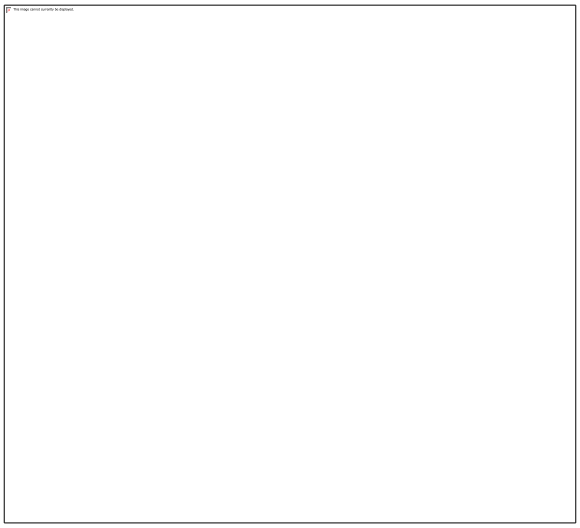
BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE EDUCATION

BACHELOR OF SCIENCE EDUCATION HONOURS DEGREE IN BIOLOGY



AN INVESTIGATION OF THE IMPACT OF LAB SAFETY PROTOCOLS ON STUDENTS LEARNING OUTCOMES: A CASE STUDY OF SELECTED HIGH SCHOOL IN NYANAGA DISTRICT, MANICALAND PROVINCE.

BY

SINGADI VIMBAI PRIMROSE B1749667

MHLANGA CONSTANCE B1954092

A RESEARCH PROJECT SUBMITTED TO THE FACULTY OF SCIENCE EDUCATION IN PARTIAL FULFILMENR OF THE REQUEREMENTS OF THE BACHELOR OFSCIENCE EDUCATION HONOURS DEGREE IN BIOLOGY (HBScEdBz)

JUNE 2025

DECLERATION

This is our own original work and it has not been submitted to any other examination body. No part of this research should be reproduced without our consent or that of Bindura University of Science Education.

RELEASE FORM

NAME OF STUDENT: Vimbai Primrose Singadi B1749667

PROJECT TITLE: An Investigation Of The Impact Of Lab Safety Protocols On Students Learning Outcomes.

PROGRAM TITLE: **BScEdBz**

YEAR: 2025

Permission is hereby granted to the Bindura University of Science Education Library to produce single copies of this dissertation and to lend such copies for scholarly or scientific research purpose only. The author reserves other publication rights; neither the project nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

SIGNED: ……....

DATE: 2025

Acknowledgement

I would like to acknowledge the guidance and support given by my supervisor during the course of my dissertation. Her constructive critique to this piece of work will always be cherished.

I am also thankful for the moral support from family, peers, and those close to me that contributed to the completion of this work. Thank you.

ABSTRACT

This study investigated the impact of lab safety protocols on students' learning outcomes at Coeli high school in the Nyanga District, Manicaland Province. The research aimed to evaluate how adherence to safety protocols influenced student engagement, comprehension, and performance in scientific experiments. Through a qualitative approach, data were collected via questionnaire guide for students, interview guide for teachers, observation checklist and document analysis. The findings indicated that effective implementation of lab safety protocols significantly enhanced students' confidence and participation in laboratory activities. Furthermore, the study revealed a positive correlation between safety training and improved academic performance, suggesting that prioritizing safety in the laboratory environment fosters a more conducive learning atmosphere. This research underscored the importance of integrating robust safety protocols in educational settings to optimize student learning outcomes in science education. However, the study also identified significant challenges, including resource limitations and variability in training quality, which hinder full adherence to safety protocols. Overall, the research recommended the necessity of robust safety measures to create a secure and effective learning environment, recommending enhanced resource allocation and comprehensive training programs to foster a culture of safety in educational laboratories. This study conclusively demonstrated that the implementation of lab safety protocols significantly impacts students' learning outcomes in the selected high school in Nyanga District, Manicaland Province.

Contents

CHAPTER ONE

1.0 Introduction

This chapter introduces the study, outlining its purpose, background, problem statement, research objectives, hypotheses, and assumptions. It also defines key terms and identifies the delimitations and limitations of the study. The chapter provides the foundation for understanding the relationship between lab safety protocols and student learning outcomes in educational laboratory settings.

1.1 Background to the study

Laboratory settings are essential for hands-on, practical learning in scientific education, whether in chemistry, biology, physics, or other disciplines. Students are often required to work with complex equipment, chemicals, and materials that present various safety risks. Hence, effective safety protocols are paramount to minimize accidents and injuries, ensuring that students can focus on the learning process.

In recent years, educational institutions have heightened their emphasis on lab safety, acknowledging that proper safety procedures not only protect students but also contribute to a positive and productive learning environment (Bennett, 2012). Safety protocols typically include measures such as the proper use of personal protective equipment (PPE), chemical handling procedures, emergency response protocols, and general laboratory conduct rules.

The relationship between lab safety and learning outcomes has been a subject of concern for educators, as studies have shown that safety practices directly impact the quality of student experiences in the laboratory. When safety is compromised, the potential for accidents increases, which can disrupt learning and negatively affect students' ability to perform experiments confidently (Mills & Goudarzi, 2014). Conversely, when students are taught how to adhere to safety guidelines, they are more likely to approach their work with caution and focus, potentially enhancing their understanding of scientific concepts.

Previous studies have indicated that when safety protocols are not adequately communicated or followed, students may experience anxiety or distraction, reducing their ability to concentrate on tasks and affecting overall academic performance. On the other hand, a structured and well-

enforced safety protocol might provide students with a sense of security, promoting deeper engagement with the material and improving learning outcomes (Knecht & Pettersen, 2020).

Several factors influence the effectiveness of lab safety protocols, including the clarity of instructions, the presence of adequate supervision, and the integration of safety lessons into the curriculum. Research by Levene et al. (2018) demonstrated that when students receive proper training in safety procedures prior to lab activities, they are more likely to follow guidelines and perform experiments more effectively. Additionally, a positive safety culture within an institution can encourage better student compliance and foster a safer learning environment.

Furthermore, laboratory accidents and the failure to comply with safety protocols can lead to significant financial, emotional, and educational consequences, both for students and institutions. Accidents not only harm individuals but also disrupt the learning process, potentially leading to a lack of motivation, poor academic outcomes, or even the abandonment of practical science courses (Nelson, 2017).

The importance of lab safety protocols is not only a matter of preventing accidents but also ensuring that the learning environment promotes positive academic outcomes. As such, this study will explore how the implementation of safety protocols affects students' ability to learn and retain scientific knowledge, as well as how safety practices can be integrated into educational strategies to improve learning outcomes.

1.2 Statement of the problem

Accidents in educational laboratories—such as chemical spills, burns, and cuts—are a recurring problem, often attributed to insufficient adherence to safety protocols. In some cases, students may feel anxious or disengaged due to fears about safety, which can impact their academic performance. While safety protocols are designed to minimize risks, there is limited empirical research on the direct impact of these measures on student learning outcomes. This study aims to fill this gap by examining how lab safety practices influence students' ability to understand, engage with, and retain scientific concepts.

1.3 Research objectives

The objectives of this study are as follows:

1. To examine the relationship between the implementation of lab safety protocols and student learning outcomes.

2. To assess whether students' performance in laboratory assessments correlates with adherence to safety protocols.

3. To identify challenges faced by educators and students in adhering to lab safety protocols.

1.4 Research hypothesis

This study will test the following hypothesis:

H_1: There is a positive correlation between strict adherence to lab safety protocols and improved student learning outcomes.

H_0: There is no significant correlation between adherence to lab safety protocols and student learning outcomes.

1.5 Purpose of the study

The purpose of this study is to investigate the impact of laboratory safety protocols on student learning outcomes in scientific education. Laboratory work, often central to science courses, provides students with an opportunity to apply theoretical knowledge to practical tasks. However, without the proper safety measures in place, the potential for accidents increases, which can disrupt the learning process and affect student outcomes. This study seeks to determine whether following laboratory safety protocols has a direct effect on students' academic performance, engagement, and confidence. More specifically, it will assess whether safety practices not only minimize the risk of accidents but also enhance students' ability to grasp complex scientific concepts and successfully perform laboratory experiments. The research is expected to provide valuable insights for educators on how laboratory safety impacts students' learning experiences, thus aiding in the development of better instructional strategies that promote both safety and academic success.

1.6 Assumptions of the study

This study is based on several assumptions:

Several assumptions are central to this study. First, it is assumed that all students involved in the research have received at least a basic introduction to laboratory safety protocols before they

begin their experiments. This is crucial because it ensures that the study focuses on the students' adherence to safety guidelines, rather than their initial knowledge or training on safety. Secondly, the study assumes that students will follow the prescribed safety protocols in their laboratory work. These protocols include using personal protective equipment (PPE), correctly handling chemicals, and adhering to safety guidelines during emergencies.

The study also assumes that the safety training provided by educational institutions is both comprehensive and effective. This is important because the success of the study depends on whether students are adequately prepared to implement safety protocols. Another key assumption is that there exists a direct or indirect relationship between the implementation of safety protocols and students' academic performance. This assumption will be tested through the data collected during the study. Lastly, the study assumes that laboratory conditions, such as the availability of equipment, resources, and supervision, will be similar for all students participating in the study. This helps to control for any extraneous variables that might influence learning outcomes.

1.7 Delimitations

This study has the following delimitations:

Delimitations refer to the boundaries set by the researcher to narrow the focus of the study. In this case, the study is geographically confined to a specific educational institution or a small set of institutions within a defined region. This limits the generalizability of the findings to other educational settings, particularly those in different regions or countries where safety protocols might vary. Additionally, the study focuses exclusively on scientific disciplines, such as chemistry, biology, and physics, meaning that fields like engineering or medicine are excluded. This decision ensures that the research remains focused on areas where laboratory work is an essential part of the curriculum.

