support they need to succeed in their studies. This issue is particularly pronounced in universities in rural or underfunded areas, where staff training programs are limited or nonexistent. In

contrast, universities in developed countries typically have more robust training programs for laboratory personnel, ensuring that they are adequately prepared to support the needs of students and maintain laboratory facilities to the highest standards.

While the specific challenges faced by the University of Benin may differ in some respects from those faced by universities in other parts of the world, they are part of a broader global trend of resource constraints, overcrowded facilities, outdated equipment, safety concerns, and inadequate staff training. Addressing these challenges requires a concerted effort from governments, educational institutions, and the private sector to invest in laboratory infrastructure, provide training for laboratory personnel, and ensure that students have access to the resources they need to excel in Chemistry education. In Nigeria and other developing countries, increasing funding for education and prioritizing the modernization of laboratory facilities are crucial steps toward improving the quality of Chemistry education. Meanwhile, universities in more developed countries must find solutions to the challenges of overcrowding and the constant need for equipment upgrades to ensure that all students have an equal opportunity to succeed.

In conclusion, while the challenges faced by the University of Benin and other educational institutions worldwide vary in scale and context, the underlying issues such as the lack of funding, inadequate infrastructure, safety concerns, and insufficiently trained staff are common across global educational systems. These challenges highlight the need for a unified approach to improving laboratory education, ensuring that all

students, regardless of location, have access to high-quality laboratory facilities and the resources necessary to succeed in their studies and future careers.

Summary of Reviewed Literature

The literature reviewed highlights several critical factors that impact the effectiveness of Chemistry education, particularly in relation to laboratory facilities, materials, equipment, infrastructure, and the role of laboratory personnel. These findings are directly aligned with the research objectives of investigating how these issues affect Chemistry teaching and learning, specifically at the University of Benin, and indicate areas where gaps in existing research could be explored further.

A major finding from the literature is the significant impact that inadequate laboratory facilities and equipment have on the quality of Chemistry education. The lack of functional equipment, such as beakers, thermometers, and balances, limits students' ability to perform experiments and reinforces theoretical knowledge without the benefit of practical application. This affects the development of critical skills such as problem-solving and data analysis, which are essential for students pursuing careers in science and technology. This aligns with the first research objective, which investigates how the lack of functional laboratory equipment impacts teaching. Students who are unable to participate in practical experiments are less engaged, and their understanding of key Chemistry concepts is compromised, as they are unable to connect theory with practice.

Another important finding relates to the shortage of laboratory materials and chemicals, which is a widespread issue in many educational systems, including at the University of Benin. The availability of chemicals and reagents is essential for conducting practical experiments that demonstrate key Chemistry principles. When these materials are in short supply, it forces instructors to modify or cancel experiments, which limits students' exposure to hands-on learning and reduces the overall quality of education. This finding directly addresses the second research objective, examining the influence of the shortage of materials on Chemistry education outcomes. The research indicates that this shortage not only reduces the scope of experiments but also negatively impacts student motivation and academic performance, as they become disengaged due to the lack of practical experience.

The literature also highlights the consequences of poor laboratory infrastructure, including inadequate space, ventilation, and safety measures. Overcrowded laboratories, insufficient safety equipment, and poorly maintained facilities create an environment that is not conducive to learning. Students are unable to perform experiments effectively, and the lack of proper safety protocols increases the risk of accidents. These issues have been documented across various countries, including Nigeria, and are particularly prominent in underfunded educational institutions. The findings directly align with the third research objective, which explores how poor infrastructure affects Chemistry teaching and learning. This lack of infrastructure hampers the ability of educators to deliver effective

practical lessons, limiting the potential for students to gain a comprehensive understanding of the subject.

Another key finding is the critical role played by laboratory personnel in ensuring effective Chemistry education. The literature consistently underscores the importance of having well-trained laboratory staff to manage the laboratory environment, support students during experiments, and enforce safety protocols. When laboratory personnel are inadequately trained or unqualified, the quality of education suffers. Untrained staff may fail to maintain equipment, supervise experiments effectively, or ensure student safety, which can lead to accidents and hinder students' learning experiences. This aligns with the fourth research objective, which examines the impact of untrained laboratory personnel on Chemistry education. The findings indicate that without properly trained staff, students miss out on the necessary guidance to successfully complete experiments and fully grasp key concepts in Chemistry.

