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Investigating the Impact of Hands-On Experiments on Biology Education: A Case Study of ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province.

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We, the undersigned certify that we have read and therefore recommend to Bindura University of Science Education for acceptance; a research project entitled: "**Investigating the Impact of Hands-On Experiments on Biology Education: A Case Study of ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province.**" submitted by Buzuzi Spiwe, Chapanda Nyasha, Machadu Bertha and Maruta Norma in partial fulfilment of the requirements of the Bachelor of Science Education Honors degree in Biology.

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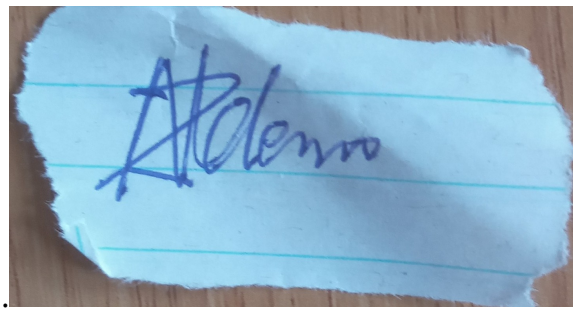

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DECLARATION

We, Buzuzi Spiwe, Chapanda Nyasha Kudzai, Machadu Bertha and Maruta Norma, do hereby declare that this research is a presentation of our own work except to the extend indicated in the Acknowledgement, References and by comments included in the body of the report and that it has not been submitted in part or in full to any other University or any other Institution of higher learning.

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DEDICATION

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LIST OF ACRONYMS

ANCOVA	Analyses of Covariance
GST	General System Theory
IT	Information Technology
MoPSE	Ministry of Primary and Secondary Education
NECO	National Examination Council
SPSAT	Science Process Skills Acquisition Test
SSCE	Secondary Short end of Course Examination
STEM	Science, Technology, Engineering &Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization
WAEC	West African Examinations Council
ZIMSEC	Zimbabwe School Examinations Council

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ABSTRACT

This study is found on the backdrop of Investigating the Impact of Hands-On Experiments on Biology Education. Biology education holds a crucial position in secondary schools as it serves as the foundation for students' comprehension of living organisms and their interactions with the environment. Despite some researchers exploring the impact of hands-on teaching on science subjects, including notable innovations and discoveries, there remains a research gap regarding the effectiveness of hands-on experiments in teaching biology to ordinary level students. The study aims to investigate the current status of hands-on experiments in teaching biology, their effectiveness in enhancing students' understanding of biology concepts, the challenges faced in implementing them, and strategies to improve their implementation. Biology has a special place in the curriculum of educational institutions. Numerous science-related courses, including those in biochemistry, medicine, pharmacy, agriculture, nursing, and other fields, heavily rely on biology. This research targets only a population of participants who happen to be ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province. A sample of 70 participants was selected to ensure the inclusion of all members with required experiences related to the impact of Hands-On Experiments on Biology Education. Summing up this research, the value of hands-on experiments towards students' learning process and academic improvement were shown in various data collected. The bulk of the data collected had shown positive results in most of the areas. As a result, this study has demonstrated that hands-on experiments promote students' knowledge and builds on their intrinsic impetus. The study found that when teachers use hands-on activities in a constructive way, students become more engaged, creative, critical thinkers, and first-hand skills are developed, and the teaching and learning process becomes more efficient. Based on the results of this study, the researcher suggests that Bruner's theory of teaching in science learning be investigated further using practical trials. Further study should involve other Ordinary level students

within the district and other districts as well as their Provinces, with a view to comparing the results with this research which are only in Zvimba District.

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CHAPTER I

INTRODUCTION

1.0 Introduction

This chapter serves as an introduction to the research study, providing a comprehensive overview of the background, problem statement, purpose, objectives, research questions, basic assumptions, significance, limitations, delimitations, future research possibilities, key term definitions, and a summary of the chapter. It sets the context by presenting the background that led to the research and identifies the specific problem to be addressed. The purpose and objectives of the study are outlined, accompanied by research questions that will guide the investigation. The chapter acknowledges the basic assumptions underlying the research and emphasizes the significance of the study. It also acknowledges the limitations and delimitations, while suggesting future research possibilities. Key terms are defined to ensure clarity, and the chapter concludes with a summary, providing a concise overview of its contents.

1.1 Background of the Study

Biology education holds a crucial position in secondary schools as it serves as the foundation for students' comprehension of living organisms and their interactions with the environment, Tugwi, (2022). Science, technology, engineering, and mathematics (STEM) education, implemented by the Ministry of Primary and Secondary Education in 2016, places significant emphasis on science subjects, including biology, as it fosters the development, preservation, and dissemination of knowledge and skills that yield personal, economic, and social benefits. Research conducted by Svodziwa (2021) highlights that STEM education produces competent graduates who drive the Zimbabwean industrialization agenda, create employment opportunities, and contribute to the country's modernization.

The remarkable achievements of biological science underscore the onset of a new era - the century of biology. Present-day biology not only serves as a discipline of study but also directly influences the living world, Svodziwa, (2021). The growing trends in designing and constructing bio-objects, as well as the management of living organisms

and systems, have become evident. With the advancements in biology and the integration of its accomplishments into human society, an increasing number of individuals will require biological education as part of their professional training. In the contemporary era of flourishing biological science, particularly in genetics, microbiology, biopsychology, bio-cybernetics, and bionics, where the creation of new types of organisms and control over human nervous activity are within reach, the state educational standard incorporates biology training programs that aim for a deeper and modern understanding of genetic branches, broader application of biological knowledge to environmental issues, and the utilization of information elements in biological processes.

The teaching of biology plays a crucial role in fostering students' dialectic thinking by providing them with a deep understanding of the scientific principles governing the organic world. Through the study of biology, students are exposed to the intricate mechanisms that govern life forms, from the smallest cells to complex ecosystems. This exposure not only enhances their knowledge of biological processes but also cultivates critical thinking skills essential for analysing and interpreting scientific information, Holstermann, Grube and Bögeholz, (2019). Furthermore, the study of biology offers students insights into the historical context of life on Earth. By exploring the evolutionary history of organisms and understanding how life has evolved over millions of years, students gain a broader perspective on the interconnectedness of all living things. This historical perspective helps students appreciate the diversity of life forms and the dynamic nature of biological systems (Ibid). Biology stands as one of the primary subjects in the natural science curriculum, playing a pivotal role in the formation and development of individuals. It is instrumental in ensuring a healthy lifestyle and the preservation of the environment - the habitat of all mankind. However, teaching biology can be challenging, particularly when dealing with complex and abstract concepts that are difficult to visualize. One proposed approach to enhance students' comprehension of biology is the use of hands-on experiments which shall be explained in greater detail in the paragraph to follow.

Hands-on experiments involve students actively participating in the learning process by manipulating materials and equipment to observe and explain phenomena, Svodziwa, (2021). These experiments provide students with opportunities to apply their knowledge

and skills, foster critical thinking and problem-solving abilities, and deepen their understanding of scientific concepts. Engaging in hands-on activities within biology classes, such as in field or laboratory settings, is widely recommended by educational authorities like the National Association of Biology Teachers, Holstermann et al., (2019). Experts believe that involving students in a holistic learning experience, where they learn by doing, significantly enhances their critical thinking skills, Man, (2015). It encourages them to rely on evidence from observed data, promotes independent thinking, and reduces their reliance on authority. Numerous studies also indicate that hands-on experiments increase students' motivation to learn and enhance their perception, creativity, and logical reasoning. Consequently, students are not only able to apply what they have learned in the classroom to their everyday lives but can also utilize their comprehensive learning experiences in various real-life situations (Shana and Abulibdeh, 2020). The focus of this study is to assess the role of hands-on experiments in teaching biology to ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province. This school, situated in a rural setting, serves students from disadvantaged backgrounds, highlighting the importance of providing them with practical and engaging learning experiences.

1.2 Statement of the Problem

Despite some researchers exploring the impact of hands-on teaching on science subjects, including notable innovations and discoveries, Alberts, (2022), there remains a research gap regarding the effectiveness of hands-on experiments in teaching biology to ordinary level students at Mutsonzowa Secondary School. In many secondary schools in Zvimba District, Mashonaland West Province and Zimbabwe as a whole, the teaching of biology relies heavily on theoretical instruction, with limited opportunities for students to engage in hands-on learning experiences. This is especially true in rural schools like Mutsonzowa Secondary School, where resources for practical learning are limited. The lack of hands-on learning experiences in teaching biology can negatively impact students' understanding of complex biology concepts, leading to poor performance in the subject. Hands-on experiments are crucial in science education as they provide students with practical and engaging learning experiences that enhance their understanding of scientific concepts. In biology, hands-on experiments can help students visualize and understand complex concepts that are difficult to grasp through theoretical

instruction alone. However, the implementation of hands-on experiments in teaching biology in rural schools like Mutsonzowa Secondary School can be challenging due to limited resources, lack of teacher training, and inadequate laboratory facilities. Therefore, there is a need to assess the role of hands-on experiments in teaching biology in ordinary level classes at Mutsonzowa Secondary School. The study aims to investigate the current status of hands-on experiments in teaching biology, their effectiveness in enhancing students' understanding of biology concepts, the challenges faced in implementing them, and strategies to improve their implementation.

1.3 Purpose of the Study

The purpose of this study is to assess the role of hands-on experiments in teaching biology in ordinary level classes at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province. The study seeks to investigate the current status of hands-on experiments in teaching biology, their effectiveness in enhancing students' understanding of biology concepts, the challenges faced in implementing them, and strategies to improve their implementation. The significance of this study lies in its potential to provide insights into the effectiveness of hands-on experiments in teaching biology in a rural setting. The findings of the study can inform the development of effective teaching strategies that can enhance students' understanding of biology concepts and improve their performance in the subject. As such, the study can contribute to the broader literature on the role of hands-on experiments in science education.

1.4 Objectives of the Study

The specific objectives of this study are as follows:

1. To determine the impact of hands-on experiments on students' understanding of biological concepts in the ordinary level class at Mutsonzowa Secondary School.

2. To assess the development of critical thinking skills among students through hands-on experimental activities.

3. Determine the impact of biology practical on the students’ academic performance in biology.

1.5 Main Research Question

The main research question that guides this study is:

How do hands-on experiments contribute to teaching biology in the ordinary level class at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province?

1.6 Sub-Research Questions

1. What is the impact of hands-on experiments on students' understanding of biological concepts in the ordinary level class at Mutsonzowa Secondary School?

2. How do hands-on experimental activities contribute to the development of critical thinking skills among students?

3. What does the impact of biology practical pose on the students' academic performance in biology?

1.7 Basic Assumptions

This study is based on the following assumptions:

i. Hands-on experiments have a positive impact on students' understanding of biological concepts.

ii. Hands-on experiments promote the development of critical thinking skills among students.

iii. Students have a positive attitude towards hands-on experiments in biology education.

1.8 Significance of the Study

The findings of this study hold several significant implications for various stakeholders, including teachers, parents, learners, and policy makers.

1.8.1 Teachers

Understanding the impact of hands-on experiments on students' understanding of biological concepts and the development of critical thinking skills can empower teachers with valuable insights. They can utilize this knowledge to enhance their instructional strategies and create more engaging and effective learning experiences for their students. The study results can inform teachers about the benefits of incorporating hands-on experiments into their lessons, enabling them to improve their teaching practices and contribute to the overall academic growth of their students.

1.8.2 Parents

Parents play a crucial role in supporting their children's education. This study's findings can benefit parents by highlighting the importance of hands-on experiments in biology education. By understanding how practical learning experiences can enhance their children's understanding of complex biological concepts and foster a deeper interest in the subject, parents can actively support and advocate for the inclusion of hands-on experiments in their children's education. This knowledge empowers parents to engage with their children's learning process and create a supportive environment that encourages curiosity and exploration.

1.8.3 Learners

ordinary level students at Mutsonzowa Secondary School and other learners stand to gain significantly from this study. Engaging in hands-on experiments can make the learning of biology more enjoyable and impactful. The research findings can provide learners with practical opportunities to explore and comprehend biology concepts, leading to a deeper understanding and the development of critical thinking skills. By actively participating in hands-on experiments, learners can develop a deeper appreciation for biology and be better prepared for future academic pursuits or careers in the field.

1.8.3.1 Enhanced Understanding

Hands-on experiments allow learners to actively engage with the subject matter, promoting a deeper understanding of biological concepts. By involving multiple senses

and providing tangible experiences, learners can visualize and experience abstract concepts first-hand, making them more concrete and easier to grasp.

1.8.3.2 Critical Thinking Development

Hands-on experiments encourage learners to think critically, analyze data, and draw conclusions. Through these activities, learners can develop problem-solving skills, logical reasoning, and the ability to evaluate evidence, which are essential skills in biology and other scientific disciplines.

1.8.3.3 Increased Interest and Motivation

Hands-on experiments make learning biology more exciting and interesting for learners. By immersing themselves in practical activities, learners can connect theoretical knowledge to real-world applications. This connection can ignite curiosity, foster a passion for biology, and motivate learners to explore the subject further.

1.8.4 Policy Makers

Policy makers and education authorities have the responsibility of shaping educational policies and allocating resources effectively. The results of this study can inform policy makers about the importance of incorporating hands-on experiments in biology education. Understanding the feasibility and practicality of implementing such experiments in a limited resource setting like Mutsonzowa Secondary School can guide policy makers in developing appropriate strategies. The findings can influence decision-making processes and help policy makers allocate resources, infrastructure, and training to support practical learning experiences in biology education. Ultimately, policy makers can work towards improving the quality of biology education by incorporating evidence-based practices supported by this study.

1.9 Limitations

This study acknowledges certain limitations that can impact the research findings. These limitations include:

1.9.1 Time constraints: The study will be conducted within a specific time-frame, which may limit the depth and scope of data collection and analysis.

1.9.2 Sample size: Due to practical constraints, the study will focus on a specific ordinary level class at Mutsonzowa Secondary School, which may limit the generalizability of the findings to other contexts.

1.9.3 Resource constraints: The limited availability of resources, such as laboratory equipment and materials, may impact the implementation of hands-on experiments and data collection.