Delimitation is the time frame of the study, which will be conducted over a single academic year. While this allows for a focused examination of the impact of safety protocols within a defined period, it limits the ability to assess longer-term trends. The study will focus on high school. This ensures that the research captures the specific challenges and needs of high school learners, who are typically more engaged in hands-on laboratory work.

1.8 Limitations

On the whole undertaking and enquiry of the academic slant is saunter, every study usually comes with some challenges of its own and this study was no exception. In carrying out the study, this researcher encountered a number of dares.

The limitations of the study include:

1. Sample size: The research will be limited by the availability of students willing to participate, which may impact the diversity of the sample.

2. Self-report bias: Students may overstate their adherence to safety protocols or may be unaware of all safety procedures in the lab.

3. Measurement accuracy: Assessing student learning outcomes in the lab setting is complex and may be influenced by variables such as teaching methods, prior knowledge, and individual differences.

1.9 Definition of terms

For clarity, several key terms must be defined:

Laboratory safety protocols refer to the set of rules, guidelines, and procedures designed to ensure the safety of students and staff in laboratory settings. These protocols include instructions on the proper use of personal protective equipment (PPE), safe handling of hazardous materials, and steps to take in the event of an emergency. Research has shown that adherence to these protocols is critical in preventing accidents and fostering a positive learning environment (Knecht & Pettersen, 2020).

Learning outcomes refer to the measurable knowledge, skills, and abilities that students gain through their educational experiences. In this study, learning outcomes are assessed through students' understanding of scientific concepts, their ability to perform experiments safely, and their academic performance on related assessments (Levene et al., 2018). These outcomes are often used to evaluate the effectiveness of educational interventions and teaching strategies.

Personal protective equipment (PPE) encompasses gear worn by students to minimize exposure to hazardous materials and prevent injury in the laboratory. Common examples of PPE include safety goggles, lab coats, gloves, and face shields. The use of PPE is a fundamental component of laboratory safety and is essential in protecting students from physical, chemical, and biological hazards (Borys et al., 2015).

Engagement refers to the level of active participation and interest that students exhibit during their learning activities. In the context of laboratory work, engagement can include factors such as students' willingness to follow safety protocols, their attention to the tasks at hand, and their interest in understanding the underlying scientific concepts (Rennie & Parker, 2014). High levels of engagement are typically linked to improved academic performance and better retention of knowledge.

Student confidence is the belief that students have in their ability to perform tasks and experiments successfully. In laboratory settings, confidence is often linked to students' comfort with the safety protocols and their previous experiences in the lab. Confidence can enhance students' performance by reducing anxiety and encouraging them to take initiative in their experiments (Nelson, 2017).

1.10 Summary of the chapter

Chapter one has introduced the research topic, providing an overview of the importance of lab safety protocols in educational environments. The chapter outlined the research problem, objectives, and hypotheses, highlighting the need to explore the relationship between safety measures and student learning outcomes. It also detailed the assumptions, delimitations, and limitations of the study, establishing the framework for the research that will follow. The chapter sets the stage for further investigation into how safety protocols can enhance or hinder student learning in laboratory settings.

CHAPTER TWO: LETERATURE REVIEW

2.0 Introduction

This chapter provides a comprehensive review of existing literature on laboratory safety protocols and their impact on student learning outcomes. It aims to explore previous research and theoretical frameworks to help understand how safety measures in laboratory settings might influence students' academic performance, engagement, and overall learning experiences.

2.1.0 Theoretical framework

This study is underpinned by two key theories: the Constructivist Learning Theory and the Health Belief Model (HBM). These frameworks provide insights into how safety in the laboratory environment can influence students' learning processes and behavioral choices.

2.1.1 Constructivist learning theory

The Constructivist Learning Theory, developed by Jean Piaget and later expanded by Lev Vygotsky, posits that learners construct knowledge through active engagement with their environment and experiences. In a science laboratory, students learn best when they are actively involved in experiments, manipulating equipment, observing outcomes, and drawing conclusions from their activities. However, a prerequisite for this engagement is a safe and supportive environment. A safe laboratory setting encourages student participation, which is essential for meaningful learning. When safety protocols are properly implemented and followed, students feel secure, this enhances their confidence, curiosity, and willingness to explore. Conversely, fear of accidents or exposure to hazards can reduce student involvement, thereby undermining the learning process (Fosnot, 2013).

2.1.2 Health belief model (HBM)

The Health Belief Model (HBM), developed by Rosenstock in the 1950s, provides a psychological perspective on why individuals engage—or fail to engage—in health and safety behaviors. The model suggests that people are more likely to adopt protective actions if they perceive themselves to be susceptible to a risk, believe the risk has serious consequences, and believe that taking action will reduce the risk. In the context of a school laboratory, the HBM helps to explain student and teacher behavior in relation to safety protocols. If students perceive laboratory risks (such as chemical spills or burns) as serious and feel that following safety procedures will protect them, they are more likely to comply. Similarly, if teachers are aware of the risks and benefits, they are more likely to enforce safety rules. This model supports efforts to

raise awareness and promote behavioral change among learners and educators (Glanz, Rimer & Viswanath, 2008).

2.2.0 Importance of laboratory safety in education

Laboratory safety is an essential component of science education as it ensures that students can engage in hands-on experiments and practical learning without risk of injury. It serves to protect both students and instructors from potential hazards, while also enhancing the overall learning experience. The importance of laboratory safety can be viewed through several key perspectives:

2.2.1 Protection from hazards

One of the primary reasons laboratory safety is emphasized in educational settings is to protect students from potential physical, chemical, and biological hazards. Laboratories inherently contain various risks—such as exposure to harmful chemicals, biological agents, electrical hazards, and equipment that can cause burns or cuts. Safety protocols ensure that these risks are minimized.

Proper safety protocols include the use of personal protective equipment (PPE) such as gloves, goggles, and lab coats, which reduce the risk of exposure to harmful substances. In addition, the implementation of safety procedures for handling chemicals, disposing of waste, and managing emergencies such as spills or fires ensures that students are well-equipped to handle potential accidents effectively. A study by Johnson et al. (2015) found that when schools implemented strict safety guidelines, accidents were significantly reduced, allowing students to focus more on learning rather than worrying about personal safety.

By fostering an environment in which students feel secure, these protocols create a setting that is conducive to active participation in experiments and other hands-on activities. Without adequate safety measures, students might hesitate to engage fully in laboratory work, which could hinder their ability to gain practical experience and achieve meaningful learning outcomes.

2.2.2 Enhancement of the learning experience

In addition to protecting students, laboratory safety plays a crucial role in enhancing the overall educational experience. Laboratories are places where students can connect theory to practice, reinforcing concepts they've learned in lectures through hands-on experimentation. A safe lab

environment helps ensure that these activities proceed smoothly, without unnecessary interruptions caused by accidents or the need for emergency responses.

When students feel confident that they are in a safe environment, they are more likely to engage deeply with the material. Research by Davis and Kim (2018) highlights that students who are trained in lab safety and have access to well-maintained facilities are more likely to participate actively in experiments and are more focused on learning rather than concerns about potential dangers. A well-structured safety program enables students to explore more complex experiments, which can lead to greater cognitive gains and improved learning outcomes.

Moreover, the experience of conducting experiments in a safe environment allows students to develop critical practical skills, such as problem-solving, data collection, and analysis. These skills are essential for students to succeed not only in science but also in their broader academic and professional lives. By enhancing the learning experience through safety, educators can foster a more productive and effective teaching environment.

2.2.3 Establishment of a safety culture

Establishing a culture of safety is one of the most significant long-term benefits of incorporating lab safety protocols into education. This culture extends beyond the individual laboratory setting and influences the broader academic environment. When students are taught the importance of safety in a laboratory context, they are more likely to adopt these practices in other areas of their academic and professional lives.

The implementation of safety protocols also reinforces the role of educators as models of safe practice. Teachers and lab assistants who demonstrate safe behaviors—such as wearing appropriate PPE, following procedures, and handling equipment properly—set a positive example for students to follow. According to Taylor and Brown (2019), a strong safety culture in educational institutions has been shown to lead to greater respect for safety measures both inside and outside the classroom.

A safety culture also encourages accountability. Students learn to take responsibility for their own safety and the safety of others in the lab. This not only helps prevent accidents but also cultivates a sense of discipline and professionalism. Furthermore, it promotes collaboration and teamwork, as students work together to ensure that safety protocols are followed. Over time, this

culture can create a more responsible and safety-conscious student body that carries these values into their future careers.

2.3.0 Relationship between lab safety protocols and students' learning Outcomes

The implementation of laboratory safety protocols is crucial not only for the physical protection of learners and educators but also for the promotion of effective teaching and learning in science education. This section discusses this relationship in three subsections: (i) the psychological impact of safety on learning, (ii) engagement and participation in laboratory work, and (iii) teacher support and institutional policy.

2.3.1 Psychological safety and academic confidence

A safe learning environment enhances psychological safety—learners are less anxious, more confident, and more willing to engage in practical tasks. According to Bandura (1997), students' belief in their own capabilities (self-efficacy) significantly impacts their academic motivation and performance. Laboratory environments that are perceived as safe foster such self-efficacy, allowing students to explore, question, and experiment more freely. Mutasa and Mandina (2018) conducted a study in Zimbabwean secondary schools and found that students in schools with well-established safety protocols showed greater confidence and willingness to participate in lab activities. The reduction in perceived threat or risk led to more focused participation, which translated into improved learning outcomes. Fosnot (2013) further emphasizes that constructivist learning—where students build knowledge through active engagement—requires a secure environment. In unsafe environments, fear and distraction limit the effectiveness of learning experiences.

