BINDURA UNIVERSITY OF SCIENCE EDUCATION

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THE EFFECT OF VIRTUAL EXPERIMENTS ON CELL BIOLOGY LEARNING OUTCOMES AND ACHIEVEMENTS AT FORM 3 AT NYAMAROPA SECONDARY SCHOOL

BY

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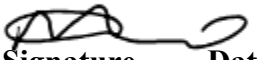
ABSTRACT

Biology is a practical subject and requires hands-on application, that is, performing real life experiments to fully grasp the concepts. With emerging technology trends, the use of virtual laboratory to perform virtual experiments is being adopted as an alternative to physical experiments performed to study effects of virtual experiments on cell biology learning achievements at Form 3. Virtual experiments are simulations conducted on a computer and mobile devices where the student conduct same scientific procedures done in traditional laboratories. In the study a pre-test – post-test non-equivalent quasi experiment was adopted to measure the effectiveness of the virtual experiments and the factors affecting student outcome achievements while using virtual experiments. Using SPSS statistical package, results were analysed and hypotheses were formulated to establish statistical relationship between factors and scores attained. From the attained results, learners achieved higher scores from virtual experiments. Factors such as availability of a device / gadget at home showed a positive strong statistical relationship to the students' performance i.e., high performing students were noted to have access to a gadget and also access to internet connection. This was also in line with other published research where access to a device and strong internet connections had a strong positive impact on learners' conceptual understanding of the subject thus leading to student performing well in the subject in matter. It was recommended that virtual experiments can be used in the teaching and learning of cell Biology at Form 3 level since it achieved good results in terms of scores from the post-tests. Further research was also recommended on the effect of virtual experiments on other Biology topics learning outcomes and achievements at Form 3 using bigger gender-balanced samples.

DECLARATION FORM

I Antonio Mandy declare that this is my original work that has not been submitted for any examination or degree in any other university and I have indicated and acknowledged all the sources that I have used or quoted.



Signature Date 10/11/22

APPROVAL FORM

The undersigned certify that they have supervised, read and recommend to the University for acceptance and examination a research project entitled: ***The effect of virtual experiments on Cell Biology learning outcomes and achievements at form 3 at Nyamaropa Secondary School.***

Signature. ***Date 10/11/ 22***

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DEDICATION

The thesis is dedicated to the Antonio family for all the support throughout the study. Their prayers and encouragement made it possible.

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CHAPTER ONE

INTRODUCTION

1.0 Chapter introduction

This chapter gives a background on the issue of using virtual experiments in learning the cells concept in Biology. The problem statements, aim, objectives and research questions guiding the study are described. Significance, limitations and delimitations regarding the study are also discussed in this chapter. The chapter concludes with an overview of the remaining chapters that review relevant literature, discuss an appropriate framework, explain the methods of the study, describe methods for analysing the data, report the results, and provide implications for practical applications and future research.

1.1 Background to the study

Aikenhead (2003), illustrated that laboratory activities are an essential part of every science curriculum as they provide the practical applications of the theories studied by the students as well as opportunities to develop practical skills. Throughout time, it has been established that laboratory activities enhance students' understanding and attitude towards the different science courses. In the field of chemistry education, laboratory activities play a vital role in the development of the students' conceptual understanding of various chemical principles and their attitude towards learning (Ainsworth, 2008). The teaching of biology, like any other science subject, greatly requires laboratory exercises as a part of the practical skills acquisition process (Borgerding et al., 2013). Most biology topics heavily rely on practical activities, especially in laboratories. Byukusenge et al. (2022) reported that learners' intellectual abilities like critical thinking, scientific inquiry, and practical skills can be developed from laboratory activities.

With the way technology has been shaping the educational landscape, an innovative way to deliver laboratory activities with limited cost is through virtual laboratories. Virtual laboratories provide simulated versions of traditional laboratories where the learner is provided with virtual representations of the real objects used in traditional laboratories (Bamu, 2020). Toth et al. (2005) mentioned that virtual laboratories allow the students to conduct the same scientific inquiry afforded by traditional laboratory activities but at a reduced cost, hazards, and time constraints. In contrast with traditional laboratory activities, virtual laboratory activities allow students to have unlimited opportunities to re-do the simulations that can aid in further conceptual development. Virtual learning environments also offer instant feedback from data manipulations, as well as opportunities to practice and prepare for conceptually complex hands-on experiments.