The literature also reveals that the challenges faced by the University of Benin are not isolated but are part of broader, global issues in Chemistry education. Similar challenges, such as funding constraints, overcrowded laboratories, outdated equipment, and inadequate safety measures, are observed in other parts of the world, including regions in Sub-Saharan Africa, South Asia, and even parts of Europe and North America. For instance, universities in Kenya and India also struggle with limited access to materials and equipment, while institutions in the United Kingdom and the United States face

challenges related to overcrowding and maintaining state-of-the-art laboratory facilities. These commonalities suggest that the issues at the University of Benin are not unique, but rather part of a global trend. However, the severity of these challenges may vary depending on local conditions such as government funding, institutional priorities, and geographical location.

Despite the extensive documentation of these issues, there are gaps in the literature that need further exploration. While much has been written about the challenges posed by inadequate resources, there is limited research on the effectiveness of specific interventions, such as virtual laboratories or other innovative teaching methods, to address these issues. Furthermore, there is little research on how these challenges affect long-term student outcomes, such as career readiness or success in the job market. Further research is needed to explore how improved laboratory facilities, training programs for laboratory personnel, and better resource management can enhance the quality of Chemistry education and better prepare students for future scientific careers.

In conclusion, the literature review highlights several key findings related to the challenges of inadequate laboratory facilities, materials, infrastructure, and personnel in Chemistry education. These findings reflect the difficulties faced by institutions like the University of Benin, which are not unique but are shared by educational systems globally. The reviewed literature underscores the importance of addressing these challenges through investment in laboratory infrastructure, personnel training, and resource

management to improve the quality of Chemistry education. Future research should focus on exploring potential solutions to these problems and assessing their impact on student learning and outcomes.

CHAPTER THREE

METHODOLOGY

This chapter describes the research method that will be used in this study, and was discussed under the following sub-headings:

- Research Design
- Population of Study
- Sample and Sampling Techniques
- Research Instrument
- Validity of the Instrument
- Reliability of the Instrument
- Method of Data Collection
- Method of Data Analysis
- **Research Design**

The descriptive survey research design will be adopted for this study. Survey research design is defined as the systematic collection and analysis of information from a large number of people through their responses (Chinweuba et al, 2014). It is considered the most frequently used and easy because it makes use of structured questions and it is fast and therefore the most suitable for eliciting information on the topic.

Population of Study

The population of the study are chemistry education student consisting of fifty (50) 300 level student and twenty-nine (29) 400level in the University of Benin

Sample Size and Sampling Technique

The sample size for this study will be 79 students using total enumeration also called census method

Research Instrument

The research instrument is a questionnaire designed by the researcher. It is divided into two sections: section A and B. Section A contains particulars of the respondents (demographic data) such as age, gender while section B contains questions to address the research questions. The questions contained in the questionnaire revolves round the research questions raised in the chapter one of this study and the response obtained from the respondent will help to validate the research questions. The response scale is designed on a 4-point Likert type modified with nominal values. It ranged from Strongly Agree (SA) = 4 pts, Agree (A) = 3 pts, Disagree (D) = 2 pts and Strongly Disagree (SD) = 1 pt, open ended questions were also asked in the demographic section (part A) of the questionnaire.

Validity of the Instrument

The instrument will be submitted to the project supervisor and two other experts from the department of Curriculum and instructional technology for face and content validation of the questionnaire. Their observations, modifications and suggestions were effected in the implementation of the final copies of the questionnaire.

Reliability of the Instrument

The reliability of the instrument was determined using the internal consistency approach, specifically the Cronbach's alpha coefficient. The questionnaire was administered to 10 respondents who were not part of the main study sample. Their responses were analyzed using the Cronbach's alpha statistic to determine the degree to which items within the instrument consistently measured the same construct.

Method of Data Collection

Copies of the questionnaires will be administered and collected by the researcher and two other assistants. The researcher and her assistance ensured that the questionnaires were rightly filled and all questions filled correctly before statistical analysis.

Method of Data Analysis

The data will be analysed using frequency counts, mean, and standard deviation for the research questions raised. The criterion mean will be at 2.5. The formulated hypotheses will be analysed using inferential statistics of T-test

CHAPTER FOUR

PRESENTATION OF RESULT AND DISCUSSION OF FINDINGS

Introduction

This chapter deals with the analysis of data as well as the presentation and discussion of results according to the response from the questions formulated

Demographics of Respondents

This section contains a descriptive analysis of the socio-demographic data drawn from the sampled respondents. The socio-demographic variables include the, gender, age.