1.10 Delimitations of the Study

To ensure focus and clarity, this study will have certain delimitations, which include:

1.10.1 Focus on ordinary level class: The study will specifically examine the use of hands-on experiments in teaching biology to ordinary level students at Mutsonzowa Secondary School.

1.10.2 Contextual limitation: The research will be conducted within the context of Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province, and may not be directly applicable to other educational institutions or regions.

1.11 Future Research

This study will pave the way for future research in the field of science education. Potential areas for future research could include:

1.11.1 Comparative studies: Comparing the effectiveness of hands-on experiments in teaching biology across different schools or educational settings.

1.11.2 Longitudinal studies: Investigating the long-term impact of hands-on experiments on students' academic performance and career choices in the field of science.

1.11.3 Teacher training: Exploring the effectiveness of professional development programs for teachers to enhance their pedagogical approaches, particularly in hands-on experimentation.

1.12 Definition of Key Terms

To ensure clarity and understanding, key terms used throughout the study are defined explicitly. These definitions provide a common understanding and context for the research.

1.12.1 Hands-on experiments

Hands-on experiments refer to practical activities or laboratory exercises in which learners actively engage with materials, equipment, and procedures to explore and investigate biological concepts. These experiments involve direct manipulation, observation, and analysis of data, allowing learners to gain first-hand experience and understanding of the subject matter.

1.12.2 Biological concepts

Biological concepts encompass the fundamental principles, theories, and ideas related to the study of living organisms and their interactions. These concepts include topics such as cell structure and function, genetics, evolution, ecology, physiology, and other branches of biology.

1.12.3 Understanding

Understanding refers to the ability to comprehend and make sense of information, concepts, or ideas. In the context of this study, understanding specifically relates to students' comprehension of biological concepts and their ability to apply that knowledge to solve problems or explain phenomena.

1.12.4 Critical thinking skills

Critical thinking skills involve the ability to analyze, evaluate, and synthesize information to make reasoned judgments and decisions. In the context of this study, critical thinking skills pertain to students' capacity to apply logical and analytical thinking in the process of engaging with hands-on experiments, interpreting data, and drawing conclusions.

1.12.5 Perceptions

Perceptions refer to individuals' subjective interpretations, beliefs, and attitudes towards a particular subject or experience. In this study, perceptions relate to students' subjective viewpoints regarding hands-on experiments in biology education, including their opinions, preferences, and beliefs about the value and effectiveness of such activities.

1.12.6 Attitudes

Attitudes denote individuals' feelings, emotions, and predispositions towards a specific topic or experience. In the context of this study, attitudes pertain to students' emotional responses, inclinations, and overall disposition towards hands-on experiments in the context of biology education.

1.12.6 Feasibility

Refers to the practicality or viability of implementing a certain activity or intervention. In this study, feasibility specifically relates to the practicality of integrating hands-on experiments into the biology curriculum in the limited resource setting of Mutsonzowa Secondary School.

1.12.8 Practicality

Practicality refers to the suitability or workability of a particular approach or method. In the context of this study, practicality relates to the workability of implementing hands-on experiments in the biology curriculum at Mutsonzowa Secondary School, considering factors such as available resources, infrastructure, and teacher capacity.

1.12.9 Academic performance

Academic performance refers to students' achievements and outcomes in their academic pursuits. In this study, academic performance specifically relates to students' performance in biology, including their understanding of biological concepts, problem-solving abilities, and overall grades or scores in biology assessments.

1.12.10 Instructional strategies

Instructional strategies encompass the methods, techniques, and approaches used by teachers to facilitate learning and instruction. In the context of this study, instructional strategies specifically refer to the approaches employed by teachers to integrate hands-

on experiments into the biology curriculum and facilitate students' engagement and understanding of biological concepts.

1.12.11 Limited resource setting

Limited resource setting refers to an educational environment with constraints or limitations in terms of materials, equipment, infrastructure, and other resources necessary for effective teaching and learning. In this study, the limited resource setting specifically pertains to the conditions and challenges faced by Mutsonzowa Secondary School in implementing hands-on experiments due to resource constraints.

1.12.12 Evidence-based practices

Evidence-based practices refer to instructional approaches or interventions that are grounded in research evidence and have demonstrated effectiveness in improving learning outcomes. In the context of this study, evidence-based practices specifically relate to teaching strategies and methods supported by research findings that highlight the benefits of hands-on experiments in biology education.

1.13 Summary

In conclusion, this chapter served as an introduction for the research study, presenting the background, problem statement, purpose, objectives, research questions, basic assumptions, significance, limitations, delimitations, future research possibilities, and key term definitions. It provided a comprehensive overview of the research study foundation and set the stage for the subsequent chapters. The literature review, to follow, will build upon this foundation, examining existing knowledge and contributing to the understanding of the impact of hands-on experiments on ordinary level students' understanding of biological concepts at Mutsonzowa Secondary School. Through a systematic analysis of relevant literature, the subsequent chapters will provide valuable insights and contribute to the body of knowledge in this field.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

Literature review is a search and evaluation of the available literature in a certain subject or topic area, Harvey (2018).the chapter looked at theories behind hands on experiments which are general system theory, Piaget's theory, constructivism theory, experimental learning theory , cognitive load theory, self-efficacy and social learning theory were identified and discussed .The concept Biology as a branch of science ,teaching and learning and also practical activities were examined .the chapter also looked at laboratory facilities and students performance in Biology, merits and demerits of laboratory based instruction, practical and academic performance, problems associated with biology practical related empirical studies and concluded with a chapter summary.

2.1 Theoretical Framework

In the field of education, hands-on experiments have been recognized as a valuable tool for enhancing student learning experiences, particularly in science subjects like biology. This theoretical framework aims to explore the impact of hands-on experiments on biology education among ordinary level students.

2.1.1 General System Theory

The General System Theory (GST) was used in this study as the theoretical foundation. System theory is a general science of organization and wholeness, according to Higgs and Smith (2018). It can also be seen as a philosophy that maintains that humans are components of a system called life. The fundamental tenets of system theory are that everything, including humans, is a system of some kind and that every system has a purpose and an objective (Ibid). To accomplish the system's objectives, each component must cooperate with the others and the surrounding environment. In 2018, the biologist Von Bertalnffy created the General System Theory. His

presumptions were mostly related to biological things, machines, galaxies, and organizations. According to his theory, system components operate within systems rather than independently. His hypothesis challenged the conventional wisdom in science, which held that a system could be better understood by dissecting it into its constituent parts and studying and analyzing each part separately. and that a system's entirety may be described by adding components in a linear method. A system is described by Bertalnffy (2018) as a collection of elements that are interrelated. The system may be left open or closed. The school is an illustration of an open system, wherein two or more people collaborate in a planned way to achieve shared objectives Norlin (2015).

All schools operate on an open system, yet students' interactions with their surroundings can differ. The following elements make up the school system: inputs from the environment, the transformation process, the output, and feedback. An open system is one that releases its output back into the environment after receiving input from it. Any alterations to the surroundings can have a significant effect on the open system. For the educational system to be successful or to identify the cause of an issue and subsequently provide a solution, many system components must work together. The school serves as an example of a socially open system with the aim of achieving excellence in all areas, thus this philosophy has been embraced for the study. One of the main objectives of biology education in secondary schools is to give students the scientific knowledge and mind set they need to pursue careers in nursing, medicine, dentistry, and pharmacy, among other fields, at universities Abugu (2015). This is not possible, therefore, unless the theoretical and practical components of biology interact as predicted to accomplish the intended outcome. According to this study, every facet of biology instruction and learning may have an impact on how well children perform on tests. If any one of the system's components is absent, the result will be detrimental; however, if all of the components function together, meaningful learning will be accomplished and student performance will rise.

2.1.2 Piaget's Theory

Piaget's theory of cognitive development provides a thorough explanation of the origins and evolution of human intellect. The Swiss developmental psychologist Jean Piaget (1896–1980) was the one who initially developed

it. The theory addresses the nature of knowledge itself as well as the process by which people acquire, create, and apply it across time. The developmental stage theory is the most common name for Piaget's theory. Piaget, according to Wikipedia, "was intrigued by the fact that children of different ages made different kinds of mistakes while solving problems". Furthermore, he thought that toddlers just think and speak in different ways than "little adults," who may know less. Piaget developed four distinct stages of cognitive development based on his belief that children possess exceptional cognitive capacities, which he then implemented. He was able to categorize them according to age within those four stages. He became aware of how kids were able to advance their cognitive abilities at each stage. He held, for instance, that children learn about the world by doing, verbally expressing, reasoning, and thinking logically.

According to Piaget, biological maturation and environmental experiences lead to a progressive rearrangement of brain processes that constitutes cognitive development. According to his theory, kids form an awareness of the world around them, notice differences between what they already know and what they see in their surroundings, and modify their beliefs accordingly. Furthermore, Piaget maintained that language depends on the knowledge and comprehension that are gained during cognitive growth and that cognitive development is the core of the human organism. Most interest was given to Piaget's early work.

"Open education" and child-centred classrooms are two clear examples of Piaget's ideas in action. Even though Piaget's theory was extremely successful, he was aware of certain limits. For instance, the theory favours discrete stages as opposed to continuous growth (horizontal and vertical decalage).

2.1.3 Constructivism Theory

Constructivism theory, which was put out by Piaget and Vygotsky, places a strong emphasis on the value of experiential learning and active learning in the educational process. This theory holds that students build their conceptual understanding by interacting with their surroundings, which

makes practical experiments a useful strategy for encouraging deeper learning Driver et al. (1994).

2.1.4 Experiential Learning Theory

According to Kolb's experiential learning theory, learning is an ongoing process that incorporates active experimentation, abstract conceptualization, reflective observation, and tangible encounters. Students can participate in all of these phases through hands-on experiments, which helps them get a more thorough understanding of biological ideas Kolb (1984).

2.1.5 Cognitive Load Theory

According to the Cognitive Load Theory, working memory's cognitive load has an impact on learning. By offering real-world examples and useful applications of theoretical concepts, hands-on experiments can assist minimize superfluous cognitive load and improve student comprehension and retention Sweller et al. (2011).

2.1.6 Self-Efficacy Theory

According to Bandura's Self-Efficacy Theory, students' motivation and academic performance are influenced by their self-perceptions. By giving students, the chance to succeed in real-world problems, practical experiments can raise their self-efficacy and confidence in their biological knowledge Bandura, (1997).

2.1.7 Social Learning Theory

Bandura's Social Learning Theory emphasizes the importance of modelling and observation in the learning process. Students can witness phenomena first-hand and engage with classmates through hands-on activities, which create collaborative learning environments that support the sharing of knowledge and the development of skills Bandura, (1977).

The above-described theoretical framework offers a thorough grasp of the ways in which practical experiments might influence biology teaching for students at the average level. Teachers can create efficient teaching

strategies that use practical experiences to improve student learningoutcomes by referencing constructivism, experiential learning, cognitive load, self-efficacy, and social learning theories.

2.2 Conceptual Framework

2.2.1 Biology as a Branch of Science

According to its definition, science is the study of natural phenomena. Additionally, science is an impartial, logical, and repeatable endeavor to comprehend the principles and forces at work in the natural world. Since the word "scientia" comes from the Latin for "know," science is not dogmatic and should instead be seen as a continuous process of testing and assessment. Adeyemi (2018) states that the three main fields of science taught in secondary schools are physics, chemistry, and biology. These topics are required for graduation from secondary school. Students who enroll in biology courses are expected to gain a better understanding of the scientific method. According to According to Nworgu (2015), science has a dual nature, meaning that the body of knowledge it comprises may be defined in terms of both its techniques and processes as well as its products. Science is a study and comprehension of observation, hypothesis, experimentation, data analysis, inference, and conclusions. Together, these comprise the scientific method. Nworgu (2015) described science as an organized body of knowledge obtained via research and experimentation, taking into account the dual character of science. Because of this, science is perceived in terms of both "processes" and "products."

The nature of science, according to Okeke (2007), is that it uses objective, repeatable investigation techniques to look for explanations. The entire process necessitates honesty, diligence, patience, and effort, all of which must produce results that are genuine. In our society, superstition is very common. This runs counter to science education, which encourages people to look for explanations based on rational, impartial, and verifiable scientific theories and principles. The reality is that explanations based on superstition and supernatural abilities are more popular than those based on

science since they are derived from cultural beliefs and do not need people to reason intellectually. Science is thus at a disadvantage when it comes to advancing utilitarian ideas.

Ukoli (2013) states that the scientific knowledge that a person gains via science education should do the following, among other things.

• A growing number of people are becoming more sceptical of conventional wisdom, leading to the methodical and critical examination of topics that were formerly accepted without doubt.

• Remove superstition from people's thoughts.

These perspectives on the intellectual benefits of science align with those of the national associations of teachers in Zimbabwe. One of the main objectives of science education is to create scientifically literate individuals who possess the knowledge, morals, and investigative abilities needed to advance the advancement of man as a rational human being.

This is only one amazing benefit of science education done right. Speaking about the nature of science, Osogbonye (2012) said that acquiring a greater body of knowledge does not automatically qualify one as a scientist; instead, children should be taught the scientific methods and mindset that are needed to find scientific information. According to Osobeonye (2012), this will provide the kids with the necessary skills to solve difficulties they may encounter in the future.

Nonetheless, science is by its very nature a tentative, dynamic, and objective activity, which has significant ramifications for scientific education. It denotes a shift from instructing students on science to instructing them via science. The Nigerian government has recognized and acknowledged this change in teaching methodology Nwosu, (1999).

The Federal Republic of Nigeria, FRN (2013) policy paper states that the teaching and understanding of scientific principles and processes should be the main focus of science education. This kind of instruction places more of

an emphasis on skill development than on rote memory and fact recitation, which encourages students to perform science rather than just memorize it.

According to Abugu (2015), science education is any methodical training and teaching that, when finished, enables students to accomplish a variety of skills, including the capacity to operate scientific equipment, evaluate data, and create tables, graphs, and charts that are appropriate for a given situation. Together with the capacity to exhibit problem-solving abilities such as observing, testing, drawing conclusions, characterizing issues, formulating hypotheses, conducting research, delineating scientific methods to test hypotheses, manipulating and controlling variables, creating models, drawing reliable conclusions, forecasting, etc.