Virtual experiments are simulations conducted on a computer and mobile devices where the student conduct same scientific procedures done in traditional laboratories with an added advantage of unlimited opportunities to re-do and reconduct the same procedures to aid further conceptual understanding and development. In Zimbabwe the use of virtual experiment has been conducted in highly financed schools, classed Group A schools where adequate of resources including computers and wireless connections are abundant.

The need for virtual laboratories in teaching and learning of biology in developing countries was emphasised by Radhamani et al. (2014) and Pearson and Kudzai (2015). They argued that science education in developing countries faces many limitations like shortage of laboratory equipment and reagents, inadequate technical support, space and time constraints, among other limitations. Challenges of insufficient laboratory equipment needed in teaching biology topics such as cells can thus be mitigated by use of virtual labs.

Amidst the COVID-19 crisis, the majority of higher education institutions have been able to replace the physical mode of delivery with online platforms as the safest immediate solution. With the recent COVID-19 pandemic there is need for increased usage of emerging technology and the need to assess the effects of virtual experiments on cell biology learning achievements at Form 3. The ongoing debate on the effective use of virtual experiments, showed a need for carrying out more investigations on the use of virtual lab in learning and teaching biology within a context. In the study, data was collected using a quasi-experiment of pre-test post-test non-equivalent group approach at a Nyamaropa Secondary School in Bindura.

1.2 Statement of problem

Third world countries have struggled to adequately teach and train professionals in the science field primarily due to a limited access to adequate resources in the form of physical laboratory facilities and laboratory consumables. The traditional emphasis on hands-on laboratory experience as an indispensable part of 'proper' and adequate training in the science disciplines has meant that third world countries have lagged far behind their first world counter-parts in terms of the quality of training, research and general quality of life. Technological advancements have created opportunities for the augmentation and or complete replacement of physical science laboratories in the teaching of science graduates. However, the acceptability and suitability of these alternatives have remained contentious issues and only the bravest and most liberal institutions have so much as dared to discuss let alone try to incorporate them in their curricular. Cell biology teaches about how cells work by examining the machinery inside of them, investigating how they communicate and determining how they form large structures. These biological processes can be better understood using experiments rather than theoretically. The emergence of COVID-19 posed a challenge where physical learning was replaced with virtual learning. There is need, at this juncture, to explore the suitability and

acceptability of virtual laboratories as potential alternatives or supplements to the expensive traditional physical laboratory facilities in the third world context exemplified by Zimbabwe in context with Biology

1.3 Aim of the study

To investigate the effect of virtual experiments on cell biology learning achievements at Form 3.

1.4 Objectives of the study

1. To assess the effectiveness of using virtual experiments on students conceptual understanding.
2. To assess the factors affecting students' outcome achievements on learning cell biology while using virtual experiments.

1.5 Research hypotheses

1. H_0: There is no significant difference between virtual and traditional experiments on students' conceptual understanding of cell biology.

   H_1: There is significant difference between virtual and traditional experiments on students' conceptual understanding of cell biology.
2. H_0: There is no significant difference in factors affecting students' outcome achievements between virtual and traditional experiments on the learning of cell biology.

   H_1: There is significant difference in factors affecting students' outcome achievements between virtual and tarditional experiments on the learning of cell biology.

1.6 Assumptions

It can be assumed for this study that students in each laboratory environment will respond to the pre-test and post-test openly, honestly, and truthfully. It is also assumed that students attending the virtual lab will independently complete all assignments and practical experiments. Furthermore, it is assumed that the two instruments to be used in this study will measure content learned and their intended constructs. The pre-test and post-tests are part of the course requirements. Therefore, it will be assumed by the researcher that students will answer all questions to the best of their abilities.

1.7 Significance of study

The development of biology learning media is currently also developing towards the use of the internet and big data so as to facilitate the spread of biology to all corners of the world, one of which is the virtual laboratory. Virtual experiments provide a better platform for learning in this time of COVID-19 pandemic so as to reduce the spread of the virus. They also offer a flexible access to both the tutor and the student. A virtual lab may be used during regular class time which narrows this benefit but still allows flexibility for the teacher who is not limited by using resources within a strict timeframe. It also lowers costs. Since most rural schools in Zimbabwe like Nyamaropa Secondary School lack proper laboratories and equipment for real or physical biology experiments due to resource contraints, this research sought to provide an equally viable and cost effective method of teaching and learning cell biology through virtual experiments.