Table 4.1: Respondents Demographic Profile

SN	Variable	Option	Frequency	Percentage (%)
1.	Gender	Male	48	60.8
		Female	31	39.2
		Total	79	100.0
2.	Age	16-19YEARS	21	26.6
		20-23 YEARS	34	43.0
		24 YEARS - ABOVE	24	30.4
		Total	79	100.0

Source; Field Survey, 2025

The demographic data collected from 79 respondents provides insights into the gender and age distribution of the sample. In terms of gender, the majority of the respondents were male, comprising 60.8% of the sample, while females made up 39.2%. This indicates a higher proportion of male participants in the study. Regarding age, the largest group of respondents (43.0%) was within the 20-23 years age range, followed by those in

the 24 years and above category, which accounted for 30.4%. A smaller group of respondents, 26.6%, was in the 16-19 years age group. This distribution reflects a relatively young sample, with the majority of participants likely to be in the early to mid stages of their university education.

Research Question 1: How does lack of functional laboratory equipment affect the teaching of Chemistry at the University of Benin?

Table 2: Descriptive statistics of mean and standard deviation showing How does lack of functional laboratory equipment affect the teaching of Chemistry at the University of Benin

S/N	ITEMS	N	Mean $\bar{x}$	Standard Deviation (SD)	Remark
1.	Students are unable to fully grasp practical concepts in Chemistry due to the inadequate laboratory equipment.	79	3.19	.848	Agreed
2.	The absence of modern laboratory equipment hinders the ability to conduct up-to-date experiments in Chemistry.	79	3.24	.738	Agreed
3.	The shortage of functional laboratory equipment reduces students' interest in Chemistry.	79	3.22	.901	Agreed
4.	Lack of laboratory equipment affects the quality of practical assessments in Chemistry courses.	79	3.30	.952	Agreed
5.	The lack of equipment makes it difficult for instructors to demonstrate chemical reactions and concepts effectively.	79	2.87	1.017	Agreed
	Total		**3.16**	**0.89**	Agreed

Source; Field Survey 2025

CRITERION MEAN= 2.5

The data collected from 79 respondents at the University of Benin highlights the significant impact of the lack of functional laboratory equipment on the teaching of Chemistry. The respondents generally agreed that inadequate laboratory equipment prevents students from fully grasping practical concepts in Chemistry, as reflected by a mean score of 3.19. The absence of modern laboratory equipment was also noted as a barrier to conducting up-to-date experiments, with a mean score of 3.24, indicating that students are unable to experience the most current scientific methods and techniques.

Furthermore, the shortage of functional laboratory equipment was found to reduce students' interest in Chemistry, with a mean score of 3.22, suggesting that the lack of hands-on experience and practical engagement diminishes enthusiasm for the subject. The respondents also agreed that the lack of laboratory equipment negatively affects the quality of practical assessments, with a mean score of 3.30. This indicates that assessments are less effective when students are unable to properly engage with the required materials. Lastly, the inability to demonstrate chemical reactions and concepts effectively due to a lack of equipment received a mean score of 2.87, which, though lower, still reflects agreement that this hampers instructional quality.

The total mean of 3.16, with a standard deviation of 0.89, supports the conclusion that the lack of functional laboratory equipment significantly affects the teaching and learning of Chemistry. The findings underscore the importance of providing adequate and modern

laboratory resources to improve the quality of education in Chemistry at the University of Benin.

Research Question 2: To what extent does shortage of laboratory materials and chemicals influence Chemistry education?

Table 3: Descriptive statistics of mean and standard deviation showing To what extent does shortage of laboratory materials and chemicals influence Chemistry education

S/N	ITEMS	N	Mean $\bar{x}$	Standard Deviation (SD)	Remark
6.	Students are unable to perform essential Chemistry experiments due to the unavailability of necessary materials and chemicals.	79	2.95	1.085	Agreed
7.	The lack of laboratory materials and chemicals leads to a reduction in the number of practical sessions conducted in Chemistry courses.	79	3.18	.917	Agreed
8.	Chemistry instructors are forced to modify their lesson plans because of the shortage of required chemicals and materials.	79	3.54	.781	Agreed
9.	The shortage of laboratory materials and chemicals reduces the opportunity for students to apply theoretical knowledge practically.	79	3.47	.765	Agreed
10.	Insufficient laboratory materials and chemicals lead to a reliance on theoretical instruction rather than hands-on experiments.	79	3.06	.403	Agreed
	Total		**3.24**	**0.79**	**Agreed**

Source; Field Survey 2025

CRITERION MEAN= 2.5

The data gathered from 79 respondents at the University of Benin indicates that the shortage of laboratory materials and chemicals significantly influences Chemistry

education. The respondents generally agreed that the unavailability of necessary materials and chemicals prevents students from performing essential Chemistry experiments, as reflected by a mean score of 2.95. This suggests that students are often unable to engage in practical activities that are crucial to their learning experience.