According to Adey and Harlen (2011), all of these demonstrate the importance of science process skills and support the adoption of a process approach rather than a content approach when teaching science.

2.2.2 Biology Teaching and Learning

Biology has a special place in the curriculum of educational institutions. Numerous science-related courses, including those in biochemistry, medicine, pharmacy, agriculture, nursing, and other fields, heavily rely on biology. It is evident that no student planning to major in these fields could study biology without it.

Biology, according to the Longman Dictionary of Contemporary English (2018), is the scientific study of living organisms. The study of life and living things, including their structure, function, growth, origin, evolution, distribution, and classification, is the focus of biology, another natural science.

As previously mentioned, Odigie (2011) clarified that biology is a required subject for numerous academic disciplines that significantly advance the country's technological advancement. This covers fields including biotechnology, forestry, and medicine.
According to Onwuka (2012), teaching is the process of guiding students' activities toward worthwhile educational objectives. Ngwoke (2010) provided a broad definition of learning as a process that results in a change in an individual's behavior.

Experience or interactions between the person and his surroundings lead to this behavioral shift. Additionally, he pointed out that learning is an activity that students undertake on their own, not something that teachers do for them. Students learn meaningfully when they can connect what they've learned to real-world situations.

Despite the relevance and appeal of biology to Nigerian pupils, senior secondary school performance had been subpar Ahmed (2018). According to Kareem (2013), overcrowding in classrooms, inadequate science equipment, and incompetent science professors are the main reasons why science students do poorly. When it comes to teaching and studying biology, the technique of instruction is crucial. Regarding this, Ajaja (2015) stated that, regrettably, the laboratory is underutilized and teachers control the majority of the instructional process. In his inquiry into the "evaluation of science teaching in secondary school in Delta State," he made notice of this. The ineffectiveness of biology education and learning is a result of all of these things and many more. Nworgu (2015) listed the characteristics of an effective biology class, emphasizing the following. There should be a clear set of learning objectives for biology classes, that involves utilizing pertinent, action-oriented and aids in the dissemination of information to a larger segment of society.

2.3 Biology Hands-on experiments

Biology practical activities, according to Opuh, Eze, and Ezemagu (2018), is the scientific study of the life and structure of plants and animals as well as their relevant environments in actual or experimental setups, as opposed to focusing on theory and concepts. According to UNESCO (2015), children are more likely to learn about the nature of science through making observations and creating and carrying out their own experiments. Similarly, Onah (2013) thought that if experimental science's advancements have shown anything, it is that real knowledge and insightful comprehension are the best. This is the lesson that all educators need to learn from the laboratory. Emmanuel and Eze (2007) referenced a Chinese saying that goes, "We hear, we forget; what we see, we remember, but that which we participate in, we understand." They went on to explain that students must participate in hands-on activities during biology lessons, and it is via these practical experiences that they learn. According to Lunette (2018), scientific educators have indicated that there are numerous advantages

to learning through laboratory activities, and the laboratory has been assigned a central, distinct position in science education.

UNESCO (2015) reported that carrying out set experiments and creating models to comprehend other practical tasks offer opportunities for developing many of the essential learning, such as realizing and appreciating the need to adapt to a new audience, learning new information from the work done so far that can be applied to creating new scenarios, imparting knowledge and comprehending new situations, helping to establish a culture of learning in a community, and functioning well as a team member to accomplish individual and shared goals, among other things. The aforementioned illustrates how widely acknowledged practical lessons are as essential to the effective teaching and learning of biology. According to Emmanuel and Eze (2007), who cited the Nigeria Council on Science Education's annual report on secondary schools' science instruction, many schools teach science subjects—including biology—without requiring students to complete any laboratory work.

According to Udeh's (2014) research, a deficiency in laboratory equipment and a lack of time for biology practicals are two issues that hinder the successful teaching of biology with practical activities in secondary schools in Enugu East L.G.A. of Enugu state. In a similar vein, Eze and Ezemagu (2018) concurred that learning science, especially biology, requires doing experiments with instruments in a lab rather than reading a book. According to Emmanuel and Eze (2007), biology must be studied with the assistance of laboratory classes due to its highly empirical nature. According to Okoye (2014), laboratory exercises ought to use an investigative approach in order to give students the chance to learn process skills. He firmly believes that laboratory work helps students develop the fundamental abilities necessary to manage laboratory operations by requiring them to conduct rigorous research or inquiry. However, Lunette (2018) departed from the original path, stating that the argument for laboratory teaching is no longer as strong as it had appeared and that some educators are now beginning to doubt the value and efficacy of laboratory work.

However, Nnamonu (2013) and other proponents of practical biology activities have proposed that the most advantageous way to teach biology is to make efficient use of a well-maintained biology laboratory.

It is evident from the foregoing that practical biology is extremely important to biology education. Since laboratory (practical) activities are the lifeblood of biology and without which it loses its scientific nature, the value of practical biology classes can never be overstated.

2.4 The impact of biology practical on students' academic performance

According to Hofstein and Lunetta (2014), a laboratory is a suitable learning setting that fosters meaningful learning and improves students' comprehension of scientific concepts and the nature of science. In a laboratory, students engage with materials and/or models to observe and comprehend the natural world.

A laboratory is a space or facility used for scientific experimentation and study, according to Nworgu (2015). She continued by saying that the center of science activity is the laboratory. She continued by saying that laboratory exercises must be included in biology classes in order for them to be meaningful. The location of laboratory operations was summed up by Akpan (2012) as follows: "In the laboratory, people carry out measurements, verify situations, obtain basic information, manipulate instruments, and become familiar with the names of the equipment and materials."

In the laboratory, people carry out measurement, verify situations, obtain basic information, manipulate instruments, get to know the equipment and materials by name and are exposed to the activities of scientists and are trailed in experimental procedures, according to Akpan (2012), who summarized the role of laboratory activities. People learn to understand the fundamental concepts and abstractions involved in the process in the laboratory, which helps them comprehend the material provided in textbooks or lecture lectures. The learner is the ultimate goal of all instruction. If students are not participating in the laboratory activities, the significance of the lab is not genuine. Regretfully, rather than using hands-on methods, the majority of laboratory examinations are conducted using objective items and paper and pencil equipment, Hofstein and Lunetta, (2014).

Tobin (2011) proposed that students can engage in meaningful learning in the laboratory by being given the chance to work with materials and equipment in a setting that allows them to build their understanding of scientific concepts and phenomena.

As was said previously in this book, not all schools use the laboratory to its full potential while teaching biology. Parents and teachers start to expect their children to perform like magicians and ace the Senior Secondary School Examinations because they only schedule practical for the pupils right before the one short-end-of-course examination (SSCE). Ahmed (2018) has discovered that inadequately equipped biology laboratories contribute to the low performance of biology students in the SSCE.

It's not intended to be that way; in order for students to gain the necessary abilities, the laboratory must be furnished and they must frequently visit it to conduct experiments. A crucial part of the educational system for scientific students, according to Lunetta (2007), is played by science laboratories. Once again, he pointed out how these labs had progressed civilization and made it more scientific.

According to Osogbonye (2012), current improvements to science curricula appear to support the idea that the laboratory's primary roles are to help students understand the process and spirit of scientific inquiry and to give them the chance to do independent research. According to Osogbonye (2012), scientific laboratories are the ideal settings for teaching students how to perform tasks carried out by scientists.

According to Osogbonye (2012), the laboratory is the ideal setting for teaching students how to replicate the actions of scientists, i.e., applying scientific methods and mindsets to the process of conducting research in order to gain information. These scientific abilities and mindsets that will help children become independent in the future are put into practice in the lab. As a result, according to Osogbonye (2012), the purpose of laboratory instruction in contemporary science courses "focuses upon the inquiry/discovery process or methodological phase of science and upon its intellectual components." In addition, laboratories are crucial for teaching science-related courses, as their effectiveness greatly depends on the resources provided. Students rely on the laboratory, according to Osogbonye (2012), as a place where they may both observe the lecturers demonstrate and complete practical work themselves. Science subjects like biology generally include experimentation.

Higher quality laboratory programs, in the opinion of Osogbonye (2012), can inspire students' critical thinking abilities and motivation in order to generate a cohort of scientists, engineers, biologists, and citizens who are ready to tackle the environmental

and scientific issues of the twenty-first century. Dienye and Gbananje (2011) reported, based on the aforementioned, that the functions and merits of the laboratory are grouped into five main categories that represent important goals in biology education and also show how laboratory-based biology education is appropriate given the advancements in science and technology.

2.5 Advantages and disadvantages of hands-on experiments.

2.5.1 Advantages

With this approach, the student gains an awareness of the nature of science and technology, which helps to develop their comprehension of human endeavors in science and, in turn, improves their aesthetic and intellectual development.

Developing problem-solving abilities: The primary objective of science the goal of teaching is to impart abilities that students can use in many situations throughout their lives. By developing their manipulating skills, students learn to respect and model the job of scientists. Develop your values, attitudes, and interests: Students' interest in science grows as they want to learn more about their surroundings and are given the opportunity to gain first-hand experience with genuine objects.

Additionally, they study the main ideas, hypotheses, models, and principles of science and comprehend that they are all speculative. Students have the opportunity to learn about the facts pertaining to scientific phenomena through their laboratory experience.

2.5.2 Disadvantages

The following are the two main problems with using the laboratory:

- The planning and preparations take a lot of time.
- It's expensive because of the materials and equipment needed.

2.6 The contributions of Biology practical to effective teaching

It is accepted that many teachers have long since implemented the necessary learning into their lessons in an instinctive way (UNESCO, 2015). They understood the importance of knowledge and skills in a given field. Opportunities in the classroom or provided by the individual are acknowledged and taken advantage of. Based on the available literature, the researchers found that there are several factors that contribute to

good biology instruction, including topic knowledge, laboratory proficiency, and teacher qualification. According to the Science Teachers Conference report on Udeh (2014), "Nigerian teachers must be well-trained for their job if they are to be able to cope with the tasks assigned to them." The national conference argued that having highly qualified, trained, effective, content, and educated teachers is vital if we are to meet the country's educational goals. According to Opuh, Eze, and Ezemagu (2018), it is difficult to imagine biology being taught effectively in the workforce without educated teachers. Eze (2012) expressed regret over the dearth of skilled educators in secondary education, particularly in the practical subject areas. It is commonly asserted that educators serve as the central figure in every educational system since schools are only as good as their teachers. This implies that kids will receive higher-quality instruction or greater information from highly competent teachers. Orjika (2014) According to Ajaelu in Opuh (2018), education experts have stated that biology teachers are not remarkable and that science teachers should have a strong professional background.

Many experts believe that a major factor in the success of biology education is the type of instruction used in science classes. According to Nnamonuh (2013), the laboratory technique is the most effective way to teach and understand science courses, particularly biology. It includes tasks completed by an individual or a group with the intention of learning. In a previous opinion, Okoye (2014) suggested looking into the laboratory method of instruction as a way to give students the chance to learn process skills through this kind of work. According to Meregini (2015), recent research on classroom observations revealed that teachers' instructional strategies and materials did not align with the scientific curriculum's implied approach. As a result, Nnamonu (2013) claimed that field and laboratory activity are essential to teaching science. The laboratory technique is essential to the effectiveness of science instruction. Work in the lab should be viewed as a way to connect scientific concepts, the inquiry process, data observation, and data interpretation.

According to Fafunwa and Ugwu (2015), the majority of educators still cling to the notion that the greatest learning occurs via intentional practical action, even when they are uncomfortable with the way lectures are delivered. According to Ugwu (2015), educators should employ as many strategies as they can to capture students' interest and attention. Any motivational strategy should be used by the teacher to lift the pupils'

spirits. Biology education must use the laboratory method. Nnamonu (2013) said that in order to prevent biology from becoming primarily a memorization exercise, educators should focus primarily on the laboratory technique. He also noticed that schools with well-functioning labs outperformed others in terms of science performance. In his own work, Okri was cited by Uche (2014) in the following way: the methods used to influence students' perceptions of the material may have an impact on their development of positive or negative ideas about biology.

The ability to teach biology effectively is also influenced by subject matter expertise. According to Ugwu (2015), teachers who exhibit a depth of knowledge about the material they are teaching will instill confidence in their students. Effective teaching and learning are also influenced by the subject-matter expertise of the teachers, according to Okoye (2015). A highly knowledgeable instructor explains concepts to his students in his own language and backs them up with real-world examples. According to Killdara (2007), in order for teaching to be effective, the instructor must possess extensive subject-matter expertise and make appropriate use of specialized terminology throughout the course. Similarly, strong subject-matter expertise is a hallmark of a bad instructor, according to Opuh, Eze, and Ezemagu (2018). The instructor must be an expert on the subject. According to Eze (2015), certain inexperienced educators misuse instructional techniques. Keldare (2007) went on to emphasize that new material should be connected to prior knowledge in order to maintain continuity from earlier lessons. Considering the aforementioned, Ude (2014) suggested that the essential laboratory be used as the teaching space for biology. Every biology instructor must become certified in a teaching strategy that will enable his pupils to meet their learning goals. In conclusion, educators have an impact on societal change. If educators are themselves well-educated, capable, diligent, and disciplined, these changes may be felt. Biology instruction can be successful when the intended and desirable changes in the students' learning have been observed. The quality of the teacher has an impact on how well students learn and are taught.

2.7 The impact of hands-on experiments on students understanding

As was previously established, good teaching being a prerequisite for effective learning. This work has also highlighted the need of biology practical in the effective teaching of biology. Therefore, it also makes sense to say that biology practical aid in the efficient

learning of biology. Kuren, Zonntja, Navelle, and Jeanne (2015) state that a large number of students indicated how much they enjoyed doing practical exercises. It's common knowledge that kids who enjoy scientific classes perform well in science classes. Ude (2014) acknowledged that practical biology instruction and successful biology learning are positively correlated. She used the ministry of education's statement, which supports her proposal, to argue that as biology is a science subject, efforts should be made to maintain appropriate, extensive science equipment in addition to appropriate teaching methods. The researchers thought that a student's mindset and level of interest in hands-on learning greatly influenced how well they learned biology. The opinions of Karental, Ime, Smi, and Henry (2015) are comparable. They felt that enhancing student-based courses was important. According to Karase, Hartley, James, and Mclus (2015), it's crucial to address these difficulties (students' interest in and attitudes toward practical work). Additionally, they believed that hands-on laboratory experience is a highly significant aspect in the effective learning of science in general and biology in particular. According to Nnamonu (2013), students' attitudes toward lab work contribute to more effective science teaching and learning as well as improved academic achievement. As a result, Cosbourne, Simon, and Collins (2013) concurred that, provided it is available, the laboratory and practical experience ought to have a significant impact on students' attitudes and academic performance. In actuality, it can characterize how well pupils achieve in science. According to Hofstein and Lunette (2013), one important factor that keeps learning in the lab from increasing is the recipe-book style, which restricts students' chances to take charge of their education, be creative, and build effective learning strategies.