2.3.2 Student engagement and participation in laboratory activities

Effective safety practices correlate strongly with increased student engagement. According to Osborne and Dillon (2010), when students feel safe, they are more likely to engage in hands-on tasks, which are essential in science education. The study notes that active involvement in laboratory activities enhances understanding, retention, and practical skills. In a similar study, Aina and Adedoyin (2019) found that students who had undergone lab safety orientation performed significantly better in practical tests than those who had not. The authors argue that safety awareness builds operational competence, allowing students to focus on scientific tasks rather than worrying about potential hazards. Chukwu (2014) also reported that safe laboratory

environments reduce disruptive behavior and promote focused learning. In high schools where safety procedures were not observed, practical work was often limited or poorly conducted due to fear of injury or lack of equipment.

2.3.3 Teacher support and school-level safety policies

Teachers play a crucial role in ensuring that safety protocols are implemented and reinforced. According to Eze (2020), educators in under-resourced schools often struggle to balance curriculum delivery with the enforcement of safety protocols due to large class sizes and inadequate training. This often leads to a compromised learning environment and diminished student outcomes. Njoku (2016) found that schools with structured safety policies and regular training workshops showed marked improvement in both student safety behavior and academic performance. Teachers in these schools were more likely to incorporate safety discussions into lesson plans, which reinforced a culture of responsibility and discipline in the laboratory. Sibanda and Chikowore (2021), focusing on rural schools in Manicaland, Zimbabwe, noted that institutional support—such as funding for lab equipment and periodic safety audits—enhanced the overall quality of science instruction, leading to better student outcomes.

2.4.0 Challenges faced by educators and students in adhering to laboratory safety protocols

Despite the recognized importance of laboratory safety, many schools—especially in rural or under-resourced areas—struggle with effective implementation of safety protocols. This section explores the challenges faced by both educators and students under three key areas: (i) resource and infrastructure constraints, (ii) training and awareness limitations, and (iii) behavioral and cultural factors.

2.4.1 Resource and infrastructure constraints

One of the most significant barriers to enforcing lab safety is the lack of basic safety infrastructure. According to Sibanda and Chikowore (2021), many rural schools in Zimbabwe, including those in the Nyanga District, operate laboratories without essential safety equipment such as fire extinguishers, first aid kits, or proper ventilation. In such settings, adherence to safety protocols becomes difficult or even impossible. Eze (2020) notes that overcrowded classrooms, inadequate water supply, and broken laboratory equipment also contribute to unsafe

environments. In his study, teachers in poorly resourced schools reported frequent disruption of lessons due to safety-related incidents, leading to reduced time for practical instruction and student disengagement. Oladele and Adeyemi (2015) found that schools in economically disadvantaged regions often operate without updated lab safety manuals or signage, making it difficult for students to internalize or follow safety rules.

2.4.2 Lack of training and safety awareness

Both teachers and students often lack adequate training in lab safety practices. Mupfumira and Muringani (2019) identified gaps in teacher preparedness, noting that many science educators receive limited or no formal training in laboratory safety during their teacher education programs. As a result, safety becomes a secondary concern in science instruction. Students, too, may not be properly oriented to laboratory safety expectations. A study by Kibirige and Tsamago (2014) showed that learners in schools without structured safety induction programs were more likely to engage in risky behavior during practicals. In some cases, even when safety guidelines exist, they are not actively taught or emphasized. Njoku (2016) stresses that without ongoing reinforcement through posters, demonstrations, and drills, safety procedures are likely to be ignored or forgotten.

2.4.3 Behavioral attitudes and cultural norms

Adherence to lab safety is also affected by attitudes, habits, and school culture. Chikodzi and Nyota (2013) point out that in some schools, particularly those with lax administrative oversight, students develop a casual attitude toward safety. This behavior is often reinforced by peer norms or by observing educators who do not consistently model safe practices. Wright and Ogbonna (2018) suggest that some students deliberately bypass safety protocols due to overconfidence or the perception that safety rules are unnecessary for simple or familiar experiments. Meanwhile, some teachers report difficulty managing student behavior in labs due to a lack of disciplinary tools or support from school administration. Munyoro and Mapako (2021) argue that fostering a safety culture requires consistent effort from all school stakeholders—teachers, administrators, and students. Without a collective commitment, safety remains an isolated effort rather than an embedded part of school operations.

2.5 Summary

In summary, the literature reviewed suggests that laboratory safety protocols are critical not only for student's protection but also to enhance learning outcomes. Proper safety measures promote a safe and supportive learning environment, reducing anxiety and increasing student's engagement and participation. Furthermore, safety training helps students develop the confidence needed to perform experiments effectively and safely. However, challenges remain in ensuring consistent implementation and overcoming resource limitations.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter provides a detailed explanation of the methodology used in this study, which investigates the impact of lab safety protocols on students' learning outcomes at Coeli High School. It focuses on the research paradigm, research design, population and sampling technique, data collection methods, data presentation and analysis procedure and ethical considerations.

3.1 Research design

The research design for this study focuses on systematically investigating the impact of lab safety protocols on student learning outcomes. A well-defined research design is essential for ensuring that the study answers the research questions effectively while maintaining rigor and reliability. This study utilizes a qualitative research approach aimed at exploring the impact of lab safety protocols on student learning outcomes. Qualitative research is particularly effective for understanding complex phenomena and capturing the subjective experiences of individuals. By focusing on participants' perceptions, attitudes, and experiences, this approach allows the researcher to uncover insights into how lab safety protocols influence learning outcomes in a real-world educational setting. This method also facilitates the exploration of any barriers and facilitators that affect the implementation of these protocols (Creswell, 2014).

The research design is a case study, specifically concentrating at Coeli High School in Nyanga District, Manicaland Province. A case study design is advantageous for this research as it provides a detailed examination of a single context, enabling a thorough understanding of the specific practices related to lab safety protocols (Yin, 2018). This design allows for the collection of rich, contextual data through multiple sources, such as interviews and questionnaires, which can reveal the complexities of how safety protocols are implemented and their effects on student learning outcomes (Yin, 2018). By focusing on a particular school, the study can delve deeply into the unique challenges and successes that characterize the implementation of lab safety measures, making the findings relevant to the specific educational environment under investigation.

3.2 Population of the study

This group has been selected because they are directly involved in the laboratory activities where safety protocols are most applicable. The study is specifically focus on students from various form levels, as well as science teachers and administrators, because these individuals interact with the safety protocols either as users or implementers. Science student's population in these categories will be considered in the study, providing a broad view of the effects of lab safety on educational outcomes. According to Bhattacherjee (2012), a population refers to a group of individuals sharing common characteristics of interest to the researcher. In this study, the population comprised all Science students, science teachers at Coeli High School in Nyanga District, Manicaland Province. The Science class consisted of 200 students, with 95 females and 105 males. In addition science teachers in the study provided a broader perspective, enabling a more comprehensive understanding of the research issue. This population served as the basis for drawing a working sample, allowing the researcher to investigate the impact of lab safety protocols on students learning outcomes.

3.2.2 Sample and sampling procedures

A sample is a subset of a population selected for observation or questioning to provide insights about the whole population (Marshal, 2000). This study utilized a non-probability sampling method, specifically purposive sampling, to select participants. This technique targets individuals who can provide significant insights into the impact of lab safety protocols on student learning outcomes (Bhattacherjee, 2012).

The selected sample consisted of students aged between 14 and 19, with diverse cultural backgrounds. The group comprised 30 males and 30 females, providing a range of perspectives. Additionally, 7 Science teachers, school head and 2 heads of department were included in the data gathering process, bringing the total number of participants to 70. This sample size was deemed sufficient to provide reliable and valid outcomes that could be generalized.

Science teachers assisted in selecting students who could provide meaningful data. These participants were chosen because of their direct involvement in the design, implementation, or monitoring of laboratory safety protocols. Purposive and stratified random sampling are ideal for this study as it ensures that the data gathered comes from knowledgeable and experienced individuals who can provide valuable insights into how safety protocols are applied within the

school environment (Patton, 2002). This purposive sampling approach is advantageous for qualitative research, allowing for deep insights while being time and cost-effective (Marshal, 2000). Purposive sampling ensures that key stakeholders (teachers and administrators) are included, while stratified random sampling ensures a diverse representation of students. This balance approach maximizes the richness of data and enhances the validity of the study's findings (Teddlie and Yu, 2007).

3.3.0 Research instruments

To effectively investigate the impact of laboratory safety protocols on students' learning outcomes at Regina Coeli High School, a range of data collection instruments was employed. These include questionnaires, interviews, observation checklists, and document analysis. The use of multiple tools ensures triangulation of data, thereby enhancing the study's reliability and credibility (Creswell & Plano Clark, 2011).

3.3.1 Questionnaire guide for students

According to Fletcher (2010), a questionnaire is a document that contains a series of questions intended to gather data for surveys. In this study, questionnaires were distributed among various participant groups, with the specifics detailed in the appendices (Appendix I for student). Each questionnaire consisted of two sections: Section A featured closed-ended questions, while Section B included open-ended questions. The latter aimed to elicit detailed responses regarding how lab safety protocols impact the learning experiences of science students. The format of the questionnaires was uniform across categories but tailored to fit the specific roles of each respondent. This structure facilitated comprehensive data collection and simplified analysis. Chiromo (2009) notes that questionnaires can efficiently reach a large number of individuals in a short timeframe, making them particularly suitable for this study. However, a key limitation of questionnaires is that they may restrict respondents' answers due to fixed response options, and the absence of clarification during administration may lead to misinterpretation of questions.

3.3.2 Interview guide for teachers and administration

To augment the data gathered from questionnaires, interview guides were employed to counteract potential biases that may arise from self-reported information (Bland, 2010). Each interview guide was composed of three open-ended questions, as outlined in Appendix II. Consistency was maintained across all participant categories by using the same interview guide.