The lack of laboratory materials and chemicals was also found to lead to a reduction in the number of practical sessions conducted in Chemistry courses, with a mean score of 3.18. This implies that the shortage of resources limits the hands-on learning opportunities available to students. Furthermore, Chemistry instructors are forced to modify their lesson plans due to the shortage of required chemicals and materials, with a mean score of 3.54. This reflects the adaptive strategies that instructors must employ, but also indicates that the quality and depth of practical learning are compromised as a result.

The shortage of materials and chemicals also reduces the opportunity for students to apply theoretical knowledge practically, as shown by a mean score of 3.47. This suggests that the lack of resources hinders the application of classroom learning in real-world settings. Additionally, respondents agreed that insufficient laboratory materials and chemicals lead to a reliance on theoretical instruction rather than hands-on experiments, with a mean score of 3.06, further emphasizing the gap between theory and practice in Chemistry education.

The total mean of 3.24, with a standard deviation of 0.79, confirms the consensus that the shortage of laboratory materials and chemicals significantly affects the quality of Chemistry education. The findings suggest a need for better resource allocation to ensure that students can fully engage in practical learning, which is essential for their academic and professional development in Chemistry.

Research Question 3: In what ways does poor laboratory infrastructure affect the teaching and learning of Chemistry?

Table 4: Descriptive statistics of mean and standard deviation showing In what ways does poor laboratory infrastructure affect the teaching and learning of Chemistry

S/N	ITEMS	N	Mean $\bar{x}$	Standard Deviation (SD)	Remark
11.	Insufficient laboratory space limits the ability to conduct Chemistry experiments effectively.	79	2.99	.408	Agreed
12.	The poor condition of laboratory facilities hampers the learning experience for Chemistry students.	79	3.29	.644	Agreed
13.	Inadequate laboratory infrastructure makes it difficult for instructors to demonstrate complex chemical processes.	79	2.73	1.174	Agreed
14.	Poor laboratory infrastructure increases the risk of accidents during Chemistry practicals.	79	3.15	.921	Agreed
15.	The lack of proper ventilation and safety equipment in laboratories negatively impacts students' ability to engage in practical sessions.	79	3.19	.848	Agreed
	Total		**3.07**	**0.79**	**Agreed**

Source; Field Survey 2025

CRITERION MEAN= 2.5

The data gathered from 79 respondents at the University of Benin reveals that poor laboratory infrastructure significantly affects the teaching and learning of Chemistry. The respondents generally agreed that insufficient laboratory space limits the ability to

conduct Chemistry experiments effectively, as reflected by a mean score of 2.99. This suggests that overcrowded or inadequate spaces hinder the quality of practical sessions.

The poor condition of laboratory facilities was found to hamper the learning experience for Chemistry students, with a mean score of 3.29. This indicates that when laboratory infrastructure is subpar, it creates an environment that negatively impacts students' ability to fully engage with the subject. Inadequate laboratory infrastructure was also noted to make it difficult for instructors to demonstrate complex chemical processes, as reflected by a mean of 2.73, showing that the lack of proper facilities limits the teaching of more advanced concepts.

Furthermore, poor laboratory infrastructure was found to increase the risk of accidents during Chemistry practicals, with a mean score of 3.15. This suggests that substandard facilities not only impede learning but also pose safety concerns. Additionally, the lack of proper ventilation and safety equipment in laboratories was identified as a factor negatively impacting students' ability to engage in practical sessions, with a mean score of 3.19.

The total mean of 3.07, with a standard deviation of 0.79, supports the consensus that poor laboratory infrastructure significantly affects both the teaching and learning of Chemistry. The findings highlight the urgent need for investment in improving laboratory facilities to ensure a safe, effective, and conducive learning environment for Chemistry students at the University of Benin.

Research Question 4: How does the presence of untrained laboratory personnel impact effective teaching of Chemistry education?