According to Uzel, who was mentioned by Eze (2013) and Orjika (2007), students' motivation is positively impacted by practical agriculture, which is similar to biology. Additionally, he argued that practice improves both the development of new skills and the standard of instruction since each student can contribute their own understanding through discussion of their completed work. According to Somi and Henry (2013), giving students a positive laboratory experience raised mean grades and improved attention, enjoyment, and learning awareness. In his research, Anichebe (2007) highlighted that in order for children to receive an education, teachers need to know how each student learns best and how to impart skills and knowledge to them.

Lastly, biology lab experiences are distinct in that they give students a hands-on opportunity to learn about the subject. It undoubtedly gives pupils the chance to become more involved in the learning process and enhances their academic achievement.

2.8 The contribution of Biology practical to students critical thinking

Students are more likely to interact with assignments meaningfully and receive higher evaluation grades when given academically stimulating practical laboratory courses (Karen et al 2015). However, the ZIMSEC Chief Examiner (2013) had noted before that the student's academic performance in biology was below average. "Many candidates could not answer correctly a single question in the biology practical," the head examiner bemoaned. "Most of the time, they have wild guesses and guess unrelated answers that were sometimes unbiological." Additionally, the applicants performed poorly in the experimental processes. Students who shun practical labor frequently run into issues with difficulties involving mathematical concepts, logical reasoning, accurate observation, and data interpretation.

Furthermore, Sandbarey, Armstrong, and Wischusen (2015) clarified that inquiry-based practicals give students a more realistic experience since they require them to generate their own ideas based on their own observations and do not necessarily have the answer predefined. According to Allan, Rob, and Jonathan (2013), students who shun practical classes are constantly afraid of the graph figures in exams, which prevents them from understanding the numbers for accurate interpretations. Adeleye was used by Eze and Ezemagu (2018) to observe that schools that participate in practical classes outperform those that ignore them in the SSCE.

According to Sandberg (2015), teachers were first hesitant to alter their biology teaching methods, but with positive outcomes (better academic achievement) and assistance from national scientific and educational organizations, progress has been made (Myer and Burgess 2013). Based on the aforementioned information, it is definitively clear that biology practicals improve students' academic achievement on biology exams.

2.9 Challenges Associated with Conduct of Biology Practical

2.9.1 Inadequate Laboratory Facilities.

One issue with biology education and learning in secondary schools has been the lack of suitable laboratory space. According to Ani and Eze (2007), students learn best through hands-on experience. When students conduct experiments during a practical to get the right answer, they not only remember the steps involved but also feel accomplished for getting the right answer. Because it is a proven truth that students do better when they participate in the activities, it is imperative that the laboratory be well prepared for the study of biology. Additionally, students should be permitted to utilize the equipment in the laboratory.

According to Lunette (2018), the lab supports students' ability to make precise observations, formulate hypotheses, determine the causes of the outcomes, organize control, and refrain from passing judgment.

2.9.2 Time management.

This has an adverse effect on students, since many applicants have examination fever due to anxiety and stress. Some students prioritize reading and formulating their responses to a given question over those of other pupils. In an attempt to impress their examiner, students tend to rush through some questions and become verbose, providing extra details in some of their responses. According to Tan (2018), students ought to be aware that issues pertaining to practical biology typically necessitate clear, concise responses.

2.9.3 Comparing and Contrasting Specimen.

A crucial issue with biological approaches in science studies is comparing and contrasting the qualities of different specimens. Pupils typically do badly on these assignments because they lack the necessary technical knowledge or skills. Using tabulation is the most straightforward and trustworthy way to compare. Finding and expressing the similarities and differences between one specimen and the other is the process of comparing or contrasting a specimen's traits with those of another specimen.

2.9.4 Drawing and Labelling.

In practical classes, biologists place great emphasis on creating diagrams that accurately name the specimens being studied. According to Tan (2018), biological diagrams differ

from fine art diagrams, which call for colorful, beautiful diagrams from artists. The following factors are taken into account while drawing and labeling biological specimens: size, proportionality, title, and view or viewpoint.

2.9.5 Observation.

A crucial component of practical biology is observation. It is impossible to overstate the value of closely observing the specimen during a practical biology examination. It is expected of candidates to examine the specimen closely and critically, as this is necessary for accurate specimen identification, complete drawing representation, and realistic comparative analysis.

Various explanations have been offered for the issues surrounding laboratory work (Tan 2018). Benze and Hodan (2015) claim that when students only obey their lecturers' instructions without question, issues with laboratory work occur. On the other hand, some academics assert that the laboratory has evolved from a location for science experiments and practical to one where students' complete assignments assigned by their teachers. During laboratory work, just the assigned tasks are completed; technique or purpose are ignored, Hurtegal (2012). The issue with laboratory work has been linked by Jimenz Alexander (2014), Wikinson and Wand (2007) to an inadequate assessment of the goals of the tasks performed in the laboratory.

2.10 Related Empirical Studies

In Enugu State secondary schools, Henry (2018) conducted research on the impact of biology practical on students' academic achievement in the subject (a case study of Nsukka Local Government Area). The practical work done in biology in secondary schools was the focus of this study. It looked studied whether or whether students' interaction with and presentation of real-world experiences improved their ability to meet the objectives of their practical work. The methods used to carry out biology practical work were very important, and in particular, the skills that were stressed during these sessions' practical work. The survey also looked at how instructors and students felt about doing biology practical work. All of these actions are taken with the intention of identifying the issues and providing suggestions that could direct practice and effectively teach and learn practical work in biology, both in specific and generally. A descriptive survey research design was used in the study. All 47 public secondary

schools in the local government made up the study's population, from which nine sample schools were chosen by a combination of stratified, purposive, and systematic selection techniques. There were 29 biology teachers and 309 biology students involved, with 170 boys and 139 girls in each group. The study's primary conclusion showed that students were engaged in a range of practical biology activities and that scientific labs in secondary schools in the Nsukka local government region were reasonably equipped with better tools, chemicals, and materials. However, it was discovered that pupils lacked fundamental scientific abilities like designing experiments and formulating hypotheses. According to the report, NECO should evaluate students on a wide range of abilities in the biology exam, even the most basic elements of experimental design.

Additionally, Nwagbo, Chukelu, and Uzomaka (2015) looked into how biology practical activities affected secondary school students' learning of process skills in the Abuja Municipal Area Council. The study's non-equivalent control group pre- and post-test design was quasi-experimental in nature. For the study, samples of eleven2 senior secondary one (SS1) biology students were chosen at random from two coeducational schools. Data was gathered using a tool called the Science Process Skills Acquisition Test (SPSAT). At the 0.05 level of significance, the obtained data were analyzed using the mean, standard deviation, and Analyses of Covariance (ANCOVA). The findings showed that the practical activity approach was superior to the lecture mode of instruction in promoting students' learning of science process abilities. When it came to students' learning of process skills, there was no interaction between gender and approach.

In Zimbabwean context, biology education holds a crucial position in secondary schools as it serves as the foundation for students' comprehension of living organisms and their interactions with the environment, Tugwi, (2022). Science, technology, engineering, and mathematics (STEM) education, implemented by the Ministry of Primary and Secondary Education in 2016, places significant emphasis on science subjects, including biology, as it fosters the development, preservation, and dissemination of knowledge and skills that yield personal, economic, and social benefits. Research conducted by Svodziwa (2021) highlights that STEM education produces competent graduates who drive the Zimbabwean industrialization agenda, create employment opportunities, and contribute to the country's modernization.

The remarkable achievements of biological science underscore the onset of a new era - the century of biology. Present-day biology not only serves as a discipline of study but also directly influences the living world, Svodziwa, (2021). The growing trends in designing and constructing bio-objects, as well as the management of living organisms and systems, have become evident. With the advancements in biology and the integration of its accomplishments into human society, an increasing number of individuals will require biological education as part of their professional training. In the contemporary era of flourishing biological science, particularly in genetics, microbiology, biopsychology, bio-cybernetics, and bionics, where the creation of new types of organisms and control over human nervous activity are within reach, the state educational standard incorporates biology training programs that aim for a deeper and modern understanding of genetic branches, broader application of biological knowledge to environmental issues, and the utilization of information elements in biological processes.

The teaching of biology plays a crucial role in fostering students' dialectic thinking by providing them with a deep understanding of the scientific principles governing the organic world. Through the study of biology, students are exposed to the intricate mechanisms that govern life forms, from the smallest cells to complex ecosystems. This exposure not only enhances their knowledge of biological processes but also cultivates critical thinking skills essential for analysing and interpreting scientific information, Holstermann, Grube and Bögeholz, (2019). Furthermore, the study of biology offers students insights into the historical context of life on Earth. By exploring the evolutionary history of organisms and understanding how life has evolved over millions of years, students gain a broader perspective on the interconnectedness of all living things. This historical perspective helps students appreciate the diversity of life forms and the dynamic nature of biological systems (Ibid). Biology stands as one of the primary subjects in the natural science curriculum, playing a pivotal role in the formation and development of individuals. It is instrumental in ensuring a healthy lifestyle and the preservation of the environment - the habitat of all mankind. However, teaching biology can be challenging, particularly when dealing with complex and abstract concepts that are difficult to visualize. One proposed approach to enhance students' comprehension of biology is the use of hands-on experiments which shall be explained in greater detail in the paragraph to follow.

Hands-on experiments involve students actively participating in the learning process by manipulating materials and equipment to observe and explain phenomena (Svodziwa, 2021). These experiments provide students with opportunities to apply their knowledge and skills, foster critical thinking and problem-solving abilities, and deepen their understanding of scientific concepts. Engaging in hands-on activities within biology classes, field or laboratory settings, is widely recommended by educational authorities like the National Association of Biology Teachers, Holstermann et al., (2019). Experts believe that involving students in a holistic learning experience, where they learn by doing, significantly enhances their critical thinking skills, Man, (2015). It encourages them to rely on evidence from observed data, promotes independent thinking, and reduces their reliance on authority. Numerous studies also indicate that hands-on experiments increase students' motivation to learn and enhance their perception, creativity, and logical reasoning. Consequently, students are not only able to apply what they have learned in the classroom to their everyday lives but can also utilize their comprehensive learning experiences in various real-life situations, Shana and Abulibdeh, (2020). The focus of this study is to assess the role of hands-on experiments in teaching biology to ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province. This school, situated in a rural setting, serves students from disadvantaged backgrounds, highlighting the importance of providing them with practical and engaging learning experiences

2.11 Chapter Summary

Science was defined in this study as a method of learning about natural events. Additionally, as a methodical, rational, and objective effort to comprehend the principles and forces at work in the natural cosmos. The word "Scientia" in Latin means "to know." Good science should be seen as a continuous process of testing and assessment rather than becoming dogmatic. However, biology was regarded as the scientific study of living organisms. The study of life and living things, including their structure, function, growth, origin, evolution, distribution, and classification, is the focus of biology, another natural science. As previously mentioned, Odigie (2011) clarified that biology is a required subject for numerous academic disciplines that significantly advance the country's technological advancement. This covers a variety of fields that were also covered in-depth under the conceptual framework, such as biotechnology, forestry, and

medicine. Von Bertalnffy's (2018) General System Theory served as the foundation for the theoretical framework. According to the notion, everything including people is a system of some kind, and all systems have goals and purposes. To accomplish the system's objectives, each component must cooperate with the others and the surrounding environment. This chapter meticulously reviewed and acknowledged empirical studies.

CHAPTER III

RESEARCH METHODOLOGY

3.0 Introduction

This section outlined the research methodology that was used in this study. It extricated the significance of qualitative methods and procedures that were used in this study. According to Ritchie (2003) the development of qualitative research is strongly influenced by ideas about the importance of understanding human behaviors in their social and material contexts; and meanings that people attach to their own experiences. Thus, 'Interpretivism'; which is integral to the qualitative research tradition, is seen to overcome some of the perceived limitations associated with 'positivism', the tradition most commonly associated with statistical social enquiry (Ritchie, ibid). As such, this study sought to investigate the impact of hands-on experiments on biology education in schools using face to face interviews, focus group discussion, and observation to solicit data based on their lived experiences. The study drew lessons from different theories underpinning biology as a science, used in the developed and developing countries. It's worth mentioning that the idea of interpretative research corresponds with how designers undertake research to learn and understand behavior, and analyze culture to acquire empathy for consumers. Research design, like other types of research, tries to analyze findings in order to produce theories about the problem's nature and potential solutions.

3.1 Research Design

Research design refers to the overall strategy and plan for conducting a research study, including the methods and procedures used to collect and analyze data. According to

Creswell (2014), A research design is a plan for collecting and analyzing data to answer research questions or test hypotheses. Dawson (2012) mentioned that a research design may include observational research, case studies and surveys. This study being mixed, thus qualitatively and quantitatively informed; adopted the phenomenological research design which in general terms means describing for several individuals, the meaning and calculation of their lived experiences of a concept or phenomenon in gathering data. Ritchie, (2003). According to Denzin and Lincoln (2005), qualitative research consists of a set of interpretive material practices that make the world visible and study things in their natural settings attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. Creswell (2014) defines quantitative research as an approach for testing objective theories by examining the relationship among variables. These variables in turn can be measured typically on instruments, so that numbered data can be analyzed using statistical procedures

Adding on, this design describes what all participants have in common as they experience the practicality of an experiment, but in this case it will be looking at Investigating the Impact of Hands-On Experiments on Biology Education. Phenomenology is not only a description, but it is also seen as an interpretive process in which the researcher makes an interpretation (i.e., the researcher "mediates" between different meanings of the meaning of the hands-on experiments, van Manen, (1990). In this regard, the phenomenological paradigm reduces individual experiences to a description of universal experience like in this case, the Impact of Hands-On Experiments on Biology Education. The researcher is therefore able to collect data from people who have experienced a common phenomenon in order to develop a generalized description of how they experienced this phenomenon. Morrison (2005) argues that through in-depth investigation of complex phenomena, qualitative research offers valuable insights into the underlying causes, motives, and behaviors of individuals or groups. Conversely, quantitative research facilitates the quantification of correlations between variables and the extrapolation of findings to a broader population. Researchers can have a thorough grasp of the study subject from several angles by integrating the two methodologies. Hence, Douglas and Moustakas (1984) posited that integrating qualitative and quantitative research designs has several advantages, one of which is triangulation, which is the use of several approaches to investigate the same topic. While quantitative data can confirm conclusions drawn from qualitative investigation,

qualitative data can assist in understanding the outcomes of quantitative analysis. This cross-validation increases the reliability and trustworthiness of the research findings.