1.8 Limitations of the study

The study will be conducted through students from Nyamaropa Secondary School but however the class of Science students has a small population of seventeen students, thus the study

incorporated a relatively small sample. This population pose as a limitation because the sample is too small to present a more generalized conclusion. This study reflected the performance of Nyamaropa Secondary school in Madziwa that is only one central school, hence, the results of this study cannot be extrapolated to the entire community due to differences in socio-background, intelligence and perception of the students.

Also, another limitation is that to access the virtual laboratory a mobile device or personal computer was needed and also they required internet access therefore not all students might to be able to access the virtual laboratory due to network challenges.

1.9 Delimitations of the study

The research was conducted at Nyamaropa Secondary School. The school is located in Shamva District in Mashonaland Central Province, Zimbabwe. The research involved Form 3 learners from the school enrolled in the Form 3 Biology class of 2022 third term. The research zeroed on the concept of cell biology taught to the learners. The learners were of varying majors and not distributed equally by gender, age or socioeconomic status.

1.10 Definition of terms

Cell biology: (also cellular biology or cytology) is a branch of biology that studies the structure, function, and behaviour of cells.

Virtual experiment - multimedia applications, which allow video and digital simulations of laboratory activities in a real manner but without the risks and costs associated with laboratory experiments.

Laboratory experiment: an experiment conducted under highly controlled conditions, where accurate measurements are possible.

1.11 Summary

This chapter looked at the background of the study, where the main focus was on laboratory activities as an essential part of every science curriculum as they provide the practical applications of the theories studied by the students as well as opportunities to develop practical skills. The research problem was also stated: limited access to adequate resources in the form of physical laboratory facilities and laboratory consumables. The research aims, objectives, research questions, significance of the study, limitations and delimitations have all been discussed. The chapter therefore, lays the foundation of the research study on the effect of virtual experiments on Cell Biology learning outcomes and achievements at Form 3 level at Nyamaropa Secondary School.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

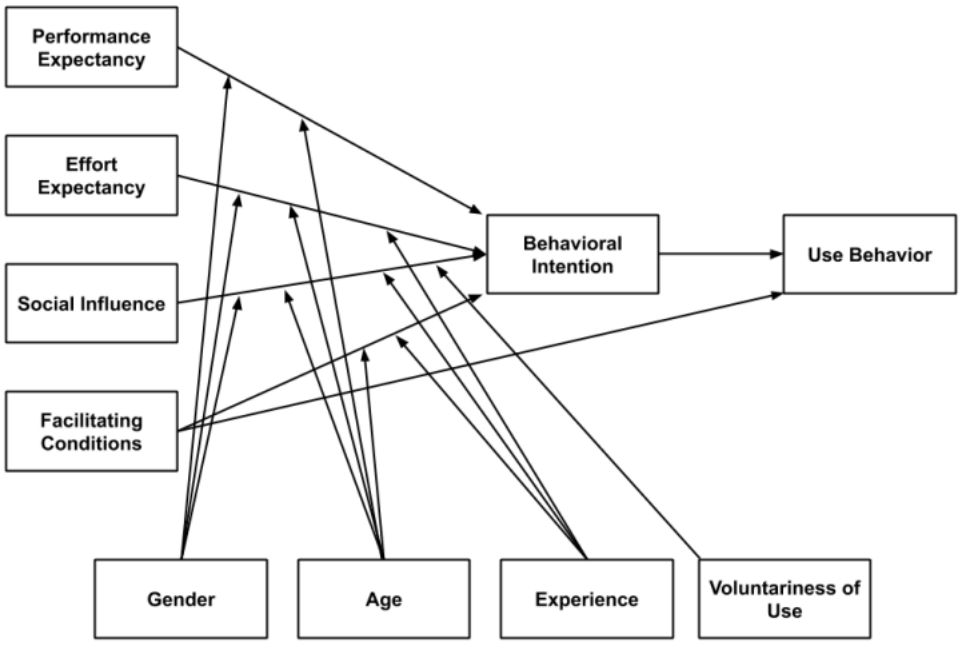
The previous chapter sought to introduce the reader to the research. It briefly described the background of the study. Furthermore, the chapter highlighted the statement of the problem. The chapter went on to highlight the research aim, research objectives, and the research question. This chapter presents the theoretical and conceptual framework informing this research on the investigation which is effects of virtual experiments on cell biology learning achievements at Form 3. This chapter also reviews global and national literature on teaching and learning in secondary schools; application of virtual experiments in biology teaching and the impact of virtual labs on students' achievement. The purpose of the literature review is to identify information that is already available concerning the research problem.