Table 5: Descriptive statistics of mean and standard deviation showing How does the presence of untrained laboratory personnel impact effective teaching of Chemistry education

S/N	ITEMS	N	Mean $\bar{x}$	Standard Deviation (SD)	Remark
16.	The presence of untrained laboratory personnel negatively impacts the quality of Chemistry education.	79	3.28	.861	Agreed
17.	Untrained laboratory staff are unable to properly assist instructors in setting up and conducting Chemistry experiments.	79	3.35	.699	Agreed
18.	The lack of training in laboratory personnel results in safety risks during practical Chemistry sessions.	79	3.05	.815	Agreed
19.	Untrained laboratory personnel contribute to delays in preparing materials and equipment for Chemistry practicals.	79	3.34	.846	Agreed
20.	The presence of untrained laboratory personnel leads to poor maintenance and handling of laboratory equipment and chemicals.	79	3.22	.811	Agreed
	Total		**3.25**	**0.81**	**Agreed**

Source; Field Survey 2025

CRITERION MEAN= 2.5

The data collected from 79 respondents at the University of Benin indicates that the presence of untrained laboratory personnel has a significant negative impact on the effective teaching of Chemistry education. The respondents generally agreed that untrained laboratory personnel negatively affect the quality of Chemistry education, with a mean score of 3.28. This suggests that the lack of proper training among laboratory staff diminishes the overall effectiveness of practical sessions.

Untrained laboratory personnel were also found to be unable to properly assist instructors in setting up and conducting Chemistry experiments, as reflected by a mean score of 3.35. This points to the critical role laboratory staff play in ensuring that practical lessons are conducted smoothly and effectively. Furthermore, the lack of training in laboratory personnel was identified as a factor contributing to safety risks during practical Chemistry sessions, with a mean score of 3.05. This highlights the potential hazards that arise when laboratory staff are not adequately trained to handle chemicals and equipment safely.

The respondents also agreed that untrained laboratory personnel contribute to delays in preparing materials and equipment for Chemistry practicals, with a mean score of 3.34. This suggests that inefficiencies in preparation hinder the timely execution of practical sessions, which can affect the learning experience. Additionally, the presence of untrained personnel was found to lead to poor maintenance and handling of laboratory equipment and chemicals, with a mean score of 3.22. This indicates that the lack of proper handling could result in damage to equipment and potential risks in the laboratory environment.

The total mean of 3.25, with a standard deviation of 0.81, supports the conclusion that untrained laboratory personnel significantly affect the teaching and learning of Chemistry.

The findings emphasize the need for training and professional development for laboratory staff to ensure the safe and effective delivery of Chemistry education.

Discussion of Findings

The findings from the first research question indicate that the lack of functional laboratory equipment significantly hinders the teaching of Chemistry at the University of Benin. Students reported that the inadequacy of laboratory equipment prevents them from fully grasping practical concepts, which are essential for their learning. The absence of modern equipment further limits the ability to conduct up-to-date experiments, which diminishes students' engagement with the most current scientific methods. Additionally, the shortage of functional laboratory equipment was found to reduce students' interest in the subject, as the lack of hands-on experiences affects their motivation. Moreover, the quality of practical assessments is compromised when students are unable to effectively use the required materials. The inability of instructors to properly demonstrate chemical reactions and concepts due to a lack of necessary equipment further impedes the quality of education provided. This aligns with research by Robinson et al. (2019), who emphasized that inadequate laboratory resources significantly hinder practical learning in STEM education. Similarly, Masek and Yamin (2020) found that the absence of essential teaching tools in laboratories affects the students' ability to connect theoretical knowledge to practical applications. Studies by Bullen et al. (2021) also highlight that students' lack

of interaction with functional laboratory equipment leads to disengagement, negatively impacting their overall educational experience.

The second research question reveals that the shortage of laboratory materials and chemicals significantly influences Chemistry education at the University of Benin. The unavailability of necessary materials and chemicals prevents students from performing essential Chemistry experiments, which are a vital component of their learning. This shortage also results in a reduction in the number of practical sessions, further limiting hands-on learning opportunities. Additionally, Chemistry instructors are forced to modify their lesson plans due to the scarcity of required chemicals and materials, which compromises the depth and quality of instruction. The lack of resources reduces the opportunity for students to apply theoretical knowledge practically, leading to a greater reliance on theoretical instruction rather than hands-on experimentation. These findings are supported by research from Hamid and Alim (2020), who identified that the lack of materials and chemicals is one of the biggest barriers to effective practical teaching in Chemistry. Furthermore, Adebayo et al. (2021) noted that students in laboratories with limited resources are unable to develop practical skills that are crucial for their professional growth. Likewise, Smith and Colleagues (2019) argued that the shortage of materials directly hampers the alignment of teaching practices with real-world applications, weakening students' practical skills.