This design begins by acknowledging that there is a gap in our understanding and that clarification or illumination will be of benefit. This therefore justifies the main scope of this study of Investigating the Impact of Hands-On Experiments on Biology Education. To sum up, there are several advantages to using both qualitative and quantitative research approaches in a study, including thorough comprehension, validation through triangulation, improved research validity, complementary data collecting, and deeper insights for decision-making.

3.2 Population of the study

In any research, there is need to identify a population and has to be geographically clustered. This means that group composition based on commonality between people in their relationship to the research topic or in the social-demographic characteristics which are most relevant to it are central, (Ritchie, 2003:56). Certainly, significant difference in status between participants in the same group should be avoided. This is why, Frankel and Wallen, (1996) define a population as the entire group of persons having the same characteristics that are of interest to the researcher. Henceforth, a population has fundamental characteristics which are of significance in ascertaining a sample. As such, this brings in the solid ground where a sample can be withdrawn. It is from this understanding that; this research targets only a population of participants who happen to be ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province. This research sought to target only form three and four students of Mutsonzowa Secondary School. Thus, this selection sought to cater for the differences in experiences these categories of people had in their view of the Impact of Hands-On Experiments on Biology Education.

3.3 Sample Size

The researcher took a sample from Form three and four students, who represented the target population. A sample size of thirty-four form four students and thirty-six form three students was used. The researcher regards this sample size to be convenient in terms of time and cost limitations. A sample is defined by McLeod (2014) as a group of

people who take part in an investigation. The individuals who participate in the research are referred to as respondents or participants. A sample is intended to represent the population under study. According to Tull and Hawkins (1993), a sample may not give a true picture of the entire population because it is only a representative of the total population. However, sampling was used because it was impractical to treat the whole population in this research study. Sampling enabled the researcher to collect data more quickly and to analyze it faster than when the whole population is involved. Use of the entire population has challenges related to accessibility of the whole population, time and financial constraints as well as the amount of data that needs to be handled and analyzed.

3.4 Sampling Procedure and Technique

According to Foley (2018), a sampling technique refers to the way the sample units are to be selected. In this study, the researcher used both probability and non-probability sampling techniques for the two groups of respondents in the study. For form three students, stratified random sampling was used, where the population was divided into two relevant strata or groups, namely those aged fifteen, and those aged sixteen. A total of 36 form three students, that is, 18 from each stratum were then selected randomly. This technique ensured that specific groups of the population were represented, free of bias, in the sample. The cost of implementing the procedure was also minimal. Saunders, Lewis and Thornhill (2009) contend that, with probability sampling, the chance of each case being selected from the population is known and is usually equal for all cases.

A further thirty-four form four students were selected using purposive sampling, which is a non-probability sampling technique. Thus, a total of seventy was selected. With purposive sampling, the researcher used judgment, based on the knowledge of the people from whom the required information can be acquired, Lavrakas, (2011). Researcher teaches the respondents and therefore is professionally linked to them. Purposive sampling enabled the researcher to squeeze a lot of information out of the data collected. It is extremely time and cost effective when compared to other sampling methods, Foley, (2018).

3.5 Data Collection Instruments

This section sought to triangulate a myriad of qualitative instruments such as focus group discussion, interviews and observations to minimize error or biases of data collection and analysis that may accrue as a result of over relying on one set of research instrument over another. This ensured that evidence from multiple tool sources could be cross-checked and searched for consistencies, regularities and irregularities, Creswell, (2017).

3.5.1 Questionnaires

The study made use of questionnaires to obtain primary data from students The survey questions on the research instrument were both open ended and closed. Some closed-ended questions were designed in the form of Likert-scale options. A questionnaire is an orderly set of questions to a targeted sample of the study population with an aim of getting relevant answers Griffin (2013). Kumar (2012) defined a questionnaire as a research instrument that consists of a set of questions, or other types of prompts, for the purpose of gathering information from respondents through survey or statistical study. A questionnaire may include open ended questions and closed ended questions. This research used both open and close ended questions in order to get views from the respondents and they helped in confirming the research findings in a mixed way. Due care and diligence were considered in the expression and arrangement of the questions so as to create simple, direct and non-biased questions.

3.5.1.1 Close-ended Questions

Spillers (2014) stated that closed ended questions have limited choices of response and were used in this current study because of the limited time which was available. The respondent opinions in this case were expressed without confusions. This system is directly linked to the usage of a Likert scale.

3.5.1.2 Likert Scale

This is a scale is a system which allows respondents to agree or disagree using a numerical scale, Cooper, (2013). According to Erwin (2014) a Likert scale comes in a form of main speeches which are pre-set by the author from which respondents will choose from. A Likert scale includes measures which are five opinions that is strongly agree, agree, neutral, disagree and strongly disagree

Table 3.1: Rating of Likert Scale

Strongly agree	5
Agree	4
Uncertain (Neither agree nor disagree)	3
Disagree	2
Strongly disagree	1

In this research a Likert scale was used to have a direct and dependable evaluation of attitudes from the respondents. Students from Mutsonzowa Secondary School were able to express their beliefs and views by marking in the boxes provided and quantitative data was drawn from the use Likert scale. However, the Likert scale limits choice and type of responses.

3.5.2 Focused Group Discussion

This study sought to employ this data gathering technique that falls under the qualitative research paradigm. As such, Hughes and Dumont (1993:776) characterize focus group discussions as group interviews or in-depth group interviews employing relatively homogeneous groups in terms of experiences or other characteristics to provide information around topics specified by the researchers. The Focused Group Discussion (FGDs) are being increasingly suggested as a good method for understanding cultural variations and differences, Capestake and Morris, (2008). In using this tool, research participants were understood to be active co-researchers or participants rather than passive subjects as informed by the phenomenological design. An important question therefore is how do participants use (FGDs) methodology for their benefit? Capestake and Morris, (2003) posit that, FGDs are not simply a means of eliciting knowledge from participants, but are often reported to be quite creative experiences for the participants themselves. As it has been the norm under this tool that arguments and disagreements may ensue, the researcher acted as the “moderator” or facilitator. Sim (2002; 345) noted that, specific issues that the moderator is expected to deal with include dealing with disagreements and arguments in the groups including all participants, noticing when participants are uncomfortable with a discussion and dealing with this appropriately,

ensuring that essential topics, queries are covered in the time available. According to Shumba and Kaziboni (2005) this method is credited for the advantage that, it saves time, and also the provision of a democratic platform to discuss or engage in debates in a livelier manner. As such, a group of 12 participants was used in the FDG in this study significantly provided a leeway to encroach various themes in the form of debates that might not be captured using other instruments, thus churning out relevant issues more comprehensively.

3.5.3 In-depth face to face Interviews

In general terms, interviews are optimal for collecting data on individuals' personal experiences, histories and perspectives particularly when very sensitive topics are being investigated. The researcher may use these interviews in various ways. The interview may be unstructured and semi-structured, characterized by open-ended questions. The researcher will need an interview guide or set of questions to keep the interview in line with issues understudy (Sim, ibid). Face to face interviews are qualitative tools used to solicit data. As such, they provide an interface between the researcher and respondents, thus allowing a smooth platform of interaction that clearly amounts to convenience in this research. Central to the face to face interviews as tools of soliciting data is the advantage that, they maximize chances of clarifying questions, issues and answers between the interviewer and the research subjects, Dooley, (2005). However, there is need to underscore that, interviews in the qualitative paradigm take the following distinctive forms; key informant interviews and unstructured interviews. In this study, selected students', male and female were interviewed in relation to the problem under study. Secondly, this research utilized unstructured interviews which are obviously recommended for their ability to unravel and explore a phenomenon from the actor's point of view (Dooley, ibid). Hence, interviewing selected students enabled the researcher to have a detailed and meaningful information with regards to the Impact of Hands-On Experiments on Biology Education**.**

3.5.4 Observations

Observations can be defined as an activity by the researcher to understand social events or anything of interest by watching or closely monitoring events as they unfold, Courtney, (2007). This method of enquiry has been supported by phenomenological research design which holds that research is not only a description, but it is also seen as

an interpretive process in which the researcher makes an interpretation (i.e., the researcher "mediates" between different meanings of the meaning of the hands-on experiments, van Manen, (1990: 26). Through observations, the researcher managed to come face to face with the contextual experiences such as failure to complete an assigned experiment by some students. This helped this study to obtain accurate information as there were face to face encounter with some of the experiences they underwent.

3.6 Data Collection Procedures

3.6.1 Permission and Access

The researcher obtained permission from the Ministry of Primary and Secondary Education to conduct the research study. Following permission, the researcher contacted Mutsonzowa Secondary School authorities, briefed them on the research topic, and scheduled interviews, focus group discussions and distributed questionnaires.

3.6.2 Participant Recruitment and Consent

Participants for the study included form three and four students of the school. The researcher sought written consent from each participant before data collection began, ensuring their voluntary participation and confidentiality.

3.6.3 Data Collection Methods

The researcher personally administered the following data collection methods: In-depth interviews, Focus group discussions and Questionnaires.

3.6.4 Data Recording and Management

All data collected during the interviews and focus group discussions were accurately recorded using audio recorders, note-taking. The recorded data was then transcribed verbatim and stored securely to maintain confidentiality and integrity.

3.6.5 Data Quality Control

To ensure data quality, the researcher verified the accuracy of the transcribed data, conducted member checking with participants to validate the data, stored the data in a secure location, accessible only to the researcher

By following these data collection procedures, the researcher ensured the collection of high-quality data that addressed the research questions and objectives while maintaining ethical standards.

3.7 Data Presentation and Analysis Procedures

It is of significance to note that, both the qualitative and quantitative paradigm that pervaded this research required a descriptive analysis of data. As such, a case area of study for this research was used to solicit data from the selected school. This naturally called for this study to employ the thematic analysis for identifying, analyzing and reporting patterns (themes) within data. It minimally organizes and describes your data set in "rich" detail, Bogdan, and Taylor, (2006). It is a qualitative analysis approach which involves searching and reading through data to identify any recurrent patterns. In the same vein, Dooley (2005) notes that presentation and analysis of qualitative data is supposed to be put under a screening process that involves the following; reading through data, tallying of data into relevant themes and drawing up of conclusions which then informs recommendations to be made in a study.

3.8 Ethical considerations

The final aspect of the negotiation of research relationships we need to consider here are ethical arrangements. Ethics are scientific rules that guarantee the safety of both participants and the researcher in a social research process, Kelman, (1982). As such, any research study raises ethical considerations, and those discussed here are pertinent to other forms of research than qualitative research studies alone. However, the in-depth, unstructured nature of qualitative research and the fact that it raises issues that are not always anticipated mean that ethical considerations have a particular resonance in qualitative research studies, Ritchie, (2003:66). Likewise, in any research-based study involved, members' informed consent to participate must be obtained. The researcher provided them with information about the purpose of the study, the funder, who the research team is, how the data will be used, and what participation would require of them - the subjects covered, how much time was required and so on. Also, that on whether participants will be identified or comments attributed to them in any report should be made clear to them at the onset of any research. This was done so that the participants participated voluntarily without coercion. However, a balance in the amount

of detail given needs to be struck (Ritchie, ibid). As such, to ensure that safety prevailed on the part of respondents; this study aimed to use pseudonyms to conceal the identity of the respondents as a way of eliminating harm and other forms of ethical malpractices. The findings of the research will only be used for academic purposes only. This research focusses primarily on human beings (students), it is necessary for the researcher to remain within the confines of acceptable ways of doing things, Amin, (2005). Thus, in conducting the empirical study, the research was conformed to a set of generally accepted research norms and values.

3.9 Validity and Reliability

Validity was referred to as the accuracy and appropriateness of each step of data gathering so as to match the right objectives Kumar (2012). Silva (2013) mentioned that validity is shown when the data truly reflects what is being studied. To validate the research, opinions of experts in the study area was sought for, their ideas and corrections are included in this research. This enabled the research instruments to be thoroughly investigated and modified hence enhancing the overall validity of the study. This research can be said to be correct and valid since research instruments used in data gathering in this research was done before a clear analysis of the main research objectives and main research questions. Reliability is a measure of the degree of consistency with instruments which will be used to measure a certain attribute this is according to Sherman et al (2011). Reliability as mentioned by Silva (2012) will be increased if repeated measurements are taken using different instruments producers. Increasing reliability reduces errors encountered in research finding. More than one data collection instrument and methods were used in this research and this eliminated the weakness which may be created by other instruments. In this research same questions were asked using questionnaires to 40 people and also a number of respondents were interviewed on the same note using same questions to different people.

3.10 Chapter Summary

This section outlined the descriptions of method that were used to carry out the study. The sub sections include research design, target population, sample size, sampling procedures, research instrumentation and ethical considerations have been premised on

exploring their relevance and significance in this study as methodological procedures. The next chapter looks at data presentation and its analysis.

CHAPTER IV

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Introduction

Chapter three considered the research methodology which was adopted by this study. Chapter Four dwells on data presentation, analysis and interpretation. The research presents data using pie charts, graphs and tables. These brought out comparisons and trends which numerical data might not have revealed if data remained in a very raw form.

4.1 Response Rate

Table 4.1 Questionnaire Response Rate

Questionnaires distributed	Questionnaires returned	Response rate
30	30	100 %

The researcher administered 30 questionnaires, of which all questionnaires were returned fully completed. Thus, the response rate was 100%.