2.1 Theoretical Framework

This study is grounded in the theories of Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT is a technology acceptance model often used to predict behavioural intention and behavioural use of technology (Venkatesh et al., 2012). This model has been purposefully selected as the theoretical framework to investigate the effects of virtual experiments on cell biology learning outcomes and achievements at Form 3, because of their focus on technology adoption and use.

UTAUT was developed by Venkatesh et al. (2003) in an attempt to unify the various models used to describe technology acceptance, including: Theory of Reasoned Action, Technology Acceptance Model (TAM), Motivational Model, Theory of Planned Behaviour (TPB), Combined TAM and TPB, Model of Personal Computer (PC) Utilization, Innovation Diffusion Theory, and Social Cognitive Theory. TAM is commonly employed in technology acceptance,

however it is not without limitations. The major limitation is that it does not explain how to accept mobile technology and how to use mobile technology (LópezNicolás et al., 2008). UTAUT theory has been selected as a theoretical base for the current research study. The UTAUT model outperforms the original models as it considers all of the potential aspects identified by previous theories in order to better discover factors that may impact behavioural intention and usage. Performance expectancy, effort expectancy, social influence, and enabling factors are identified as the primary variables determining intention to use, with some important moderators influencing their usage (Teo, 2013; Venkatesh et al., 2003).



Adopted from Venkatesh et al. (2003)

Figure 1: Unified Theory of Acceptance and Use of Technology (UTAUT) Model

Performance expectancy is belief that the use of a particular technology will be advantageous or performance enhancing to the individual. In this context, performance expectancy can be considered as the extent to which students perceive that using virtual experiments would

improve their performance in learning science. Performance expectancy is considered to have the largest effect for technology adoption in education (Kuehne, 2020).

Venkatesh et al. (2003) distinguishes effort expectancy as "the degree of ease associated with the use of the system." Based on the technology usage behaviour (either easy or difficult) students decide if either the use of virtual experiments is feasible in their practical lives. In studying effort expectancy, Teo and Noyes (2014) found that making technology easy to use and practically effortless would increase pre-service teacher intention to use technology. Therefore, ease of use needs to be taken into consideration to influence behavioural intention and use.

Social influence is described by Venkatesh et al. (2003) as "the degree to which an individual perceives that important others believe he or she should use the new system." Different factors can can influence technology adoption in the science classroom. Teachers require leadership, incentives, and assistance to encourage the use of virtual laboratories. Literature on social influence for digital simulations and virtual labs in the science classroom is severely lacking, and what little is available focuses on the teacher's influence on the students.

These fundamental elements are influenced by the key moderators gender, age, experience, and voluntariness of use (Teo, 2013; Venkatesh et al., 2003). Venkatesh et al. (2003) described key moderators that influenced the four core determinants (performance expectancy, effort expectancy, social influence, and facilitating conditions) of intention and usage as being gender, age, experience, and voluntariness of use.

2.2 Teaching and learning of Biology in secondary schools

Biology is a discipline with a wide variety of theoretical knowledge and strict practice. Traditional daily teaching is often restricted by factors such as teacher strength, experimental equipment, teaching expenses, and biosafety. As a result, students' understanding of theoretical

knowledge is not thorough, and experimental hands-on operation is lacking, which greatly affects teaching quality and teaching progress. In 1989, Professor William Wolf of the University of Virginia first proposed the concept of virtual laboratory, and detailed an open platform that integrates various tool technologies and allows users to freely share data and conduct experiments by breaking through time and space constraints. With the continuous development of Internet and multimedia technology, mathematical modelling and simulation technology, virtual laboratories can realize three-dimensional simulation of real-life processes, experimental processes, and physical and chemical phenomena on the basis of specific numerical models. The signals input into the virtual scene through the keyboard and mouse are calculated by software, and the specific operation results and experimental phenomena are visually outputted, and the entire process of the experimental system is simulated and reproduced.

In recent years, with the continuous development of computer network technology and multimedia technology, virtual labs are introduced into biology teaching, virtual auxiliary teaching is used to supplement regular teaching, and human-computer interaction and interaction have become a new direction of current teaching reform and development. The virtual laboratory has become a relatively new media for biology learning, although it had been used in many other fields of science. The virtual laboratory was first used in biology learning to help students learn an abstract and difficult-to-visualize topics i.e., Cell and DNA (Udin, et al., 2020).