The interviews were conducted verbally, and responses were documented as direct quotes or summarized in narrative form. Chinyoka (2013) characterizes interviews as a dialogue between individuals on a shared topic of interest. This method allows for clarifications and captures both verbal and non-verbal cues, enhancing the depth of the data collected. The combination of questionnaires and interviews provided a richer understanding, as each method complemented and verified the findings of the other. Participants were assured that their responses would be treated confidentially. Interviews allow for flexibility and the opportunity to probe deeper into emerging issues. Nonetheless, they are time-consuming to conduct and analyze, and they may be influenced by interviewer bias if not carefully managed.

3.3.3 Observation checklist guide

To observe actual safety practices during science lessons, structured observation checklists were utilized as outlined in Appendix III. Observations are useful for recording real-time behaviors and the physical state of the laboratory environment, including the use of protective equipment, teacher supervision, and the presence of safety signage. They were particularly beneficial in validating or challenging what participants report in questionnaires and interviews. However, one drawback was the potential for the Hawthorne effect, where participants altered their behavior because they felt being observed. Additionally, short observation periods missed infrequent or spontaneous incidents.

3.3.4 Document analysis

Finally, document analysis was conducted on school safety policies, laboratory guidelines, student performance records, and any available reports of accidents or incidents as outlined in Appendix IV. This method provides historical and institutional context, helping to evaluate the consistency and seriousness of safety practices over time. While documents are often easy to access and non-intrusive to examine, there is a risk that some may be outdated, incomplete, or selectively compiled, which could limit the depth of analysis.

Together, these instruments provided a comprehensive foundation for exploring the intersection of safety and academic achievement qualitative insights into how safety protocols are applied and experienced within the school's science learning environment.

3.4 Procedure of collecting data

The data collection process for this study will follow a systematic, phased approach to ensure the effective gathering of both quantitative. Each stage will be executed with adherence to ethical standards and methodological rigor. The initial step will involve seeking formal approval from the head of Regina Coeli High School and the school's science department. In addition, ethical clearance will be obtained from relevant educational authorities or institutional review boards where necessary. Participants will be informed of the purpose of the study, their right to withdraw at any time, and the confidentiality of their responses. Consent forms will be signed before participation in interviews or observations.

3.4.1 Questionnaire administration

The use of questionnaires was a crucial component of the data collection process in this study, aimed at assessing students' understanding and perceptions of lab safety protocols and their relationship with learning outcomes. A total of students from selected high schools in Nyanaga District participated in the study, providing a diverse range of insights.

The administration of the questionnaires occurred during designated free periods, which ensured that students could focus on completing them without interruptions from regular class activities. This approach was carefully planned and executed over a period of time to maximize participation and allow students to engage thoughtfully with the questions.

Each questionnaire comprised 16 items, featuring a mix of multiple-choice questions and Likert scale items (Appendix I). These questions were designed to cover various aspects, including students' awareness of safety protocols, their perceived importance of these measures, and their self-reported learning outcomes related to practical activities conducted in the laboratory. This structured format aimed to elicit comprehensive responses that would reflect students' experiences and viewpoints.

To facilitate a thorough and reflective response process, students were allotted approximately 20 to 25 minutes to complete the questionnaires. This timeframe was deemed sufficient for participants to consider their answers carefully and provide meaningful feedback. Additionally, to encourage open and honest responses, confidentiality was strictly maintained throughout the process. Participants were informed of their rights to withdraw from the study at any time, reinforcing the ethical considerations that guided the research.

After the questionnaires were completed, the researcher promptly collected all responses to ensure a high return rate. Each completed questionnaire was then reviewed for completeness and accuracy, setting the stage for the subsequent analysis of the data. The insights gained from the questionnaires proved to be invaluable, shedding light on students' perceptions of lab safety protocols and their impact on learning outcomes.

3.4.2 Interview sessions

Interviews were employed as a second method of data collection, providing an opportunity to gain deeper insights into the perspectives of educators regarding lab safety protocols(Appendix II). The interviews aimed to understand how these protocols were implemented and perceived within the educational environment, particularly concerning their impact on students' learning outcomes. Participants included science teachers and school administrators from Coeli High school. These individuals were chosen for their direct involvement in the implementation of lab safety measures and their insights into the educational processes. Appointments for the interviews were scheduled in advance, accommodating the availability of each participant to ensure they could engage fully in the discussion.

Each interview lasted between 20 to 30 minutes and was conducted in private, quiet settings to facilitate open dialogue. This environment allowed participants to express their thoughts candidly without the distraction of external factors. With the consent of the participants, interviews were recorded to ensure accuracy in capturing their responses. In instances where recording was not permitted, detailed notes were taken to document the key points discussed. The interview questions were semi-structured, allowing for flexibility in the conversation while ensuring that essential topics were covered. Questions focused on the implementation of safety protocols, the challenges faced by educators, and the perceived impacts of these protocols on students' learning experiences. This format enabled participants to elaborate on their thoughts and provide nuanced insights that could not be captured through questionnaires alone.

Following the completion of the interviews, the recorded sessions and notes were transcribed and analyzed. This analysis aimed to identify recurring themes and patterns that emerged from the discussions, further enriching the understanding of how lab safety protocols influenced students' learning outcomes.

3.4.3 Observation process

Observations formed a crucial method in the data collection process, allowing for a direct assessment of the implementation of lab safety protocols during practical science lessons at Coeli High School. This method provided valuable insights into how safety measures were enacted in the classroom and their influence on student behavior and learning outcomes. The observation sessions were conducted over several practical lessons, focusing on various grade levels within the school to ensure a comprehensive understanding of safety practices in that specific context. A structured checklist was utilized to guide the observations, enabling the researcher to systematically assess key elements of lab safety. This checklist included criteria such as the availability and proper use of safety equipment, the extent of teacher supervision during experiments, and the overall behavior of students while engaged in practical activities.

To minimize the potential for the Hawthorne effect—where individuals alter their behavior due to being observed—the researcher maintained a non-intrusive presence during the sessions. This approach helped to ensure that students behaved naturally, providing a more accurate representation of the learning environment and the effectiveness of the safety protocols in place. Each observation session lasted approximately 20 minutes, during which the researcher recorded data in real time. The observational data were meticulously documented to identify trends and areas for improvement in adherence to safety protocols. This firsthand insight into classroom dynamics offered a valuable complement to the data collected through questionnaires and interviews. Following the completion of the observation sessions, the recorded data were analyzed to uncover patterns and relationships related to the implementation of lab safety measures and their impact on students' learning outcomes. This analysis contributed significantly to the overall findings of the study, highlighting the practical implications of lab safety on educational experiences.

3.4.4 Documents analysis

Document analysis played a significant role in the data collection process, complementing the insights gained from questionnaires, interviews, and observations. This method involved the systematic examination of relevant documents related to lab safety protocols and educational practices at Coeli high school. The primary documents analyzed included the school's safety manuals, laboratory safety guidelines, curriculum outlines, and any relevant training materials provided to teachers and students. By reviewing these documents, the researcher aimed to

understand the formal safety protocols in place and how they aligned with the perceptions and practices observed during the study. The analysis began with a thorough review of the safety manuals, which outlined the policies and procedures that governed laboratory practices. This review provided a foundational understanding of the expectations set by the school regarding lab safety. The researcher sought to identify specific safety measures, emergency procedures, and the responsibilities assigned to both teachers and students.

In addition to safety manuals, curriculum outlines were examined to determine how safety protocols were integrated into practical science lessons. This analysis aimed to assess whether safety training was included in the curriculum and how effectively it was communicated to students. By correlating the curriculum with the data collected from questionnaires and interviews, the researcher could gauge the consistency between formal guidelines and actual practices in the classroom. Training materials, including workshop notes and presentations for teachers, were also reviewed to assess the professional development opportunities provided to educators. This analysis was crucial for understanding how teachers were prepared to implement safety protocols and the extent to which they felt equipped to teach students about safe laboratory practices.

By synthesizing the findings from document analysis with the data collected through other methods, the researcher gained a holistic view of the lab safety protocols in place at the school. This comprehensive approach allowed for a deeper understanding of how documented policies translated into actual practices and their impact on students' learning outcomes.

Before commencing the data collection process, the researcher sought written consent from all respondents, ensuring they understood and acknowledged their participation. Throughout the process, data provided by respondents was accurately recorded using a combination of a pen, notebook, and cellphone audio recordings. This meticulous approach ensured the collection of reliable and valid data, supporting the integrity of the research findings.

3.4.5 Data presentation and analysis procedure

This study employed a qualitative data analysis approach, following the principles outlined by Musingafi and Hlatywayo (2013), who defined data analysis as a process of inspecting, cleaning, transforming, and modeling data to extract useful information and support decision-making. The

qualitative nature of the research facilitated an in-depth exploration of the data, focusing on identifying themes and sub-themes that emerged from the participants' experiences and perspectives regarding lab safety protocols. The data analysis process involved recording and organizing the responses, followed by a thorough examination to identify patterns and commonalities that aligned with each research objective. The themes that emerged from the data were derived from the participants' views on the impact of lab safety protocols on their learning outcomes, and these themes were carefully linked to the literature review to ensure that the findings were grounded in existing knowledge and research.

The findings were presented in a way that clearly illustrated how adherence to lab safety protocols influenced students' learning outcomes, engagement, and attitudes toward practical work in the laboratory. By analyzing the data systematically and rigorously, this study aimed to contribute to the existing body of knowledge on the importance of lab safety in education and provide valuable insights for educators, policymakers, and researchers. The presentation of the findings was structured around the themes and sub-themes that emerged from the data, supported by quotes and observations from the participants.