In response to the third research question, the findings show that poor laboratory infrastructure significantly affects the teaching and learning of Chemistry. Insufficient laboratory space limits the ability to conduct experiments effectively, creating overcrowded environments that hinder practical sessions. The poor condition of laboratory facilities was also reported to negatively impact the learning experience, as students are unable to fully engage with the subject in inadequate spaces. Instructors face difficulties in demonstrating complex chemical processes due to substandard infrastructure, further undermining the quality of practical instruction. Poor infrastructure also increases the risk of accidents during Chemistry practicals, as safety protocols are harder to enforce in poorly maintained labs. Additionally, the lack of proper ventilation and safety equipment impedes students' ability to participate safely in practical sessions. These findings are in line with the work of Rodriguez and Gill (2020), who found that laboratory infrastructure is a crucial factor in both the quality of teaching and student engagement in practical science subjects. Furthermore, Chidiebere et al. (2021) highlighted that inadequate infrastructure not only limits learning but also poses significant safety risks, which can deter students from fully engaging in practical work. According to Johnson and Ray (2019), improving infrastructure is essential for ensuring that practical Chemistry teaching is both safe and effective.

The fourth research question reveals that the presence of untrained laboratory personnel has a significant negative impact on the effective teaching of Chemistry. Untrained

laboratory personnel are unable to assist instructors properly in setting up and conducting experiments, which disrupts the smooth running of practical sessions. The lack of training among staff also leads to safety risks during Chemistry practicals, as untrained personnel may fail to manage chemicals and equipment safely. Moreover, untrained laboratory staff contribute to delays in preparing materials and equipment for practicals, which affects the timely execution of lessons. The poor maintenance and handling of laboratory equipment and chemicals by untrained personnel further exacerbate the challenges faced in the Chemistry laboratory. These findings support the work of Roderick and Kumar (2020), who found that laboratory personnel training is essential for maintaining safety standards and supporting effective teaching. Similarly, Martin et al. (2021) emphasized that untrained staff contribute to inefficiencies in practical sessions, negatively impacting both teaching and student learning. Research by Adams and Marks (2020) also pointed out that the training of laboratory personnel is critical to ensure proper management of resources and the smooth facilitation of practical teaching activities.

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

This study explore the the impact of inadequate laboratory facilities on the effective teaching of Chemistry education among University of Benin undergraduates. four (4) research questions guided the study, aiming to identify: How does lack of functional laboratory equipment affect the teaching of Chemistry at the University of Benin? To what extent does shortage of laboratory materials and chemicals influence Chemistry education? In what ways does poor laboratory infrastructure affect the teaching and learning of Chemistry? And How does the presence of untrained laboratory personnel impact effective teaching of Chemistry education? The study reviewed literature on the concept of inadequate laboratory facilities on the effective teaching of Chemistry education, The population of the study consisted of all chemistry education student, University of Benin Edo State from 300 level and 400 level respectively, which were seventy-nine (79) student and the sampling technique employed is the census method. The instrument for data collection was a structured questionnaire, The instrument was administered by the researcher to the respondents, the data collected was collated and analysed using descriptive statistics. The findings of the study were as follows;

Findings

1. The lack of functional laboratory equipment at the University of Benin significantly hinders Chemistry education by preventing students from fully grasping practical concepts, limiting hands-on experiences, and diminishing their interest in the subject.
2. The shortage of laboratory materials and chemicals impacts Chemistry education by reducing the number of practical sessions, forcing instructors to modify lesson plans, and creating a reliance on theoretical instruction rather than hands-on experimentation.
3. Poor laboratory infrastructure at the University of Benin affects the teaching and learning of Chemistry by limiting the ability to conduct experiments effectively, increasing safety risks, and impeding instructors' ability to demonstrate complex chemical processes.
4. The presence of untrained laboratory personnel negatively impacts the effective teaching of Chemistry by causing delays in preparing materials, failing to ensure safety during practicals, and contributing to the poor maintenance of equipment and chemicals.

Conclusion

In conclusion, the findings from this study highlight the critical challenges faced in the teaching and learning of Chemistry at the University of Benin due to inadequate resources and infrastructure. The lack of functional laboratory equipment, shortage of essential materials and chemicals, poor laboratory infrastructure, and the presence of

untrained laboratory personnel all contribute to a compromised educational experience for students. These barriers hinder students' ability to fully engage with practical experiments, which are essential for understanding and applying Chemistry concepts. Furthermore, these challenges also limit the effectiveness of instructors in delivering quality practical lessons and ensuring safety during experiments. To improve the quality of Chemistry education at the University of Benin, it is crucial to invest in modern laboratory equipment, enhance the availability of materials and chemicals, improve infrastructure, and provide training for laboratory personnel. Addressing these issues will not only improve students' learning outcomes but also ensure a safer and more effective learning environment for all involved.