Amidst the COVID-19 crisis, the majority of higher education institutions have been able to replace the physical mode of delivery with online platforms as the safest immediate solution. Online learning, computer-mediated learning, web-based learning, a few of which falls under the widespread virtual reality and distant education paradigm. Although shifting to an online platform is the safest. The use of virtual laboratory in online education has become the new

normal of education throughout the world. Virtual laboratories enhance learning experiences by providing the student with a supplement to the physical lab. The laboratories allow students to perform exercises as in an actual lab and to gather data for preparing lab reports. To increase student's engagement and interest, they are allowed to make errors and take wrong directions, and then backtrack to correctly perform the exercise (Gunasekara, et al., 2021; Subramanian & Marsic, 2001)

2.3 Application of virtual experiments in biology teaching

The virtual laboratory functions by constructing a realistic three-dimensional environment and applies it to traditional biology teaching, which will have a profound impact on the biological education mode, teaching methods and teaching methods. The virtual laboratory uses virtual simulation technology to simulate the actual biological experiment process and phenomena, and visually reproduce the corresponding experimental process. Learning, using virtual biology laboratories, can effectively solve the difficulties that are difficult to overcome in the above traditional experimental teaching process, improve the experimental teaching mode, and further improve the teaching quality and students' innovative ability. The traditional anatomy teaching is mainly based on classroom face-to-face teaching, assisting with teaching tools such as pictures, specimens, models, etc., and with practical operations such as autopsy to deepen students' understanding of organizational structure. In recent years, with the continuous shortage of human body specimen resources for teaching, the quality of human anatomy teaching has been greatly restricted. The virtual anatomy teaching combines the frozen section technology and the three-dimensional image processing technology, and the section slice information is processed by the virtual simulation software to form a digital model of the physiological structure having a three-dimensional effect, which can be arbitrarily rotated, cut, and can be performed on a certain part (Giallousi et al., 2010).

The virtual laboratory has the advantages of high efficiency, easy operation, openness, flexibility, powerful function, high-cost performance, and free definition of users. It can make up for the shortcomings of traditional teaching, improve teaching efficiency and teaching quality, and thus is widely respected by universities s (Martin-Dunlop and Fraser, 2007).

The virtual laboratory integrates information such as images, texts, sounds, and animations to generate a digital environment that is highly similar to a real range of visual, auditory, and tactile aspects, realizing and abstracting abstract concepts and principles. , keyboards, etc. submit different operational instructions and accept feedback information to complete human-computer interaction, so that students have an immersive experience and experience (Zandvliet and Fraser, 2005). This kind of immersion and interactivity makes students truly become participants in the experiment. They are in a state of excitement and thinking throughout the whole process, which fully stimulates students' interest in learning and greatly enhances the enthusiasm and initiative of learning.

According to Raaflaub and Fraser, (2002), the virtual laboratory is based on the development of the network, so that the teaching process is no longer limited by time, geography and experiment times. Teachers and students can participate at any time and place, exchange and interact, and obtain teaching resources. In the actual teaching, some biological experiments involve a long experimental period. For example, the establishment of knockout mice requires that the mice be crossed for several generations to obtain homozygous mice. In the virtual experiment, this long development process can be vividly displayed in front of students in a short time. In addition, for some experiments that may involve expensive equipment consumables and specific experimental sites, the use of virtual laboratories can significantly reduce laboratory construction, equipment consumables purchase, energy consumption and maintenance costs, and reduce the need for real experimental equipment. And the dependence of consumables, saving a lot of experimental funding (Wolf and Fraser, 2008).

In real biological experiments, it is inevitable to be exposed to some toxic, harmful, flammable, explosive, radioactive reagents, which will cause irreversible damage to the experimenter and the environment, and also limit the development of some experiments. In addition, due to insufficient student experience, operational errors can have unpredictable and dangerous consequences. If in the virtual experiment operation, the danger signal prompt and the dangerous scene forecast are set in the key position or the dangerous step, it is helpful to deepen the student's impression and cultivate good experimental habits, so as to avoid rushing in the actual operation and avoiding the safety and hidden danger. In addition, the use of virtual laboratories can also reduce the environmental pollution and personal safety caused by the discharge of a large number of discarded reagents in real-life experiments (Raaflaub & Fraser, 2002).

Although virtual labs have many advantages, they also have some drawbacks. In the actual teaching, it cannot completely replace the real laboratory, nor can it blindly completely virtualize the experiment in the textbook and abandon the reality experiment. At present, the virtual experiment has the following problems in practical application.