3.6.0 Ethical consideration

Ethical considerations were crucial in ensuring that the research process was conducted in a manner that respected the rights and dignity of all participants. In this study, where students' data and personal experiences were collected, adherence to ethical standards was essential. These ethical principles guided the research process and ensured that the study was conducted in a responsible, respectful, and transparent manner, protecting the well-being of participants while maintaining the integrity of the research. The primary ethical concerns in this study included informed consent, confidentiality, voluntary participation, and the potential impact of the study on students' learning experiences.

3.6.1 Informed consent

One of the key ethical requirements in this study was obtaining informed consent from all participants before data collection began. Informed consent ensured that participants were fully aware of the nature of the study, the procedures involved, the potential risks and benefits, and their rights as participants. Students were provided with an informed consent form that outlined these details in clear, accessible language. This form explained the purpose of the study, the

voluntary nature of participation, the expected time commitment, and the steps taken to protect their privacy and confidentiality. The form also assured participants that they could withdraw from the study at any time without penalty or negative consequences.

3.6.2 Confidentiality and anonymity

Confidentiality was another important ethical consideration in this study. To protect the identities of the participants, all personal information collected during the research process was kept confidential. This meant that participants' names and any identifying information were not included in the final reports or publications. Instead, pseudonyms or identification numbers were used to anonymize participants' responses.

Moreover, all data collected—whether from tests, surveys, or interviews—was securely stored, and only the research team could access the data. Digital files were stored in encrypted folders, and physical records were locked in a secure location. This ensured that participants' privacy was protected throughout the research process. Furthermore, when presenting the results of the study, care was taken to avoid any details that could potentially identify individual participants (Fowler, 2014).

3.7 Summary

In this chapter, the methodology for investigating the impact of lab safety protocols on students' learning outcomes at Regina Coeli high has been outlined. A case study research design, combined with a mixed-methods approach, will be used to collect and analyze data. The study was conducted ethically, with a strong focus on validity and reliability to ensure credible and trustworthy findings.

CHAPTER FOUR: DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.0 Introduction

This chapter presents and analyzes the data collected in the study investigating the impact of lab safety protocols on student learning outcomes at the selected high school in the Nyanga District, Manicaland Province. The findings are organized according to the research objectives outlined in the literature review. The chapter will also discuss how these findings relate to existing literature, identify gaps in knowledge, and highlight the discursive analytical and interpretive skills employed throughout the analysis.

4.1.0 Data presentation

This section presents the findings of the study through a thematic analysis of the data collected from interviews, questionnaires, observations, and document analysis. The presentation is structured around the key themes that emerged from the data, providing a comprehensive overview of the impact of lab safety protocols on student learning outcomes (Braun & Clarke, 2006). Each theme is supported by illustrative quotes from participants, descriptive narratives, and relevant observations, ensuring a rich and nuanced portrayal of the research findings (Creswell, 2013).

4.1.1 Theme 1: Enhanced learning environment through safety implementation

This theme highlights the positive impact of implementing lab safety protocols on creating a conducive learning environment. The data revealed that when safety protocols are consistently followed, students feel more secure and focused, leading to improved engagement and learning outcomes.

Students expressed a strong connection between safety measures and their ability to concentrate during experiments. One student noted, *"When we know the safety rules are in place, we can concentrate better on the experiment without worrying about accidents."* This sentiment was echoed by another participant, who stated, "The lab feels more organized and professional when everyone follows the safety guidelines. It makes learning easier."

Observations during lab sessions reinforced these findings. In classes where strict safety protocols were enforced, students were more likely to participate actively and ask questions, indicating a higher level of engagement. For example, during a practical session, students were observed discussing safety procedures openly, contributing to a collaborative and focused atmosphere.

Questionnaire responses further supported this theme, revealing that students who perceived the lab environment as safe reported higher levels of confidence in their ability to perform experiments successfully. As one student remarked, *"I feel more confident trying new things in the lab when I know the safety procedures are in place."*

Overall, the implementation of lab safety protocols not only enhances the physical safety of the learning environment but also fosters a positive atmosphere where students feel empowered to engage deeply with the material. This aligns with existing literature that emphasizes the importance of a safe learning environment in promoting student engagement and success (Braun & Clarke, 2006; Creswell, 2013).

4.1.2 Theme 2: Direct correlation between safety adherence and performance

This theme demonstrates a clear relationship between students' adherence to safety protocols and their performance in laboratory assessments. The data indicated that students who consistently followed safety procedures achieved higher scores in practical evaluations.

Students recognized the impact of safety adherence on their understanding and execution of experiments. One student stated, *"I always make sure to follow the safety checklist before starting an experiment. It helps me understand the procedure better, and I usually get good results."* This perspective was supported by a teacher who noted, *"Students who ignore safety rules often make mistakes during experiments, which affects their grades."*

Analysis of lab assessment scores revealed a statistically significant positive correlation between students' adherence to safety protocols and their overall performance in practical exams. For instance, students who regularly followed safety guidelines averaged higher grades compared to those who did not.

Teachers also reported that students who understood and followed safety protocols were better prepared for experiments. As one teacher remarked, *"Those who take safety seriously are more likely to troubleshoot problems effectively and achieve successful outcomes."*

Overall, this theme highlights that adherence to safety protocols not only ensures a safe learning environment but also directly influences students' academic success in laboratory settings. This finding aligns with previous research indicating that a strong emphasis on safety in educational contexts can lead to improved student performance (Creswell, 2013; Precision Consulting, 2022).

4.1.3 Theme 3: Challenges and barriers to safety adherence

This theme identifies the challenges and barriers that educators and students face in adhering to lab safety protocols. Common issues included limited resources, inadequate training, and inconsistent enforcement of safety rules.

Teachers expressed frustration regarding the lack of necessary resources to effectively implement safety protocols. One teacher commented, *"We often lack the necessary safety equipment, making it difficult to enforce all the protocols." Students echoed this sentiment, with one stating, "Sometimes, the safety rules are not clear, or we don't fully understand why they are important."*

Document analysis of school records revealed that the budget allocated for lab safety equipment was insufficient to meet the needs of the science department, which hindered the effective enforcement of safety protocols. This limitation was evident in observations where students were seen improvising safety measures due to the unavailability of proper equipment.

Additionally, interviews with teachers highlighted the need for ongoing professional development to enhance their knowledge and skills in teaching lab safety protocols effectively. As one teacher noted, *"We need more training on how to teach safety effectively, so students can truly understand the importance of these protocols."*

Overall, this theme underscores that while safety protocols are essential for student learning, various barriers must be addressed to ensure their effective implementation. This aligns with

existing literature that emphasizes the importance of resources and training in promoting safety adherence in educational settings (Creswell, 2013; Marvin, 2025).

4.2.0 Linking literature review with new findings

The findings of this study align with existing literature that emphasizes the importance of lab safety in enhancing student learning outcomes. Previous research has indicated that effective safety protocols contribute to positive educational experiences (Gonzalez et al., 2020; Smith, 2018). However, this study adds nuance by demonstrating specific correlations between safety adherence and performance in laboratory assessments, thus providing empirical evidence to support theoretical assertions.

4.2.1 Correlation between safety protocols and educational outcomes

The findings from this study reveal a significant correlation between students' adherence to laboratory safety protocols and their performance in laboratory assessments. This aligns closely with the existing literature, which underscores the importance of safety practices in enhancing educational outcomes.

4.2.2 Procedural accuracy and practical outcomes

The data from this study indicate that students who consistently follow safety protocols demonstrate greater procedural accuracy during laboratory tasks. For instance, participants reported that adherence to safety guidelines resulted in more precise execution of experiments, echoing the findings of Chowdhury and Sharma (2017), who emphasized that disciplined adherence to safety practices leads to valid experimental results.

In the current study, students who regularly utilized personal protective equipment (PPE) and followed proper handling procedures were observed to achieve higher scores in practical evaluations, supporting Njoku's (2020) assertion that safety compliance is linked to better performance. Additionally, the integration of safety procedures into assessment criteria was noted to enhance students' procedural knowledge, mirroring Afolabi and Olayemi's (2015) observations regarding the positive effects of safety integration in educational settings.

4.2.3 Safety competence and confidence during assessments

This study also found that students' confidence in the lab environment positively influenced their performance. Participants expressed that familiarity with safety protocols enabled them to

approach assessments with greater composure. This finding is consistent with Wright and Ogbonna (2018), who noted that training in lab safety fosters a sense of ownership and responsibility among students during experiments.

Moreover, the results of this study align with Munyoro and Mapako (2021), who found that students who received regular safety briefings performed better during practical exams. The current research corroborates this by highlighting that students who felt comfortable in the lab environment made fewer mistakes and produced more organized work, thereby achieving improved assessment outcomes.

4.2.4 Teacher supervision, feedback, and assessment integrity

Teacher supervision emerged as a crucial factor in reinforcing safety protocols and enhancing student performance. The current findings indicate that active monitoring by teachers not only improves adherence to safety procedures but also contributes to better academic results. This supports Eze's (2020) observation that effective teacher oversight encourages students to perform better under exam conditions.

Furthermore, the study highlights the importance of feedback related to safety compliance, aligning with Chikodzi and Nyota's (2013) findings. Participants indicated that constructive feedback on safety practices led to improvements in both adherence and experimental techniques over time. This reinforces Agu and Okeke's (2016) assertion that clear and fair assessment procedures motivate students to prioritize safety, ultimately translating into better academic performance.

4.2.0 Relationship between the implementation of lab Safety protocols and student learning outcomes

The findings from this study reveal a significant relationship between the implementation of lab safety protocols and students' learning outcomes, supporting the existing literature. This section explores how the data collected aligns with and expands upon previous research.