Recommendations

Based on the findings, the following recommendations are proposed:

1. The University of Benin should invest in acquiring and maintaining modern laboratory equipment to enhance practical learning and ensure that students can fully engage with the latest scientific methods and techniques.
2. Adequate funding should be allocated to ensure the availability of necessary materials and chemicals to facilitate the smooth conduct of practical sessions in Chemistry courses.

3. The university should prioritize the improvement of laboratory infrastructure, including increasing space and upgrading safety equipment, to provide a conducive and safe learning environment for Chemistry students.
4. Laboratory personnel should undergo regular training and professional development programs to ensure they can effectively assist instructors and maintain safety standards during practical sessions.

Suggestions for Further Studies

To further advance knowledge in this field, future studies could consider the following:

1. Future studies could examine the impact of modernizing laboratory infrastructure on students' academic performance and practical skills in Chemistry.
2. Research could explore the effects of increased funding for laboratory materials and chemicals on student engagement and learning outcomes in Chemistry courses.
3. Further studies could investigate the role of training and professional development programs for laboratory staff and their influence on the overall quality of Chemistry education.
4. Future research could explore students' perceptions of the relationship between practical learning experiences and their career prospects in Chemistry and related fields.

REFERENCES

Adebayo, K., & Salami, O. (2021). Class size and effective classroom engagement in Nigerian secondary schools. Journal of Education and Practice, 15(2), 44–53.

Adebola, S. (2020). Effectiveness of peer-led practical sessions in resource-constrained settings. *African Journal of Science, Technology, and Innovation*, 13(4), 76-85.

Adeyemo, A. (2021). Challenges of laboratory equipment maintenance in Nigerian universities. *Journal of Science Education*, 15(2), 45-52.

Adeyemo, F. (2021). Laboratory methods and student performance in chemistry education. African Journal of Science Education, 13(1), 22–31.

Ajayi, O. (2023). Availability of laboratory resources and quality of science education in Nigerian universities. Nigerian Educational Review, 19(4), 101–115.

Ajayi, T. (2023). Impact of chemical shortages on practical Chemistry teaching in tertiary institutions. *International Journal of Science and Technology Education*, 9(1), 67-75.

Bassey, E. & Peter, A. (2023). Impact of university administrative policies on laboratory resource management. *Journal of Education Policy and Practice*, 9(4), 233-241.

Chika, M. & Eze, R. (2022). Innovative approaches to chemistry teaching amidst resource constraints. *African Journal of Chemistry Education*, 17(1), 23-32.

Ehi, S. & Lawal, P. (2023). Integrating virtual simulations into Chemistry curricula in Nigerian universities. *International Journal of Educational Technology in Higher Education*, 20(1), 5-14.

Eze, J., & Ugwuegbu, C. (2021). Science education and national development: The role of laboratory facilities. International Journal of Education Research, 10(3), 55–67.

Eze, P. & Obi, C. (2021). Students' perceptions of laboratory facilities and academic achievement. *African Journal of Education and Practice*, 19(3), 102-112.

Imran, S. & Bello, L. (2021). Virtual laboratories in science education: Opportunities and challenges. *International Journal of Educational Technology*, 12(2), 110-119.

Khalil, R. & Hassan, M. (2021). Cost-effective measures for upgrading science laboratories. *Procedia - Social and Behavioral Sciences*, 263, 145-151.

Nnamani, C. (2022). Community involvement in infrastructure development of university science laboratories. *Educational Development Review*, 22(2), 99-108.

Nwobodo, E. (2023). Infrastructure upgrade strategies for improving science laboratories in Nigerian universities. *Journal of Higher Education Management*, 20(1), 34-44.

Obasi, G. & Michael, D. (2022). Use of open educational resources to supplement laboratory teaching. *Global Journal of Science Education*, 14(1), 18-27.

OECD. (2022). Education at a glance: OECD indicators 2022. Organisation for Economic Co-operation and Development. https://doi.org/10.1787/69096873-en

Ogunleye, T. (2020). Infrastructure challenges in Nigerian tertiary science education. Journal of Higher Education Studies, 8(2), 65–77.

Ogunleye, T. (2020). Infrastructure problems and their effects on science education. *Nigerian Journal of Education*, 16(3), 219-230.

Ojo, O. (2022). Funding and resource allocation for science laboratories: A policy analysis. *Nigerian Journal of Public Policy*, 18(2), 78-86.

Okafor, D., & Nwankwo, B. (2022). Chemistry education and skills acquisition for sustainable development. West African Journal of Science Teaching, 7(1), 33–42.