As mentioned by Saunders et al (2012) and Bryman (2016) a response rate of 100% is overwhelming, hence it is taken to be acceptable for deeper statistical data analytics. Sekeran and Bougie (2013) echoed the same sentiments by mentioning that for deeper statistics any response rate above 50% is considered to be of great value. The 100% response rate was mainly due to the fact that the researcher personally administered the questionnaires and collected them.

The saturation point was reached when the researcher had interviewed 9 interviewees. The last person to be interviewed did not say anything that had not been mentioned by the first ones to be interviewed.

4.2 Demographic Data

4.2.1 Gender Distribution

Table 4.2: Gender Distribution

	Frequency	Percent	Valid Percent	Cumulative Percent
Boys	32	45.7	45.7	45.7
Girls	38	54.3	54.3	100.0
Total	70	100.0	100.0	

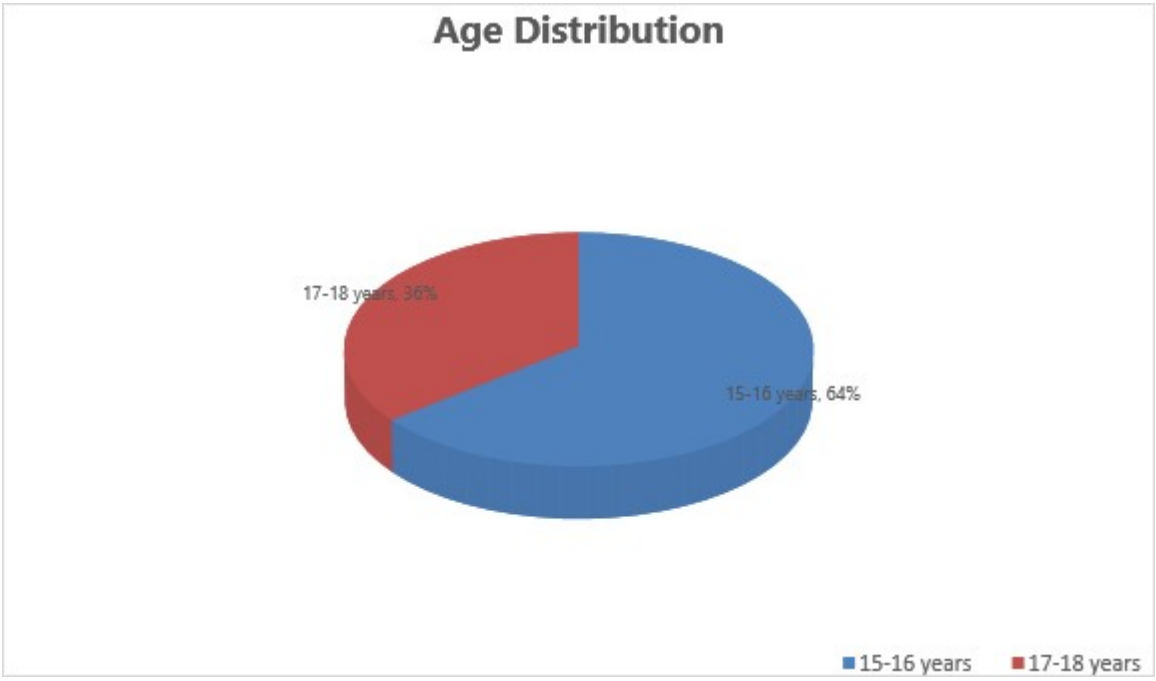
The first element of this research survey question was requesting that the respondents indicate their gender. The results were as indicated in table 4.3 below. As depicted by the table above, there is an indication that 54.3% of members were boys and 45.7% of the respondents were boys. These results are a clear indication that schools in Zimbabwe are no longer viewed as places which are reserved for boys only as was the case two decades ago. This is a big indication that emancipation rates in Zimbabwe is increasing. Hove (2013) argued that there are no more males at gatherings of learning than their female counterparts and this shows a remarkable increase in women empowerment in Zimbabwe.

4.3 Age

Below is a diagrammatic presentation of how the age was distributed among the respondents who participated during this survey.

The pie chart below shows the age distribution of respondents.

Figure 4.1: Age Distribution



The large number of those who participated in the survey was in the range of 15 to 16 years which had 64% followed by 17-18 years with 36%. This research shows how the school is accepting the younger generation and how in Zimbabwe it is not easy for the older generation to stay in school especially the 17 - 18 years and above age range.

4.4 Current Grade Level

In a bid to understand background of the respondents, the respondents were tasked to mention their current grade by indicating their levels. The current grade levels of the study participants are depicted in figure 4.2 below

Figure 4.2: Current Grade Level

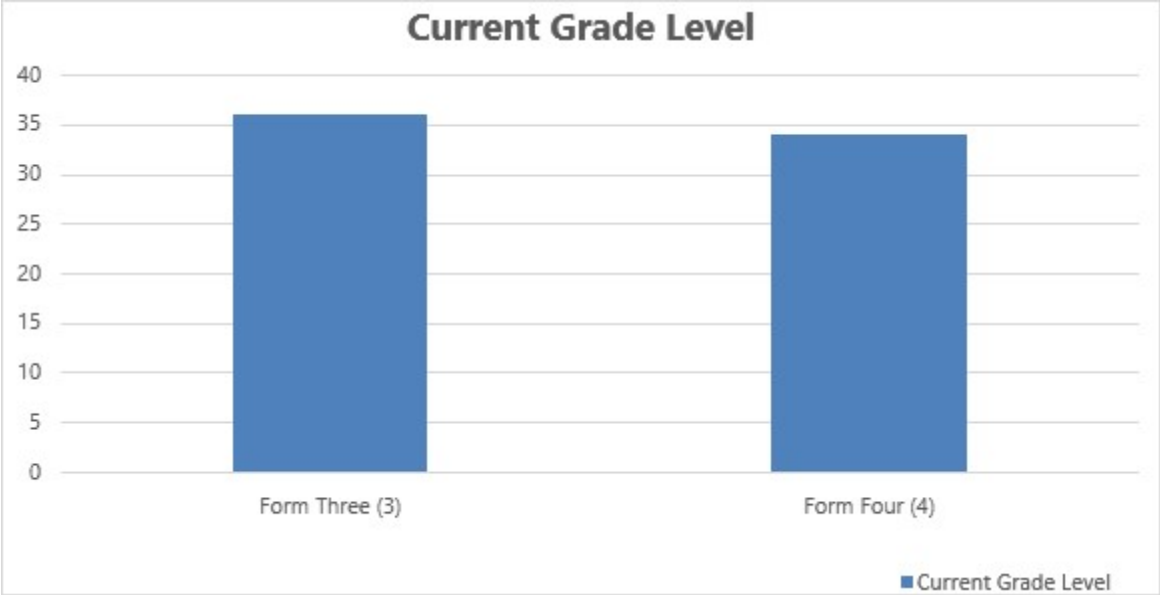


Figure 4.2 depicts that form three students established 51.43% whereas 48.57% of the contributors were form four students. These results indicate that for biology students, the retention rate may be reduced from Form 3 to Form 4. This might be the result of a number of things, like pupils choosing to transfer to another course because the subject matter became more challenging in Form 4.

4.5 Type of Student

In the same vein to understand background of the respondents, the respondents were tasked to mention the type of student they were as either conventional students or repeaters. The type of student is thus depicted in figure 4.3 below

Figure 4.3: Type of Student

Figure 4.3 illustrates that from the selected respondents, conventional students established 77.14% whereas 22.86% of the contributors were repeaters. These results indicate that Biologists are in high demand across a number of industries, including education, research institutes, and pharmaceuticals. Many students are encouraged to enrol in biology programs for the first time and also retaking the course because of the bright employment possibilities.

4.6 Responses

The research questions that directed the study are addressed by the data presentation and analysis below. The scale used is thus: Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)

4.6.1 Experience with hands-on experiments

Table 4.3 Mean response from the respondents on their experience with hands on experiments.

SEQ	ITEM STATEMENT	1	2	3	4	5	N	EFX	X	REMARK
1	You have participated in hands-on biology experiments before attending Mutsonzowa Secondary School.	7	6	5	33	19	70	261	3.72	Agreed
2	You are interested in biology experiments.	3	11	1	20	35	70	283	4.04	Agreed
3	Hands-on experiments help you understand biological concepts better than traditional methods.	1	3	2	24	40	70	309	4.41	Agreed
4	You have a choice in the assignments you do.	30	10	15	5	10	70	165	2.36	Disagreed
Grand Mean									**3.63**	**Agreed**

In the context of research on the effect of hands on experiments in Biology education, the term “criteria mean” refers to the average or central tendency of the specific criteria or measures used to evaluate the effectiveness of the hands-on experiments. By analysing the criteria means, the researcher can determine the relative effectiveness of the hands-on experiments in achieving the desired outcomes. They can compare the criteria means between the experimental and control groups to assess the impact of hands-on approach and draw conclusions about its effectiveness in Biology education.

In reference to the first research question which aimed to determine the experience with hands on experiments in biology, the researcher gives the replies from the respondents to items 1 to 4 in table 4.3 above.

According to the calculations above, the mean score for the first question is 3.72, which is above the 2.50 criteria mean; the mean score for the second question is 4.04, which is above the 2.50 criteria mean; the mean score for the third statement is 4.41, which is above the 2.50 criteria mean and is deemed agreed; and the mean score for the fourth statement is 2.36, which are below the criteria mean of 2.50, and is deemed disagreed.

According to the computed grand mean, which has a mean score of 3.63, it was concluded that some students have experience with hands on experiments whereas other do not. It is nevertheless, a clear indication that most students are interested in the practical aspect of the subject.

4.6.2 How hands-on experimental activities contribute to the development of critical thinking skills among students.

Table 4.4 Mean response from the respondents on how hands on experimental activities contribute to the development of critical thinking skills among students.

SEQ	ITEM STATEMENT	1	2	3	4	5	N	EFX	X	REMARK
5	Hands-on experiments bring benefits to your learning experience.	1	2	2	30	35	70	306	4.37	Agreed
6	You have faced challenges while conducting hands-on experiments in biology class.	5	5	5	30	25	70	275	3.92	Agreed
7	Hands-on experiments should be incorporated more frequently into the biology curriculum.	2	2	1	27	38	70	307	4.39	Agreed
Grand Mean									**4.23**	**Agreed**

Table 4.4 above displays the respondent's response to Questions 2 with statements 5 through 7 seeking to solicit views/perceptions on the level of perceived benefits and challenges faced by the students on hands-on experiments.

According to the calculations above, the first question's mean score is 4.37, above the 2.50 criteria mean; the second question's mean score is 3.92, above the 2.50 criteria mean, and both are categorized as agreed; the third question’s mean score is 4.39, above the agreed-upon term and the criterion mean of 2.50.

According to the calculated grand mean, which had a mean score of 4.23 and was marked as agreed upon, students unanimously agreed that in as much as biology practical has obvious benefits, it also has challenges attached to it.

4.6.3 What the impact of biology practical pose on the students' academic performance in biology

Table 4.5 Mean response from the respondents on the impact the biology practical pose on the students' academic performance in biology.

SEQ	ITEM STATEMENT	1	2	3	4	5	N	EFX	X	REMARK
8	How well do you feel hands-on experiments have influenced your academic performance in biology?	7	2	1	30	30	70	284	4.06	Agreed
9	Do you feel more engaged and motivated when participating in hands-on experiments compared to traditional lectures?	5	5	5	30	25	70	275	3.93	Agreed
10	Has your interest in pursuing a career related to biology increased due to engaging in hands-on experiments?	5	5	5	20	35	70	285	4.07	Agreed
Grand Mean									**4.02**	**Agreed**

The researcher has provided the answers to items 8 through 10 of the questionnaires in regard to the third research question, which aimed to determine the influence biology practical had on students' academic achievement in biology. This is shown in table 4.5 above.

According to the calculations above, the mean score for the first question is 4.06, which is higher than the 2.50 criteria mean. The mean scores for the second and last questions are 3.93 and 4.07, respectively, which are also higher than the 2.50 criteria mean and are therefore classified as agreed.

Practical activities have a significant impact on students' academic achievement in biology, as evidenced by the grand mean calculation, which has a mean score of 4.02, which is stated as agreed

4.7 The impact of biology practical on students' academic performance

According to 83.6% of the study participants backed by Hofstein and Lunetta (2014), a laboratory is a suitable learning setting that fosters meaningful learning and improves students' comprehension of scientific concepts and the nature of science. In a laboratory, students engage with materials and/or models to observe and comprehend the natural world.

A laboratory is a space or facility used for scientific experimentation and study, according to Nwogu (2015). She continued by saying that the center of science activity is the laboratory and that the exercises must be included in biology classes in order for them to be meaningful. Akpan (2012) provided a summary of the role that laboratory activities play: "People perform measurements, validate situations, gather fundamental data, operate instruments, become familiar with the equipment and materials by name, observe scientists at work, and follow experimental protocols. "By learning the fundamental concepts and abstractions involved in the process, individuals can better understand the material provided in the textbook or in lecture classes while they work in the laboratory. Every instructional effort aims to develop its students. The significance of the lab cannot be truly understood, should students not participate in the laboratory activities. Regretfully, rather than utilizing hands-on methods, the majority of laboratory evaluations are conducted using paper and pencil equipment and objective items, Hofstein and Lunetta, (2014).

According to Tobin (2011), supported by 79.3% of the respondents, students can engage in meaningful learning in the lab if they are provided with opportunities to work with tools and materials in a setting that allows them to build their understanding of phenomena and associated scientific ideas. A number of schools underutilize the laboratory when teaching biology classes. Teachers and parents start to anticipate their kids to perform some sort of magic and pass the Ordinary Examinations with flying colors because they only organize practical for the students when the final examinations start. Ahmed (2018) has provided evidence to support the claim that inadequately equipped biology laboratories contribute to the low final achievement of biology students.

This is not meant to be so, the laboratory needs to be equipped, and students regularly visit it for experiment in order to acquire necessary skills. According to Lunetta (2007), science laboratories have very important role in the educational system for science students. He noted again that these laboratories have made this world very advanced and scientific in its purpose.