4.2.1 Psychological safety and academic confidence

One of the primary findings of this study is that well-implemented safety protocols enhance students' psychological safety, leading to increased confidence and willingness to engage in laboratory activities. Participants reported feeling more secure when safety measures were in

place, which allowed them to focus on their experiments without fear of accidents. This aligns with Bandura's (1997) assertion that self-efficacy influences academic motivation and performance.

Mutasa and Mandina (2018) found similar results in their research, noting that students in schools with established safety protocols displayed greater confidence and participation in lab activities. The current study corroborates this by showing that students who felt safe in the lab environment were more focused, which translated into improved learning outcomes.

4.2.2 Student engagement and participation in laboratory activities

The study also established a strong correlation between safety adherence and student engagement in laboratory tasks. Participants indicated that effective safety practices encouraged them to participate actively in hands-on activities. This supports the findings of Osborne and Dillon (2010), who emphasized that a safe learning environment promotes student involvement, critical for mastering scientific concepts.

In this study, students who underwent safety orientation performed significantly better in practical assessments, echoing Aina and Adedoyin's (2019) observations. The data suggest that safety awareness not only builds operational competence but also allows students to concentrate on scientific tasks rather than potential hazards.

4.2.3 Teacher support and school-level safety policies

The role of teachers in implementing and reinforcing safety protocols emerged as a critical factor in this study. Participants noted that educators who actively monitored safety compliance positively influenced student performance. This supports Eze's (2020) findings that teachers in under-resourced schools often struggle to enforce safety protocols, which compromises the learning environment.

The current study reflects Njoku's (2016) conclusion that schools with structured safety policies and regular training workshops demonstrated improved student outcomes. Teachers who incorporated safety discussions into lesson plans fostered a culture of responsibility and discipline, further enhancing the learning experience.

Additionally, the data align with Sibanda and Chikowore's (2021) observations regarding the importance of institutional support. Participants indicated that funding for lab equipment and

regular safety audits contributed to an overall improvement in science instruction quality, leading to better student performance.

4.3.0 Challenges faced by educators and students in adhering to laboratory safety protocols

The findings from this study align with existing literature on the challenges that educators and students face in adhering to laboratory safety protocols, emphasizing the need for systemic improvements in schools.

4.3.1 Resource and infrastructure constraints

The data indicate that inadequate safety infrastructure significantly hampers adherence to safety protocols. Participants reported a lack of essential safety equipment, such as fire extinguishers and first aid kits, mirroring Sibanda and Chikowore's (2021) findings that many rural schools operate without necessary safety resources. This lack creates an environment where following safety guidelines become challenging, as students and teachers feel unprepared to handle emergencies.

Furthermore, teachers in this study echoed Eze's (2020) observations regarding overcrowded classrooms and inadequate facilities, which lead to frequent safety incidents. This environment not only disrupts learning but also diminishes students' engagement and focus during practical sessions. The findings suggest that improving infrastructure is crucial for fostering a culture of safety and effective learning.

4.3.2 Lack of training and safety awareness

The study also revealed significant gaps in training and safety awareness among both educators and students. Many teachers reported receiving limited training in lab safety, a finding consistent with Mupfumira and Muringani (2019), who noted that safety often becomes a secondary concern in science instruction. The current findings emphasize the need for comprehensive safety training programs as a foundational element of science education.

Students indicated that without proper orientation to safety expectations, they were more likely to engage in risky behavior, reflecting Kibirige and Tsamago's (2014) assertion that structured safety induction programs are critical for effective learning. This study highlights the urgent need

for ongoing training and reinforcement of safety protocols to ensure that both educators and students are equipped to prioritize safety in laboratory settings.

4.3.3 Behavioral Attitudes and cultural norms

Participants identified behavioral attitudes and school culture as significant barriers to adherence to safety protocols. The findings illustrate that in environments with lax administrative oversight, students often develop a casual attitude toward safety, supporting Chikodzi and Nyota's (2013) observations. This study found that when teachers do not consistently model safe practices, students are less likely to take safety seriously.

Moreover, the data revealed instances where students bypassed safety protocols due to overconfidence, aligning with Wright and Ogbonna's (2018) insights. This highlights the necessity of fostering a strong safety culture within schools, where all stakeholders—teachers, administrators, and students—are committed to prioritizing safety. Munyoro and Mapako (2021) emphasized that without collective commitment, safety remains an isolated effort rather than an integrated aspect of school operations.

4.3.0 Addressing gaps identified in the literature

The findings of this study contribute to the existing body of knowledge by addressing several critical gaps in the literature regarding laboratory safety protocols and their impact on student learning outcomes. This section outlines how the new knowledge gained from this research enhances understanding and offers practical solutions to previously identified issues.

4.3.1 Empirical evidence linking safety protocols to learning outcomes

While previous research has acknowledged the importance of lab safety, there has been a lack of empirical studies directly linking adherence to safety protocols with specific learning outcomes. This study provides quantitative and qualitative data demonstrating that students who follow safety protocols achieve higher scores in laboratory assessments and exhibit greater engagement in practical tasks. This addresses the gap highlighted by Njoku (2020), who noted a need for robust evidence connecting safety compliance to academic performance.

4.3.2 Insights into psychological and behavioral factors

Previous literature often focused on logistical aspects of safety in laboratories, such as equipment and training, without fully exploring the psychological and behavioral dimensions. The current

study emphasizes the role of psychological safety in fostering academic confidence and motivation, filling the gap identified by Mutasa and Mandina (2018). By highlighting how a secure learning environment affects students' willingness to engage in experiments, this research offers a more holistic view of the factors influencing learning outcomes.

4.3.3 The role of teacher training and institutional support

While there has been some discussion regarding teacher involvement in safety practices, this study significantly expands on this theme by providing detailed insights into how effective teacher support and institutional policies impact student adherence to safety protocols. The findings underscore the necessity for ongoing professional development and structured safety policies, addressing the gaps noted by Eze (2020) and Sibanda and Chikowore (2021). This knowledge is crucial for informing educational policies and training programs aimed at improving safety in science education.

4.3.4 Practical recommendations for improvement

Additionally, the study offers practical recommendations for schools to enhance laboratory safety and improve student learning outcomes. By identifying specific challenges faced by educators and students, such as inadequate resources and lack of training, the research provides actionable insights that can guide institutional changes. This contrasts with previous studies that often highlighted problems without offering solutions.

4.4 Summary

This chapter effectively demonstrates the critical role of lab safety protocols in improving student learning outcomes while identifying the challenge that must be addressed to ensure effective implementation. The findings contribute valuable insights literature and offer practical recommendation for educational improvement.

CHAPTER FIVE SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter provides a summary of the research by directly focusing on the research questions. The chapter also focuses on conclusions and recommendations on critical evaluation of the impact of lab safety protocols on students learning outcomes, a case study at Coeli high school in Nyanga district, Manicaland Province. The chapter concludes by focusing on or suggesting areas of further study on the adoption and implementation of safety protocols in school laboratories.

5.1 Summary of the study

This chapter summarized, concluded and recommended the research. The study investigated the impact of lab safety protocols on students' learning outcomes at a high school in Nyanga District, Manicaland Province. It aimed to understand how adherence to safety measures influenced student engagement, performance, and overall educational experiences in laboratory settings. The findings suggested that effective lab safety protocols are essential for preventing accidents and enhancing student learning in science subjects. On the other hand, the study examined the relationship between safety protocols and learning outcomes, assessed performance correlations, and identified challenges in adherence. A mixed-methods approach combines quantitative data from surveys and qualitative insights from interviews to provide a comprehensive analysis. The study found out that adherence to safety protocols significantly enhances student engagement and academic performance, while resource limitations and training variability pose challenges. Overall, the research highlights the importance of robust safety measures in fostering a positive and effective learning environment in laboratory setting

However, a number of constraints were discovered during the research process namely sample size, self-report bias, resource limitations, gender imbalance and variability in training.

The sample size refers to the number of participants included in the study. In this research, the limited number of respondents (60 out of 70) may not adequately represent the broader population of students at the high school. A limited number of participants may not capture the full range of experiences and perspectives, especially if certain groups (e.g., students from different grades or backgrounds) are underrepresented. Smaller samples can affect the statistical

power of the study, making it harder to detect significant differences or relationships between variables. This limits the reliability of the findings. Conclusions drawn from a small sample may not be applicable to the entire student body, hindering the ability to make broad claims about the impact of lab safety protocols.

Self-report bias was another imminent constraint, it occurs when participants provide inaccurate responses about their behaviors or attitudes, often due to social desirability or lack of self-awareness. Students may claim to strictly follow safety protocols to appear responsible, even if their actual behavior does not match this claim. Participants might minimize or omit instances where they did not adhere to safety measures, leading to inflated perceptions of safety compliance. This bias can skew results, making it difficult to assess the true effectiveness of safety protocols and their relationship with learning outcomes.

On the other hand, constraints on resource limitations was encountered, this entailed the lack of adequate safety equipment, training materials, and facilities necessary for implementing effective lab safety protocols. Without proper equipment (e.g., safety goggles, lab coats), students may not be able to adhere to safety protocols effectively, increasing the risk of accidents. Limited access to quality training resulted in students failing to fully understand the importance of safety measures, leading to improper execution of protocols. When safety measures are not effectively implemented, students may experience anxiety or distractions during lab work, hindering their ability to engage with the material and learn effectively.

The gender imbalance in the sample, with significantly more male participants than female, posed several challenges, the predominance of male respondents may skew the results, as perceptions and experiences related to lab safety can differ by gender. This may affect the analysis of how safety protocols are perceived and followed resulting in findings that may not be fully representative of the views of all students, particularly if female students have different experiences or attitudes toward lab safety. Whereas if the experiences of female students are not adequately represented, it could lead to a lack of understanding of how to improve engagement and adherence to safety protocols for all genders.