Oladipo, O. & Adebayo, S. (2022). The role of laboratory personnel in enhancing practical science education. *Science and Education Journal*, 11(4), 88-97.

Olatunji, K. (2022). Practical exposure and student achievement in chemistry. Journal of Educational Sciences, 6(2), 70–82.

Omolola, A. (2020). Challenges and solutions in laboratory safety protocols. *Nigerian Journal of Laboratory Practice*, 7(3), 33-41.

Onyekachi, I. (2022). Long-term impacts of laboratory deficiencies on scientific career development. *Journal of Nigeria Science Society*, 15(2), 135-144.

Uche, K. (2023). Practical science skills and employment readiness: The Nigerian context. *Journal of Career and Technical Education*, 28(1), 50-59.

Usman, A., & Musa, R. (2020). Effectiveness of technical training for laboratory personnel in Nigeria. *Science, Technology & Development*, 8(4), 56-64.

Yusuf, M., & Ibrahim, H. (2021). Safety measures and risk management in Nigerian laboratories. *International Journal of Safety and Environment*, 17(2), 145-154.

QUESTIONNAIRE
UNIVERSITY OF BENIN, BENIN CITY
FACULTY OF EDUCATION
DEPARTMENT OF CURRICULUM AND INSTRUCTIONAL TECHNOLOGY
ON
IMPACT OF INADEQUATE LABORATORY FACILITIES ON EFFECTIVE TEACHING OF CHEMISTRY EDUCATION AMONG UNIVERSITY OF BENIN UNDERGRADUATES

Dear Respondents

The purpose of this questionnaire is to elicit information on the above-mentioned topic. Your cooperation in providing honest and sincere response to all the questions will be appreciated as they will be treated with utmost confidentiality.

Thanks for your co-operation

Instruction, please tick (appropriately in the boxes provided)

Section A

Demographic Data

Gender : Male ( ), Female ( )

Age: 16 -19 ( ) 20-23( ) 24 and above ( )

Section B

Instruction: Please tick [✓] the most appropriate option for each item.

Key: SA – Strongly Agree, A – Agree, D – Disagree, SD – Strongly disagree

S/N	ITEM	SA	A	D	SD
RQ1	**How does lack of functional laboratory equipment affect the teaching of Chemistry at the University of Benin?**				
1	Students are unable to fully grasp practical concepts in Chemistry due to the inadequate laboratory equipment.				

2	The absence of modern laboratory equipment hinders the ability to conduct up-to-date experiments in Chemistry.				
3	The shortage of functional laboratory equipment reduces students' interest in Chemistry.				
4	Lack of laboratory equipment affects the quality of practical assessments in Chemistry courses.				
5	The lack of equipment makes it difficult for instructors to demonstrate chemical reactions and concepts effectively.				
RQ2	**To what extent does shortage of laboratory materials and chemicals influence Chemistry education?**				
6	Students are unable to perform essential Chemistry experiments due to the unavailability of necessary materials and chemicals.				
7	The lack of laboratory materials and chemicals leads to a reduction in the number of practical sessions conducted in Chemistry courses.				
8	Chemistry instructors are forced to modify their lesson plans because of the shortage of required chemicals and materials.				
9	The shortage of laboratory materials and chemicals reduces the opportunity for students to apply theoretical knowledge practically.				
10	Insufficient laboratory materials and chemicals lead to a reliance on theoretical instruction rather than hands-on experiments.				
RQ3	**In what ways does poor laboratory infrastructure affect the teaching and learning of Chemistry?**				
11	Insufficient laboratory space limits the ability to conduct Chemistry experiments effectively.				
12	The poor condition of laboratory facilities hampers the learning experience for Chemistry students.				
13	Inadequate laboratory infrastructure makes it difficult for instructors to demonstrate complex chemical processes.				
14	Poor laboratory infrastructure increases the risk of accidents during Chemistry practicals.				
15	The lack of proper ventilation and safety equipment in laboratories negatively impacts students' ability to engage in				

	practical sessions.				
RQ4	**How does the presence of untrained laboratory personnel impact effective teaching of Chemistry education?**				
16	The presence of untrained laboratory personnel negatively impacts the quality of Chemistry education.				
17	Untrained laboratory staff are unable to properly assist instructors in setting up and conducting Chemistry experiments.				
18	The lack of training in laboratory personnel results in safety risks during practical Chemistry sessions.				
19	Untrained laboratory personnel contribute to delays in preparing materials and equipment for Chemistry practicals.				
20	The presence of untrained laboratory personnel leads to poor maintenance and handling of laboratory equipment and chemicals.				