Osogbonye (2012), posits that the laboratory is the ideal setting for teaching students how to replicate the actions of scientists, i.e., applying scientific methods and mind-sets to the process of conducting research in order to gain information. These scientific abilities and mind-sets that will help children become independent in the future are put into practice in the lab. As a result, Osogbonye (ibid), maintains that the purpose of laboratory instruction in contemporary science courses "focuses upon the inquiry/discovery process or methodological phase of science and upon its intellectual components." In addition, laboratories are crucial for teaching science-related courses, as their effectiveness greatly depends on the resources provided.

Kambaila (2019), states that students depend on the laboratory as a space where they may both observe their lecturers demonstrate and do practical tasks on their own. A significant portion of biology is an experimental science. Bestowing to Musharrat (2020), better laboratory programs can foster the critical thinking abilities and student motivation needed to generate a workforce of scientists, engineers, biologists, and citizens who are equipped to tackle the environmental and scientific concerns of the present and the future.

4.8 The contributions of Biology practical to effective teaching

89.1% of the study participants, buttressed by UNESCO (2015), acknowledged that many teachers who intuitively included the essential learning within their teaching recognized the need of knowledge skills at a particular subject. The research observed from the literature at hand that effective teaching of biology can be sub-divided such as qualification of teachers teaching method effective use of laboratory and mastery of the subjects. Kambaila (2019) stated that if teachers can cope adequately with tasks of them, they have to be well trained for their job. The national conference maintained that if our education is to achieve the national objective well qualified trained, efficient, satisfied and educated teachers are absolutely necessary. Opuh, Eze and Ezemagu (2018)

conceived that it is not easy to think of effective teaching of biology without qualified teachers for the work force. Eze (2012) regretted the lack of qualified teachers in the secondary schools especially in the area of practical, hence the teacher capacity development program. It is often said that teachers are the hub of any educational system for schools cannot be better than their teachers. This entail that highly qualified teachers will impact better knowledge or higher standard education on the students, Orjika (2014) Ajaelu in Opuh (2018) noted that educationists had expressed that science teachers should possess a good professional training and biology teachers are not exceptional.

Many researchers are of the opinion that the teaching methods employed during science classes contribute a lot to effective teaching of biology. Nnamonuh (2013) stated that laboratory method is the method used in effective teaching and learning of science subjects especially biology. It encompasses activities carried out by an individual or a group for the purpose of learning. Okoye (2014) had earlier opined that laboratory method of teaching should be investigated as an approach so that this activity can provide student the opportunity of acquiring process skills. Meregini (2015) reported that recent classroom observation studies have shown that teacher's instructional materials/methods were at variance with the method implied in science curriculum. Accordingly, Nnamonu (2013) stated that laboratory and field work are central to the teaching of science. Without laboratory method, teaching of science will be ineffective. Laboratory work should be seen as a mean of relating science concept, enquiry process, observation and interpretation of data.

Fafunwa in Ugwu (2015) in concurrence with 39.4% of the study population observed that most teachers resort to the use of lecture method not minding the lecture modification, the concept of education while maintaining that the best learning is that which result from purposeful practical activity. Kambaila (2019) suggested that teachers should use as many techniques as possible to gain the attention and interest of the students. The teacher should apply any method of motivation, so as to heighten the spirit of the students. Laboratory method is inevitable in the effective teaching of biology. Musharrat (2020) advocated that teachers should be using laboratory method mostly in teaching to avoid making biology largely a memory work. He further observed that schools where the laboratory is effectively used significantly performed better in science than others. In his own contribution, Okri was quoted by Uche (2014), as follows: the

techniques employed in impacting information to the students may have effect in creating favorable or unfavorable impression about biology in the mind of the students.

16.8% of the respondents indicated that another factor that affects effective teaching of biology is mastery of the subject matter. Ugwu (2015) stated that the teachers whose attitude shows a wealth of knowledge at their fingertips about what they are teaching will restore confidence on their students. Okoye (2015) stated that teachers' knowledge of the subject matter is another factor that contributes to effective teaching and learning. A teacher who knows his subject matter very well uses his own language to teach his students by using concrete examples to illustrate his points. Musharrat (2020) advocated that for effective teaching to occur the teacher should be very knowledgeable with regards to their subject matter and this should be excellent use of specific terminologies throughout the lesson. Similarly, Opuh, Eze and Ezemagu (2018), asserted that the quality of a goof teacher is good mastery of the subject matter. The teacher has to know everything concerning the subject. Eze (2015) noted that some unskilled teachers abuse the use of teaching methods. Keldare (2007) went further to stress that continuity from previous lesson s and new information should be linked to previous learning. In light of the above, Ude (2014), recommended that the place in which biology is to be taught is the indispensable laboratory. It is essential for every teacher of biology to become acquitted with teaching method that will help his students achieve their learning objectives. In summary, teachers affect change in the society. These changes can be affected if teachers themselves are well educated, competent industrious and disciplined. It is also when the desired and desirable changes in the students learning have been realized that the teaching of biology can be effective. Effective teaching and learning is dependent on the effectiveness on the quality of the teacher.

4.9 The impact of hands-on experiments on students understanding

It has been earlier deduced that effective learning is dependent on effective teaching. It has also been noted in this work that biology practical subjugates the central position of effective teaching of biology. Hence it is also logical to state that biology practical contributes to effective learning of biology. Thus, according to 56.2% of the research participants, backed by Kuren, Zonntja, Navelle and Jeanne's (2015) opinion, many students expressed their interest and enthusiasm in practical exercise. It is well known that students who enjoy science practical do well in science. Ude (2014) accepted that

there is a positive link between biology practical and effective learning of biology. Supporting her idea, she quoted the ministry of education as saying that since biology is a science subject; effort should be made to maintain reasonable extensive science equipment coupled with suitable method of teaching. The researcher also believes that student's attitude and interest towards practical classes contributes immensely to the effective learning of biology. Wan Zi Shan (2014) have a similar view. She opined that improving students' interest and attitude to practical work particularly important to achieve high grades in the course. Karase, Hartley, James and Mclus (2015) further orated that laboratory practical experience ranks highly as contributing factor towards effective learning in science in general and biology in particular. Nnamonu (2013) declared that students' attitude towards laboratory work helps for effective teaching and learning of science and improve academic performance of students. Consequently, Cosbourne, Simon and Collins (2013) agreed that if the laboratory and practical experience is accessible, it should play a major role in influencing students' attitude and academic achievement. In fact, it can define students' performance in science. Hofstein and Lunette (2013) disclosed that a significant fact that continues to reduce learning in the laboratory is the recipe-book style that limits students' opportunity to experience ownership, creativity and development of effective learning.

Uzel cited in Eze (2013) and Orjika (2007) stated that, practical agriculture (similarly Biology) has positive effect on students' motivation. He also maintained that practical enhance both skills acquisition and the quality of learning because the students can equally add their understanding by discussing about the work done. Somi and Henry (2013), demonstrated that providing a constructively laboratory experience resulted in higher mean grade and enhanced interest, enjoyment and learning awareness. Anichebe (2007) in his study emphasized that teachers must understand their students as individual knowing how they learn best and how they may best transmit their skills and knowledge in order that the students may be educated.

Hands-on laboratory experiences are unique to biology in that it allows students to gain practical experience in the subject matter. It clearly provides students with the opportunity to become highly engaged in the process of learning and promote academic performance of students.

4.10 The contribution of Biology practical to students critical thinking

According to 88.3% of the study participants, backed by Karen et al (2015), students are more likely to interact with assignments meaningfully and receive higher evaluation grades when given academically stimulating practical laboratory courses. However, the ZIMSEC Chief Examiner (2013) had noted before that the student's academic performance in biology was below average. "Many candidates could not answer correctly a single question in the biology practical," the head examiner bemoaned. "Most of the time, they have wild guesses and guess unrelated answers that were sometimes unbiological." Additionally, the applicants performed poorly in the experimental processes. Students who shun practical labor frequently run into issues with difficulties involving mathematical concepts, logical reasoning, accurate observation, and data interpretation.

Furthermore, Sandbarey, Armstrong, and Wischusen (2015) in concurrence with 69.3% respondents clarified that inquiry-based practical give students a more realistic experience since they require them to generate their own ideas based on their own observations and do not necessarily have the answer predefined. According to Allan, Rob, and Jonathan (2013), students who shun practical classes are constantly afraid of the graph figures in exams, which prevents them from understanding the numbers for accurate interpretations. Adeleye was used by Eze and Ezemagu (2018) to observe that schools that participate in practical classes outperform those that ignore them in the finals.

According to Sandberg (2015), buttressed by 39.7% of the study participants pointed out that teachers were first hesitant to alter their biology teaching methods, but with positive outcomes (better academic achievement) and assistance from national scientific and educational organizations, progress has been made, Myer and Burgess, (2013). Based on the aforementioned information, it is definitively clear that biology practical improves students' academic achievement on biology exams.

4.11 Challenges Associated with Conduct of Biology Practical

4.11.1 Inadequate Laboratory Facilities.

All respondents (i.e. 100%) opined that one issue with biology education and learning in secondary schools has been the lack of suitable laboratory space. According to Ani and Eze (2007), students learn best through hands-on experience. When students conduct experiments during a practical to get the right answer, they not only remember the steps involved but also feel accomplished for getting the right answer. Because it is a proven truth that students do better when they participate in the activities, it is imperative that the laboratory be well prepared for the study of biology. Additionally, students should be permitted to utilize the equipment in the laboratory.

According to Lunette (2018), in agreement with79.9% of the respondents, the lab supports students' ability to make precise observations, formulate hypotheses, determine the causes of the outcomes, organize control, and refrain from passing judgment.

4.11.2 Time management.

68.4% of the study participants mentioned that this has an adverse effect on students, since many applicants have examination fever due to anxiety and stress. Some students prioritize reading and formulating their responses to a given question over those of other pupils. In an attempt to impress their examiner, students tend to rush through some questions and become verbose, providing extra details in some of their responses. According to Tan (2018), students ought to be aware that issues pertaining to practical biology typically necessitate clear, concise responses.

4.11.3 Comparing and Contrasting Specimen.

A crucial issue with biological approaches in science studies is comparing and contrasting the qualities of different specimens. 88.7% of the study participants were of the view that pupils typically do badly on these assignments because they lack the necessary technical knowledge or skills. Using tabulation is the most straightforward and trustworthy way to compare. Finding and expressing the similarities and differences between one specimen and the other is the process of comparing or contrasting a specimen's traits with those of another specimen.

4.11.4 Drawing and Labelling.

In practical classes, biologists place great emphasis on creating diagrams that accurately name the specimens being studied. According to Tan (2018), and 46.8% of the respondents, biological diagrams differ from fine art diagrams, which call for colorful, beautiful diagrams from artists. The following factors are taken into account while drawing and labelling biological specimens: size, proportionality, title, and view or viewpoint.

4.11.5 Observation.

78.9% of the study participants believed that observation is a crucial component of practical biology. It is impossible to overstate the value of closely observing the specimen during a practical biology examination. It is expected of candidates to examine the specimen closely and critically, as this is necessary for accurate specimen identification, complete drawing representation, and realistic comparative analysis.

Various explanations have been offered for the issues surrounding laboratory work, Tan (2018). Benze and Hodan (2015) claim that when students only obey their lecturers' instructions without question, issues with laboratory work occur. On the other hand, 28.3% of the respondents agree with some academics' assert that the laboratory has evolved from a location for science experiments and practical to one where students complete assignments assigned by their teachers. During laboratory work, just the assigned tasks are completed; technique or purpose are ignored, Hurtegal (2012). The issue with laboratory work has been linked by Jimenz Alexander (2014), Wikinson and Wand (2007) to an inadequate assessment of the goals of the tasks performed in the laboratory.

The multiple purpose of the laboratory work has been subject of discussion worldwide for many years. Multiple lists of these purpose have been prepared for different levels of education. Many of these list focus on carrying out experiments through scientific methods and technical skills while some strongly emphasize effective objectives others have dwelled on other purpose, Johnstone and Al-Shuali, (2011), Reid and Shah (2007). When university biology laboratory is considered the general purpose of laboratory work may be:

- Supporting or strengthening theoretical knowledge

- Experiencing the pleasure of discovering and developing of the psychomotor skills
- Teaching how scientific knowledge may be used in daily life.
- Increasing creative thinking skills
- Gains in scientific working methods and high thinking skills
- Developing communication skills
- Developing manual dexterity by using tools and equipment
- Allowing students to apply skills instead of memorizing (Bayraktar 2014).

4.12 Chapter Summary

This chapter presented, analyzed, and interpreted data gathered through questionnaires, interview schedules, and document analysis in order to derive meaning from it. The quantitative data from the poll is backed up with qualitative data from interviews. The study investigated the impact of hands-on experiments on biology education This was motivated by the need to bring to the consciousness of education authorities the various benefits associated with practical biology teaching and learning by teachers and learners respectively. In this regard, the study also looked at the challenges associated with conducting hands-on experiments in biology class. This chapter has provided the foundation on which recommendations and conclusions will be revealed in the next chapter.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Introduction

This chapter provides a synopsis of the major findings in relation to the major themes developed from the research questions. The chapter extricates the conclusions and key recommendations derived from the findings.

5.1 Summary

This particular section extricates a summation of the various chapters for this research.

The first chapter of this research was based on the background of the study and it uncovered the fact that hands-on experiments involve students actively participating in the learning process by manipulating materials and equipment to observe and explain phenomena. This then gave rise to the need to investigate the current status of hands-on experiments in teaching biology, their effectiveness in enhancing students' understanding of biology concepts, the challenges faced in implementing them, and strategies to improve their implementation at Mutsonzowa Secondary School. Research objectives formulated were to determine the impact of hands-on experiments on students' understanding of biological concepts in the ordinary level class at Mutsonzowa Secondary School, to assess the development of critical thinking skills among students through hands-on experimental activities and to determine the impact of biology practical on the students' academic performance in biology.