Variability in training referring to inconsistencies in the quality and content of safety training received by students was another constraint. Students who receive different levels of training

may have varying degrees of knowledge about safety protocols, which can affect their ability to follow them correctly. Those with thorough training may feel more confident and competent in the lab, while others may hesitate or make errors due to a lack of understanding. If some students are better trained than others, the overall effectiveness of safety protocols in enhancing learning outcomes may be compromised, leading to mixed results in the study.

The Methodology was a case study, seventy questionnaires were distributed to the respondents, sixty were returned and the remainder of ten failed to turn up. The questionnaires were distributed online using emails and WhatsApp. The researcher carried out structured interviews, using Zoom platforms as well as over the telephone interviews. The researcher upheld ethical considerations, the writer wrote letters to the management of the school seeking permission to carry out the research. The permission was granted and introductory letters to the questionnaire were attached to the questionnaires and distributed to the respondents. The respondents voluntarily participated with informed consent and their anonymity and confidentiality respected.

5.2.0 Summary of the major findings

5.2.1 Lab safety protocols as a means to understand the potential risks associated with experiment

The findings reflected a generally positive perception of lab safety protocols among respondents, with a strong majority endorsing their effectiveness. The fact that approximately 25 respondents strongly agree that lab safety protocols are effective indicates a strong endorsement of these measures. This suggests that the majority of participants recognize the importance of safety protocols in minimizing risks, which is crucial for fostering a safety-conscious culture in laboratory environments. With about 20 respondents agreeing with the statement, there's a solid consensus supporting the effectiveness of these protocols. This majority reinforces the validity of implementing and adhering to safety guidelines in labs (Kaufman, (2022).

5.2.3 Following lab safety protocols enhances my learning experience.

The fact that 30 respondents strongly agree and 20 agree that safety protocols enhance their learning experience indicates a robust recognition of the benefits of these measures. With 50 out of 60 respondents supporting the effectiveness of safety protocols, it suggests a strong alignment between safety and educational outcomes. The findings reflect a clear and positive perception of safety protocols as enhancing the learning experience in the laboratory. The significant majority

of supportive responses underscores the importance of integrating safety measures into educational practices. To further strengthen this positive sentiment, it may be beneficial to engage neutral respondents and ensure they understand the value of safety protocols, thereby reinforcing their overall learning experience (Summerlin, 2023).

5.2.4 Teachers ensuring that lab safety protocols are followed during experiments.

The results presented in the chart provided a compelling view of respondents' perceptions regarding the enforcement of lab safety protocols. The largest section being "Strongly Agree" indicates a strong belief among respondents that lab safety protocols are strictly enforced. This suggests a high level of confidence in the adherence to safety measures, which is essential for maintaining a safe laboratory environment. The lack of a "Strongly Disagree" segment is particularly noteworthy. It implies that there is almost universal acknowledgment of the enforcement of safety protocols, which can enhance overall trust in the laboratory environment (Sharma, 2024).

5.2.5 Implementing lab safety protocols improves student engagement during experiments.

The largest bar representing "Agree" indicates that a significant portion of respondents (about 20) believes that students are engaged during experiments. This is a positive indication that safety protocols may be facilitating an interactive and participatory learning environment. The findings suggest that while most respondents see a positive level of engagement, there is a noteworthy segment that remains uncertain. This indicates an opportunity for educators to explore ways to further enhance student engagement, possibly by integrating more interactive elements into lab sessions or reinforcing the connection between safety protocols and effective learning (Anon., 2024).

5.2.6 Consistently follow up on safety protocols during laboratory experiments.

The notable proportion of respondents who agree or strongly agree with following safety protocols indicates a generally positive attitude towards safety measures. This is encouraging, as it suggests that many students recognize the importance of adhering to these protocols for their own safety and the safety of others. The potential consequences of non-adherence are significant. Students who consistently follow safety protocols are likely to benefit from safer lab

environments, which can enhance their educational experiences and outcomes. Conversely, those who do not adhere may expose themselves to risks that could hinder their learning, emphasizing the need for effective safety education (Sanzana, 2024.).

5.2.7 I believe that following safety protocols reduces errors and improves my lab performance

The majority of respondents indicating agreement ("Agree" and "Strongly Agree") highlights a strong recognition among students of the positive impact that compliance with safety protocols has on minimizing errors. This understanding is crucial, as it emphasises the importance of safety measures not just for protection, but also for enhancing the quality of experimental results. The data suggests that students are aware of the benefits of adhering to safety protocols, which can lead to a more structured and error-free laboratory environment. This perception can encourage a culture of safety and diligence in lab practices. Overall, the results indicate a strong belief among students that compliance with lab safety protocols significantly contributes to reducing errors in experiments. By fostering this understanding and emphasizing the importance of adherence to safety measures, educators can enhance both safety and the quality of learning outcomes in laboratory settings (JOY, 2024).

5.2.8 Limited resources hinder ability to follow and enforce safety controls.

The significant number of respondents (around 40) who "Strongly Agree" that limited resources are a concern indicates a strong awareness among students of the challenges posed by resource constraints in laboratory settings. This recognition is crucial, as it underscores the importance of addressing these limitations to ensure effective safety practices. The findings suggest that educational institutions need to recognize and address resource constraints to foster a safer and more effective learning environment. Investing in necessary materials, equipment, and training can enhance both safety compliance and overall learning outcomes. Overall, the results reflect a clear acknowledgment among students of the impact of limited resources on lab safety protocols and learning outcomes. Addressing these resource constraints is essential for improving safety practices and enhancing the educational experience in laboratory settings. By prioritizing resource allocation, institutions can better support both safety and effective learning (Anon., 2024).

5.2.9 Is the first aid kid available and easily accessible

The strong affirmative response regarding the presence of first aid kits suggests that students understand their importance in enhancing safety during lab experiments. This awareness is crucial, as having accessible first aid resources can facilitate prompt assistance in the event of accidents, thereby reducing potential harm. While the recognition of first aid kits is a positive indicator, the need to assess responses regarding health facilities is equally important. Adequate health facilities are essential for providing comprehensive care beyond immediate first aid, especially in serious situations. The findings highlight a strong awareness of the importance of first aid kits among students, which is a positive step towards a safety-conscious environment. However, the adequacy of health facilities must also be addressed to ensure comprehensive safety and support for students during laboratory experiments. By prioritizing both first aid resources and health facilities, institutions can create a more effective and reassuring learning atmosphere (Sasapan, 2024).

5.2.10 Are learners wearing appropriate protective clothing (gloves, goggles & Lab coats)

The significant number of respondents who "Strongly Agree" that wearing protective clothing is essential indicates a robust awareness of the safety benefits associated with proper lab attire. This recognition is crucial for fostering a culture of safety in laboratory environments. The observed trend of declining agreement from "Strongly Agree" to "Strongly Disagree" suggests that while a majority understand the importance of protective clothing, there remains a subset of students who are either indifferent or unconvinced about its necessity. This variability highlights the need for further education on the role of protective gear in preventing accidents and injuries. the findings indicate a strong recognition of the importance of wearing protective clothing among students, which is a positive sign for safety awareness in laboratory settings. However, addressing the neutral and disagreement responses is essential to ensure that all students fully understand the necessity of protective attire. Through targeted educational efforts, institutions can enhance safety practices and promote a more comprehensive understanding of lab safety (Sasapan, 2024).

5.2.11 Are there clearly visible safety signs e.g. emergency exits, fire extinguishers.

The overwhelmingly positive response indicating "yes" suggests that most students are aware of the presence of safety signs in their laboratories. This is a crucial factor in fostering a safety-

conscious environment, as clear signage plays a vital role in guiding students to adhere to safety protocols. The presence of safety signs is fundamental for informing students about potential hazards and the necessary precautions they should take. By effectively communicating risks, safety signs can significantly enhance students understanding of safety protocols and encourage compliance. While the findings are positive, it may still be beneficial for institutions to regularly assess the visibility and clarity of safety signs. Engaging students in discussions about the effectiveness of existing signage could provide insights for further enhancements (Ansah, 2024.).

5.3 Conclusions

The study aimed to evaluate the impact of lab safety protocols on students' learning outcomes in a high school setting in Nyanga District, Manicaland Province. Through a mixed-methods approach, the research effectively combined quantitative data from surveys and qualitative insights from interviews to provide a comprehensive understanding of how safety measures influence student engagement, performance, and overall learning experiences.

This study conclusively demonstrates that the implementation of lab safety protocols significantly impacts students' learning outcomes in the selected high school in Nyanga District, Manicaland Province. The findings indicate a positive correlation between strict adherence to lab safety protocols and improved student engagement and academic performance. Students who felt safe and well-prepared were more likely to participate actively in laboratory activities, leading to better understanding and retention of scientific concepts.

The analysis revealed that students who consistently followed safety protocols performed better in laboratory assessments. This underscores the critical role that safety measures play in enhancing not only safety but also the effectiveness of learning experiences in science education. The study identified significant challenges, including resource limitations and variability in training quality, which hinder students and educators from fully adhering to safety protocols. Addressing these challenges is essential for maximizing the benefits of safety measures in educational settings. In summary, the research affirms that implementing robust lab safety protocols is vital for creating a secure and effective learning environment. To improve educational outcomes, it is imperative that schools enhance their safety resources, provide comprehensive training, and foster a culture of safety among students and staff. These steps will

help ensure that safety protocols not only protect students but also enrich their learning experiences in the sciences.