Virtual experiments cannot fully reflect real-life experiments. The virtual experiment operation is a kind of virtual experiment in the simulated environment. Some unknown factors in the actual experiment process (different batches of experimental materials, different manufacturers' experimental equipment, human error) may cause errors in the experimental results, which cannot be completely Reflecting the reality process, it cannot fully express unexpected situations in the real environment. Therefore, teachers should treat virtual laboratories rationally, and cannot entrust virtual teaching in full. Instead, they should choose appropriate virtual experimental content to assist daily teaching (Wiggins & McTighe, 2005).

Due to technical research and development restrictions, the virtual experiment mode is still relatively simple and closed at this stage. At present, the biological virtual experiment system purchased or independently researched by major universities is still a relatively basic level. The experimental content, steps and phenomena are present. Users can only operate according to the set procedures. This mode limits the teaching content and teachers. The teaching expression is not conducive to the interaction between teachers and students to a certain extent, but also limits the way students think, which is not conducive to the creativity and individuality of students. Therefore, the development of virtual experiment system needs to be further immersed at a higher level. It develops in a direction that can flexibly adapt to different teaching environments.

Lack of teamwork and communication in virtual experiments. In the actual experimental operation, each member of the experimental group usually needs to cooperate with each other to successfully complete the experimental task. During the period, the students' teamwork awareness is gradually cultivated, and communication between each other is enhanced, which is beneficial to the wider use of each student (Dorman, Aldridge, & Fraser, 2006). Talent, improve personal comprehensiveness quality. The virtual experiment can be completed in the virtual environment only by the students themselves, and lacks the opportunity to cultivate students' cooperation, communication and communication skills. Therefore, virtual laboratories should complement and promote each other with real-life experiments to be more conducive to the cultivation of innovative talents.

2.4 The impact of virtual experiments on students' achievement

Numerous studies compare effects of physical experiments and virtual experiments however, the results of these studies remain mixed. Some studies have shown that virtual experiments can produce greater student learning and academic achievement compared to physical experiments. The impact of physical and virtual experiments on students’ performance where

researched and noted to be different with (McQueen, 2017). Some studies have shown that virtual experiments can produce greater student learning and academic achievement compared to physical experiments. In a study by Flowers (2011), on the effectiveness of virtual labs in an undergraduate biology course, found that students who completed virtual labs indicated that they provided greater understanding of biology concepts. Zacharia (2007), on measuring the effects of physical experimentation and virtual experimentation on understanding electrical 15 circuits in a sample of undergraduates enrolled in a physics course for pre-service elementary school teachers, observed that students who used the virtual labs showed greater knowledge acquisition and gained a greater conceptual understanding of Physics.

Other studies showed that physical experiments produced greater student learning and academic achievement compared to virtual experiments. A study by Dalgarno et al. (2009) found that students who interacted with a physical environment scored slightly higher on apparatus identification and laboratory navigation tests than their virtual experiments counterparts. He relates that not all of the students made efficient use of their time spent learning in the virtual experiments, and some experienced technology related issues. Additionally, Corter et al. (2011) found that undergraduate engineering students assigned to a physical experiment treatment outperformed the virtual experiment group in both a content knowledge test and individual and group data collection processes.

In the subject of biology, Gilman (2006) found that freshman students majoring in biology who completed an online mitosis and meiosis lab significantly outperformed students who completed an equivalent lab physically. They attest that online environment had time saving applications and students could get just as much out of information from the online virtual experiments as they could in the physical experiments.

In spite of the benefits of virtual lab, there is continuous debate on the role/effect of using virtual experiments/lab in students' learning science subjects (Swan et al., 2015). Many studies showed positive effects of using virtual experiments on students' level of achievement (Alneyadi, 2019; Penn & Umesh, 2019; Pyatt & Sims, 2012; Tatli & Ayas, 2013; Yang & Heh, 2007) while others showed no significant differences (Ambusaidi et al., 2018; Crandall et al., 2015; Darrah et al., 2014; Klahr et al., 2007). Alneyadi (2019) showed that virtual labs had significant effects on students' knowledge, skills, attitudes, and achievement. Efe et al. (2016) reported that gender had no effect on technology usage when attitude was taken into consideration, however Bang and Luft (2013) discovered that gender had a considerable impact on the academic use of technology in the classroom. Meanwhile, performance expectancy and effort expectancy were important drivers of gender-based intention to use technology, with a stronger link in men, although social influence was more influential in females (Lewis et al., 2013; Teo & Noyes, 2014). Males, according to Kalonde (2017), were typically more optimistic and exhibited greater interest in technology. Other moderators that were discovered to be moderators in intention to utilize technology but were not included in the UTAUT model were the place of origin and socioeconomic position.