Chapter two was based on literature review and this was gathered from different authors and scholars who have done an in-depth review and gave well synthesized knowledge in line with the impact of hands-on experiments in Secondary Schools in various settings of different countries in practical science subjects. Literature looked at biology hands on experiments, the impact of biology practical on students' academic performance, the advantages and disadvantages of hands-on experiments, the contributions of biology practical to effective teaching, the impact of hands on experiments on students understanding and the contributions of biology practical towards students critical thinking. Problems associated with biology practical and related empirical studies were also covered However, the different thoughts in different journals leave a number of debates in the way hands on experiments are conducted.

In chapter three the researcher explained both the qualitative and the quantitative research methods as they helped in giving a clear and detailed comprehension of how the how the hands-on experiments contribute to teaching biology to the ordinary level students at Mutsonzowa Secondary School. The research population was from the form three and four biology class. To select a sample, the researcher used non probability sampling and the researcher relied on the primary data gathered so as to enhance quality and data validity.

In Chapter four, the data was gathered from 70/70 respondents and was analyzed and presented in the form of tables, graphs and pie charts. This data was used in making recommendations, suggestions and conclusions. The study reveals that students are more likely to interact with assignments meaningfully and receive higher evaluation grades when given academically stimulating practical laboratory courses. The study also found that when teachers use hands-on activities in a constructive way, students become more engaged, creative, critical thinkers, and first-hand skills are developed, and the teaching and learning process becomes more efficient. An active, encouraging community of educators may make a big difference. The findings show that in as much as biology practical has obvious benefits, it also has challenges attached to it. Respondents opined that one issue with biology education and learning in secondary schools has been the lack of suitable laboratory space.

5.1.1 Main Findings

- The results indicate that Biologists are in high demand across a number of industries, including education, research institutes, and pharmaceuticals. Many students are encouraged to enrol in biology programs for the first time and also retaking the course because of the bright employment possibilities.
- The findings reveal that some students have experience with hands on experiments whereas other do not. It is nevertheless, a clear indication that most students are interested in the practical aspect of the subject.
- The study revealed that practical activities have a significant impact on students' academic achievement in biology.
- The researcher observed that students can engage in meaningful learning in the lab if they are provided with opportunities to work with tools and materials in a setting that allows them to build their understanding of phenomena and associated scientific ideas.
- A number of the study participants believe that a laboratory is a suitable learning setting that fosters meaningful learning and improves students' comprehension of scientific concepts and the nature of science. In a laboratory, students engage with materials and/or models to observe and comprehend the natural world.

- It was acknowledged that many teachers who intuitively included the essential learning within their teaching recognized the need of knowledge skills at a particular subject.
- The research observed from the literature at hand that effective teaching of biology can be sub-divided such as qualification of teachers teaching method effective use of laboratory and mastery of the subjects.
- The researcher is of the opinion that the teaching methods employed during science classes contribute a lot to effective teaching of biology. However, laboratory method is the method used in effective teaching and learning of science subjects especially biology.
- The study population observed that most teachers resort to the use of lecture method not minding the lecture modification, the concept of education while maintaining that the best learning is that which result from purposeful practical activity.
- The researcher suggested that teachers should use as many techniques as possible to gain the attention and interest of the students. The teacher should apply any method of motivation, so as to heighten the spirit of the students.
- Some of the respondents indicated that another factor that affects effective teaching of biology is mastery of the subject matter.
- Many students expressed their interest and enthusiasm in practical exercise. It is well known that students who enjoy science practical do well in science.
- The study reveals that students are more likely to interact with assignments meaningfully and receive higher evaluation grades when given academically stimulating practical laboratory courses.
- The study found that when teachers use hands-on activities in a constructive way, students become more engaged, creative, critical thinkers, and first-hand skills are developed, and the teaching and learning process becomes more efficient. An active, encouraging community of educators may make a big difference.
- The findings show that in as much as biology practical has obvious benefits, it also has challenges attached to it.
- Respondents opined that one issue with biology education and learning in secondary schools has been the lack of suitable laboratory space.
- The study participants mentioned that time management has an adverse effect

on students, since many applicants have examination fever due to anxiety and stress.

- A crucial issue with biological approaches in science studies is comparing and contrasting the qualities of different specimens. 88.7% of the study participants were of the view that pupils typically do badly on these assignments because they lack the necessary technical knowledge or skills.
- The respondents believed that observation is a crucial component of practical biology. It is impossible to overstate the value of closely observing the specimen during a practical biology examination.
- Summing up this research, the value of hands-on experiments towards students' learning process and academic improvement were shown in various data collected. The bulk of the data collected had shown positive results in most of the areas. As a result, this study has demonstrated that hands-on experiments promote students' knowledge and builds on their intrinsic impetus.

5.2 Conclusion

- It is clear from the context of the aforementioned findings that the activity-oriented method has introduced teachers and students to different assessment performance tasks.
- Students were given the chance to demonstrate their expertise and skill.
- Teachers also acknowledged that the exercise was very beneficial to them, and this has inspired them to investigate different approaches to meaningfully assess students' development of scientific and mathematical knowledge.
- By emphasizing the experience and process of researching, developing, and implementing solutions, hands-on activities encourage problem-based approaches to learning.
- Through practical investigations, students acquire knowledge of the subject topic as well as critical thinking techniques.
- In order for science concepts to be fully understood by pupils, teachers and students alike must have real-world application chances. Teachers and students alike need to be given real-world opportunities to apply their knowledge, as well as assistance in integrating or transferring that knowledge, in order for pupils to genuinely acquire science topics.

- It is impossible to overestimate the value of students researching fundamental scientific concepts.
- The study found that when teachers use hands-on activities in a constructive way, students become more engaged, creative, critical thinkers, and first-hand skills are developed, and the teaching and learning process becomes more efficient.
- An active, encouraging community of educators may make a big difference.
- The findings further confirm that the students who were instructed through a hands-on approach outperformed those who received instruction through a typical lecture style, indicating that including experimental activities into biology lessons could enhance student performance. Also, both boys and girls can improve together.
- Therefore, compared to traditional teaching methods like lecturing, which are inefficient in producing better results, experimental teaching strategies have a favourable impact on biology learners' successes.
- The study's findings indicate that most scientific students' academic achievement and their practical work are positively correlated. The results are consistent with earlier research, including a study by Abdi (2014), which found that the experimental groups understood the material far better, particularly when it came to questions that needed to be interpreted. Instructors were urged to think about how to set up and then deliver to students learning environments that encourage greater student participation.
- Indeed, comparable findings have been obtained by other studies. For instance, laboratory activity is crucial to science education and aids in learning the distinction between data presentation and observation, according to Hofstein and Lunetta (2014) and Hofstein and Mamlok-Naaman (2007). According to Musharrat (2020), students might become more motivated and interested in learning through practical practice.
- However, it has been suggested by Boyuk et al. (2010) and Kambaila (2019) that some educators are hesitant to assign laboratory work. They stated that while laboratory work is essential for learning the sciences, there are some issues that arise. These include a lack of supplies for the necessary experiment, inadequate knowledge for conducting the experiment, the procedures used, the glassware

and chemicals required for the experiment, safety regulations, what to do in the event of an accident during the experiment, and what to do after one occurs.

- The current study's researcher recognizes the significance of these constraints and advise educators and school officials to investigate and resolve them in order to enable the value of practical work to assist students in meeting more rigorous academic standard.
- Lab exercises have a major effect on students' academic performance in biology.
- Factors related to the biology teachers have a major impact on the academic success of the pupils.
- Students' academic performance in biology is impacted by how school administration strategies affect the biology practical.

5.3 Recommendations of the study

This study is found on the backdrop of investigating the impact of hands-on experiments on biology education: A case study of ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province**.** The following recommendations are made in relation to the findings generated from the study.

- The researcher recommends that most concepts in biology be taught through practical exercises. Certain concepts are incomprehensible if not used in real-world situations.
- The researcher recommends that school administrators to provide all required tools, glassware, and chemicals to enable practical work on the majority of biology topics in order to guarantee the success of such projects.
- In order to ensure that students do more than just follow teachers' guidelines, the researcher believes it is critical to provide students the opportunity to design some of their own experiments (student-centred activities).

5.4 Suggestions for Further Studies

Based on the results of this study, the researcher suggests that Bruner's theory of teaching in science learning be investigated further using practical trials. Four main components of a theory of teaching are learning disposition, knowledge structure, representational modalities, and efficient sequencing, according to Bruner (1960). In

order to help students, become independent learners who can make new discoveries, build new knowledge, analyse what they have learned, and conduct experiments to test their theories, teachers must use theory as a foundation and source of support. This research was mainly focused on investigating the impact of hands-on experiments on biology education. It was limited to responses from ordinary level students at Mutsonzowa Secondary School in Zvimba District. Further study should involve other Ordinary level students within the district and other districts as well as their Provinces, with a view to comparing the results with this research which are only in Zvimba District.

5.5 Conclusion of the Chapter

This chapter presented summaries, conclusions and recommendations of study.

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APPENDIX I: COVER LETTER TO RESPONDENTS

Dear Respondent

RE: QUESTIONNAIRE TO OBTAIN INFORMATION FROM RESPONDENTS

Buzuzi Spiwe, Chapanda Nyasha Kudzai, Machadu Bertha and Maruta Norma, are students of Bachelor of Science Education Honors degree in Biology at Bindura University of Science Education. We are carrying out a study entitled; **Investigating the Impact of Hands-On Experiments on Biology Education: A Case Study of ordinary level students at Mutsonzowa Secondary School in Zvimba District, Mashonaland West Province.**

All information obtained here in will be used by the researchers to complete the research in partial fulfillment of the requirements of the degree programme. The research is purely for academic purposes and any information provided will be treated with strict confidentiality.

Your cooperation in completing this questionnaire will be greatly appreciated.

Yours sincerely

_____

Buzuzi Spiwe **B225344B**

Chapanda Nyasha Kudzai **B1026933**

Machadu Bertha **B1027516**

Maruta Norma **B1026922**

APPENDIX II: QUESTIONNAIRE TO RESPONDENTS

Instructions

1. Answer the questions that follow as truthfully and honestly as possible

2. Do not write your name on this questionnaire

3. May you please attempt all the questions

4. Please place a tick (√) in the box of your preferred answer

Section A Demographics and general information

1. Gender

Male ☐

Female ☐

2. Age

15-16 years ☐

17-18 years ☐

3. Current Grade Level (please tick in the appropriate box)

Form Three (3) ☐

Form Four (4) ☐

4. Type of Student

Conventional ☐

Repeater ☐

Section B: What is your experience with hands-on experiments?

The following statements seek to solicit views/perceptions on the experience with hands-on experiments. Please indicate the extent to which you agree with each of the statements (Please tick the appropriate number). **Scale:** Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)						
Code	**Description**	**1**	**2**	**3**	**4**	**5**
PDTITP1	You have participated in hands-on biology experiments before attending Mutsonzowa Secondary School.					
PDTITP2	You are interested in biology experiments.					
PDTITP3	Hands-on experiments help you understand biological concepts better than traditional methods.					
PDTITP4	You have a choice in the assignments you do.					

Section C: How do hands-on experimental activities contribute to the development of critical thinking skills among students?

The following statements seek to solicit views/perceptions on the level of perceived benefits and challenges faced by the students on hands-on experiments. Please indicate the extent to which you agree with each of the statements (Please tick the appropriate number). **Scale:** Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)						
Code	**Description**	**1**	**2**	**3**	**4**	**5**
PCSITP1	Hands-on experiments bring benefits to your learning experience.					
PCSITP2	You have faced challenges while conducting hands-on experiments in biology class.					
PCSITP3	Hands-on experiments should be incorporated more frequently into the biology curriculum.					

Section D: What does the impact of biology practical pose on the students' academic performance in biology?

The following statements seek to solicit views/perceptions on the impact, the biology practical pose on students' academic performance and engagement. Please indicate the extent to which you agree with each of the statements (Please tick the appropriate number). **Scale:** Strongly disagree (1) Disagree (2) Neither agree nor disagree (3) Agree (4) Strongly Agree (5)						
Code	**Description**	**1**	**2**	**3**	**4**	**5**
MTGITP1	How well do you feel hands-on experiments have influenced your academic performance in biology?					
MTGITP2	Do you feel more engaged and motivated when participating in hands-on experiments compared to traditional lectures?					
MTGITP3	Has your interest in pursuing a career related to biology increased due to engaging in hands-on experiments?					

Section E: What are the challenges faced when implementing hands-on experiments in the classroom?

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Section F

How often do you engage in hands-on experiments in your biology classes?

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Section G

How would you describe your overall academic performance in biology?

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APPENDIX III: INTERVIEW GUIDE FOR INVESTIGATING THE IMPACT OF HANDS-ON EXPERIMENTS ON BIOLOGY EDUCATION.

1. What is your experience with incorporating hands-on experiments in biology education?
2. Did you use any specific examples of hands-on activities used and your perceived impact on your learning?
3. What are the perceived benefits of using hands-on experiments in teaching biology?
4. Discuss any challenges faced when implementing hands-on experiments in the classroom.
5. How have hands-on experiments influenced your engagement in biology classes?
6. Discuss any observed changes in your learning outcomes as a result of incorporating hands-on activities.
7. Compare the effectiveness of traditional teaching methods versus hands-on experiments in biology education.
8. Discuss any differences in your understanding between these two approaches.

APPENDIX IV: FOCUS GROUP DISCUSSION GUIDE ON INVESTIGATING THE IMPACT OF HANDS-ON EXPERIMENTS ON BIOLOGY EDUCATION.

1. **Experience with Hands-On Experiments:**
    - Can you share your experience with incorporating hands-on experiments in biology education?
    - How do you think hands-on experiments enhance learning in biology?
2. **Perceived Benefits:**
    - What do you believe are the main benefits of hands-on experiments in biology education?
    - Have you noticed any improvements in your engagement or understanding due to hands-on activities?
3. **Challenges Faced:**
    - What challenges have you encountered when applying hands-on experiments in biology classes?
    - How can these challenges be overcome to maximize the effectiveness of hands-on learning?
4. **Measuring Impact:**
    - How do you currently assess the impact of hands-on experiments on your learning outcomes?
    - Are there specific metrics or indicators that you find most useful in evaluating the effectiveness of hands-on learning?
5. **Future Recommendations:**
    - What improvements or changes would you suggest to further enhance the integration of hands-on experiments in biology education?
    - How can institutions better support educators in implementing hands-on activities effectively?