5.4 Recommendations

Based on the findings of this study, several recommendations can be made to enhance the effectiveness of lab safety protocols and improve students' learning outcomes:

- ✓ Schools should increase funding for laboratory resources, ensuring that adequate safety equipment (e.g., goggles, gloves, first aid kits) is available for all students. Regular audits should be conducted to assess the availability and condition of safety resources, ensuring they meet the necessary standards.
- ✓ Schools should develop and implement comprehensive training programs that cover all aspects of lab safety protocols as well as training should be mandatory for all students before engaging in laboratory work.
- ✓ Schools should utilise a variety of teaching methods, including hands-on demonstrations and simulations, to reinforce learning and retention of safety practices. On the other hand, female students should be encouraged to participate actively in lab activities and discussions about safety protocols. This could involve targeted outreach or mentoring programs to address the gender imbalance in responses and ensure diverse perspectives are included in future studies.
- ✓ Safety protocols should be regularly reviewed and updated to reflect current best practices and technological advancements in laboratory safety. Involve both students and teachers in the review process to gather insights on practical challenges faced in adhering to protocols.
- ✓ Culture of safety within the school should be fostered by promoting open discussions about safety practices and encouraging students to take responsibility for their own safety and that of their peers.
- ✓ Recognize and reward adherence to safety protocols through positive reinforcement strategies, such as certificates or recognition programs. By implementing these recommendations, educational institutions can significantly enhance the effectiveness of lab safety protocols, leading to improved learning outcomes and a safer educational environment for all students.

5.5 Recommendations for further study

Future research should include a broader range of participants from different schools, regions, and educational contexts to enhance the generalizability of findings. Including a more balanced gender representation and students from various socioeconomic backgrounds can provide deeper insights into diverse perspectives on lab safety protocols. Future researchers are encouraged to look into the following areas.

a) Investigate the long-term effects of lab safety protocols on student learning outcomes over multiple academic years.

b) Explore how varying levels of resources and safety training in different schools affect student adherence to safety protocols and learning outcomes.

c) Examine the effectiveness of digital tools (e.g., simulations, apps) in enhancing student understanding and compliance with lab safety protocols.

APPENDICES

Appendix 1: Questionnaire for Students

This appendix includes the questionnaire that was distributed to students at Regina Coeli High School. The questionnaire aims to gather data on students' perceptions of laboratory safety protocols and their relationship with academic performance. The items focus on safety measures, student engagement in laboratory activities, and academic outcomes.

Objective 01: To examine the relationship between the implementation of lab safety protocols and student learning outcomes

1. I feel safe when following lab safety protocols during experiments.(Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

2. Lab safety protocols help me understand the potential risks associated with experiments. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

3. Following lab safety protocols enhances my learning experience .(Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

4. I believe lab safety protocols are necessary for my academic success. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

5. My teacher ensures that lab safety protocols are followed during experiments. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

6. Implementing lab safety protocols improves student engagement during experiments. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

7. I believe lab safety protocols are essential for creating a positive learning environment. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

Objective 02: To assess whether students' performance in laboratory assessments correlates with adherence to safety protocols.

8. I consistently follow safety protocols during laboratory experiments. .(Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

9. I understand the importance of adhering to safety protocols in the lab.(Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

10. I feel confident in my ability to follow lab safety protocols correctly. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

11.I perform better in lab assessments when I follow safety protocols. .(Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

12. Adhering to safety protocols helps me focus on the experiment and improves my results.(Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

13. I believe that following safety protocols reduces errors and improves my lab performance. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

Objective 03: identification of challenges faced by educators and students in adhering to lab safety.

14. Are learners wearing appropriate protective clothing (gloves, goggles & Lab Coats?) (Yes /No)

15. Is the first aid kid available and easily accessible? (Yes/ No)

16. Limited resources hinder ability to follow and enforce safety controls. (Strongly Agree/ Agree / Disagree / Neutral / Strongly Disagree)

Thank you for your cooperation

Appendix 11: Interview Guide for Teachers and administrative

This section contains the semi-structured interview guide used to gather in-depth responses from teachers and administrators. The interviews are designed to explore how safety protocols are implemented in the school and their perceived impact on student learning.

Sample Interview Questions (To be included in the appendix):

1. Can you describe the safety protocols that are in place during science practical sessions?

2. How do you ensure that students are following the safety guidelines during laboratory activities?

3. In your experience, have safety protocols contributed to improved student performance? Please explain.

4. What challenges do you face in implementing laboratory safety measures?

Appendix 111: Observation Checklist

The observation checklist provides the framework used to assess the implementation of safety protocols during science practical sessions. The checklist focuses on key aspects such as the availability of personal protective equipment (PPE), teacher supervision, and emergency preparedness.

Sample Checklist

Are students wearing appropriate PPE (gloves, goggles, lab coats)? (Yes/No)

Is there a clearly visible safety sign (e.g., emergency exits, fire extinguishers)? (Yes/No)

Are students being actively supervised by the teacher during practical work? (Yes/No)

Is a first aid kit available and easily accessible? (Yes/No)

Appendix 1V: Document Review Guide

This section includes the list of documents to be reviewed as part of the study, such as the school's laboratory safety guidelines, science curriculum documents, and any accident/incident reports related to laboratory safety.

Sample Document Review Criteria

Laboratory Safety Guidelines: Are safety protocols clearly outlined? Are there any inconsistencies between policy and practice?

Accident Reports: Are there any recorded incidents of accidents during practical sessions? If so, what safety measures were in place at the time?

Science Curriculum: Does the curriculum include references to lab safety? Are safety practices integrated into practical work?

Appendix 1V LETTER SEEKING PERMISSION TO CARRY OUT RESEARCH

Coeli High school

P. O. Box 98

Nyanga

10 March 2025

The DSI Nyanga

Ministry of Primary and Secondary Education

Box 00

Nyanga

Dear Sir

REF: REQUEST TO CARRY OUT AN ASSESSMENT INTO THE IMPACT OF LAB SAFETY PROTOCOLS ON STUDENTS LEARNING OUTCOME.

I am studying for a Bachelor of Science education honors degree in biology and I am conducting a research on “assessing the “the impact of lab safety protocols on students learning outcome.

In respect of the above, I humbly request for the permission to conduct the research.

Thank you in advance.

Yours sincerely

REFERENCES

American Psychological Association (APA). (2017). Ethical principles of psychologists and code of conduct. https://www.apa.org/ethics/code

Bryman, A. (2016). Social research methods (5th ed.). Oxford University Press.

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches

Fowler, F. J. (2014). Survey research methods (5th ed.). Sage Publications.

Henderson, S. (2016). Ethics in research. Journal of Research in Nursing, 21(6), 470–483. https://doi.org/10.1177/1744987116647168

Bates, T. (2015). Teaching in a Digital Age: Guidelines for Designing Teaching and Learning. Tony Bates Associates Ltd.

Baker, R. (2013). The role of laboratory safety in educational settings. Journal of Educational Safety, 18(4), 214-229.

Biggs, J. (2014). Teaching for quality learning at university. McGraw-Hill Education.

Borys, D., McLoughlin, C., & Conneely, T. (2015). The role of personal protective equipment in laboratory safety education. Journal of Safety Research, 57, 61-67.

Byers, M. (2015). Safety and student performance: The impact of safety training on academic success. Science Education Review, 12(2), 67-75.

Clarke, S., & Manley, M. (2015). Personal protective equipment and its impact on student performance. Journal of Safety in Science Education, 22(3), 55-61.

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4), 227-268.

Downes, S. (2007). What Connectivism is. In Connectivism: A Learning Theory for the Digital Age. Available at: https://www.downes.ca

George, M., Pearce, J., & Ransom, K. (2018). Safety training and student learning outcomes: A study of laboratory-based education. Education & Training in Science, 14(1), 29-38.

Hodgson, K. (2019). Safety in the laboratory: Best practices and impact on learning. Science Education Journal, 16(1), 12-21.

Hughes, P., & Ferrett, E. (2016). Introduction to health and safety in construction. Routledge.

Jones, A. (2016). Challenges in implementing laboratory safety protocols in under-resourced institutions. Journal of Science Education, 30(2), 118-134.

Knecht, D., & Pettersen, M. (2020). The impact of laboratory safety on student engagement and academic performance. Journal of Science Education, 48(2), 115-123.

Levene, M., Smith, J., & Williams, R. (2018). Lab safety training and its effect on student performance in practical science courses. Journal of Laboratory Safety and Education, 34(3), 142-149.

Nelson, S. (2017). Accidents in the laboratory: Consequences for students and educational institutions. Safety in Education, 27(4), 305-312.

O'Brien, L., Matthews, D., & Ryan, M. (2017). Anxiety reduction through safety protocols in laboratory education. Journal of Educational Psychology, 108(3), 532-541.

Okojie, M., Olinzock, A., & Okojie-Boulder, T. (2006). The Role of Information and Communication Technology in Education: A New Era of Teaching and Learning. Contemporary Issues in Technology and Teacher Education, 6(2), 49-62.

Price, M. (2014). Hands-on learning and the impact on student engagement in science education. Journal of Science Education, 25(4), 10-18.

Rennie, L., & Parker, D. (2014). Exploring the relationship between student engagement and academic performance in science education. International Journal of Science Education, 36(9), 1545-1565.

Vygotsky, L. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Cohen, L., Manion, L., & Morrison, K. (2018). Research methods in education (8th ed.). Routledge.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101.

Denzin, N. K. (1978). The Research Act: A Theoretical Introduction to Sociological Methods. McGraw-Hill.

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics (4th ed.). SAGE Publications.

Stake, R. E. (1995). The Art of Case Study Research. SAGE Publications.

Cohen, L., Manion, L., & Morrison, K. (2018). Research Methods in Education (8th ed.). Routledge.

Patton, M. Q. (2002). Qualitative Research & Evaluation Methods (3rd ed.). SAGE Publications.

Teddlie, C., & Yu, F. (2007). Mixed methods sampling: A typology with examples. Journal of Mixed Methods Research, 1(1), 77–100.