However, In addition, many studies showed that virtual experiments helped students to gain better practical skills, which was reflected on their performance in the real lab (Aljuhani et al., 2018; Klahr et al., 2007; Malderlli et al., 2009; Radhamani et al., 2014; Yang & Heh, 2007) while the study of Sommer and Sommer (2003) revealed no difference. More specifically, Aljuhani et al. (2018) found that the virtual lab was an effective environment because it allowed users to conduct experiments individually and repeat them multiple times if needed. On other hand, Crandall et al. (2015) compared a traditional lab with a simulated, detected-based scene investigation of why a famous food sorbet had become a solid. Although there were no differences in the learning outcomes between the two laboratory-formats, students who

preferred the simulated lab felt they could control at their own pace and were able to stop and review the simulation to understand the concepts more clearly. Traditional lab proponents liked working in groups and having immediate access to instructors.

Different studies have shown to give inconsistent results on gender difference in studying sciences. According to Thompson (2008), claimed that gender differences in science are due to differences in levels of self-confidence in learning science, rather than intellectual ability, and, because males have more self-confidence, they tend to outperform females. On the other hand, c described more insightful deductions that gender studies vary with the grade level of students in a study's sample because it seems that, naturally, little difference exists between the sexes regarding their attitudes and achievement in science. He explained further that different age groups have different effects on gender differences that could be created by teachers or other educational interventions that may sometimes tip the scale in favour of male interest and achievement in science. According to Reece, (2015), a study conducted on performance analysis through motivation to learn biology by gender revealed no statistical significant and concluded that in general, gender factor has no effect on students' science performance.

2.5 Summary

In this chapter, the researcher reviewed related literature on the teaching and learning of Biology through use of physical and virtual experiments. The chapter briefly gave a theoretical framework of the study, which is grounded in the theories of Unified Theory of Acceptance and Use of Technology (UTAUT). The teaching and learning of Biology in secondary schools as well as the application of virtual experiments in Biology teaching were also discussed. The chapter concluded by discussing the impact of virtual experiments on students' achievement. This study therefore sought to fill the existing gaps in the literature on the teaching and learning of Biology through physical and virtual experiments.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

The chapter describes the methodology that the study adopted. In order to give full clarity, the chapter segments the methodology into different subtopics i.e., research design, research population, sampling techniques, data collection tools and the procedures followed. This chapter justifies every decision in regards to options on research approaches and methods.

3.1 Research Design

The research design selected for the study was quasi-experimental in that two treatment conditions were established to compare the effectiveness of instruction with and without virtual laboratories This quasi-experiment of pre-test-post-test non-equivalent group design was employed in the study to assess the effects of virtual experiments on cell biology learning achievements at Form 3. The 2 groups control and experiment were grouped according to their general performance i.e., the first class (being the control) and the second class (being the experiment). The student post test scores on biology content knowledge administered served as the dependent variables.

3.2 Research Approach

The research adopted a quantitative paradigm approach to investigate reasons the effect of virtual experiments on cell biology learning outcomes achievements at Form 3.

Quantitative research approach

Quantitative research deals in numbers, logic, and an objective stance. Quantitative research focuses on numeric and unchanging data and detailed, convergent reasoning rather than divergent reasoning. In obtaining relevant data on the different methods a quantitative approach

is advised to be utilized to assess students' learning outcomes and to obtain more understanding of students' experiences in the different learning environments. This is a quantitative study since it is concerned with the numbers and performance outcomes with students at Nyamaropa attained after being exposed to an innovative method of teaching and learning i.e., the use of virtual experiments was compared with the traditional use of real experiments.

3.3 Research Population

This study had 17 participants - form 3 students of Nyamaropa Secondary School studying biology subject.

3.4 Sampling

The sample size for this research were 2 classes studying biology and had a total population of 17 participants, nonequivalent group that participated in the research process. A nonequivalent group is a design in which participants have not been randomly assigned to conditions. All 17 students participated in the survey to test performance. All the participants that made up the sample were aged between 15 and 19 and they included both boys and girls.

Sampling Technique

The researcher utilized the purposive sampling technique, also known as judgmental, selective, or subjective sampling. This is a form of non-probability sampling in which the researcher relied on her own judgment when choosing members of the population to participate in the research. Thus, the 17 learners used were purposively selected by the teacher (researcher).

3.5 Data Collection Tools

Pre-test

A pre-test was developed from previously-validated learning scales (adopted from Oser, 2013). The pre-test was used to assess the performance of both groups in study the control and the

experimental groups. The pre-test contained 2 sections one to understand the sample population demographics and the other section to test the knowledge and understanding the students have of the topic Cell Biology, consisting of multiple choice questions. Appendix C contains the full version of this instrument.

Post-test

The Post test was administered after the treatment period to both the control and experimental groups to test the level performance exhibited by the two groups in study. The post-test assessed if the students had grasped the concepts in the topic. The post test had 2 sections: 15 multiple choice and structured based questions (carrying 25 marks) to test student understanding capabilities over the different treatments. Appendix D contains the full version of this instrument

3.6 Data Collection Procedure

The students were divided into 2 nonequivalent groups (in which participants have not been randomly assigned to conditions.) and each group was given a pretest in their week of learning before being taught about cell biology. The students were taught of cell biology using different methods; the experimental group used free online software virtual laboratories (OLABS, Learn Genetics and Amrita labs), to perform experiments while the control group perform real life experiments. The virtual labs provided real-life simulations laboratory practise and experiments. The virtual laboratory allowed students to perform simulated experiments with unrestricted access to repeats of the simulation. The students were taught over 3 weeks (2 lessons per week) and then a post test was administered in the third week to access if the student had understood the topic.

3.7 Data Presentation and Analysis

The researcher analysed data with guidance of the responses from the filled data by the students. Software based analysis was used whereby SPSS statistical package and Microsoft Excel were used for data analysis. The collected data brought about different variables that were points of discussion in as much as perceptions of performance of students are concerned. Data from each section was represented on bar graphs and pie charts and tables, clearly showing the distribution of each and every variable. Using SPSS, independence t-test and paired sample t-test were used to find relationship between variables. The p-values were noted, deduced and explained in relation to related literature to explained the observed relationship. Relationships obtained were explained, addressing the key points of investigation, answering the research questions and the research objectives.

3.8 Ethical Consideration

According to Terre Blanche et al. (2006), the purpose of research ethics is protecting the welfare of research participants, and this extends to scientific misconduct and plagiarism. The following principles were included in this study.

Informed consent

Informed consent is seen as the only determinant of the ethicality of research of research (Terre et al., 2006). For this study, the aims and purposes of the study was verbally explained to the head of the school and the informed consent was read so that there have a clear understanding of the purpose of the study.

Confidentiality

According to Terre et al. (2006) confidentiality requires that participants be treated with respect during the study, individual information remains confidential and that communities are not identified with research that may attract harm through foreseeable stigma and discrimination.

The names of the participants and other identification particulars for the participants were not to be published in the research report for the purpose of confidentiality of the participants. The informed consent also informs the informants that their identity will not be revealed in report.

Potential of harm

The research design needs to consider the potential of harm to the participants, the researcher, and the institution. The harm can range from physical, social, psychological, resource loss (including time), emotional, reputational and all other types of harm are kept to an absolute minimum, with the participants being fully informed on what the risks are (Fleming, 2019). For this study, the students were informed on the potential harm associated with the use of a computer and also harm associated in conducting a real experiment. An introductory lesson was conducted to cover such potential harm and mitigation solutions if anything were to happen in the event of an event that may lead to harm.

3.9 Summary

The chapter outlined the research methodology of the study. The research paradigm and design were explained. Each instrument used in the research was analysed and its strengths identified. The sampling technique and instruments selected were used to collect data on the effects of virtual experiments on Cell Biology learning outcomes and achievements at Form 3 at Nyamaropa Secondary School. The researcher was satisfied that the necessary data were collected using pre- and post-tests, and analysed using SPSS and Microsoft Excel. This chapter helped in the gathering of data relevant to the research study. The next chapter will present, analyse and discuss data collected.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.0 Introduction

This chapter presents the study results obtained from the pre- and post-test assessment issued to students focused in this research at Nyamaropa Secondary School. The tests were designed to assess the students' performance in different learning environments i.e., virtual and physical experiments. The collected date are mainly presented in the form of tables, bar graphs and pie charts. The research findings were analysed and interpreted in relation to the research hypotheses. The discussion is guided by the objectives of the study, the literature review, the theoretical and the conceptual framework discussed in earlier chapters.

4.1 Analysis of Demographic data

The age groups of participants were between 16 and 21 years which were students at Nyanaropa Secondary School.

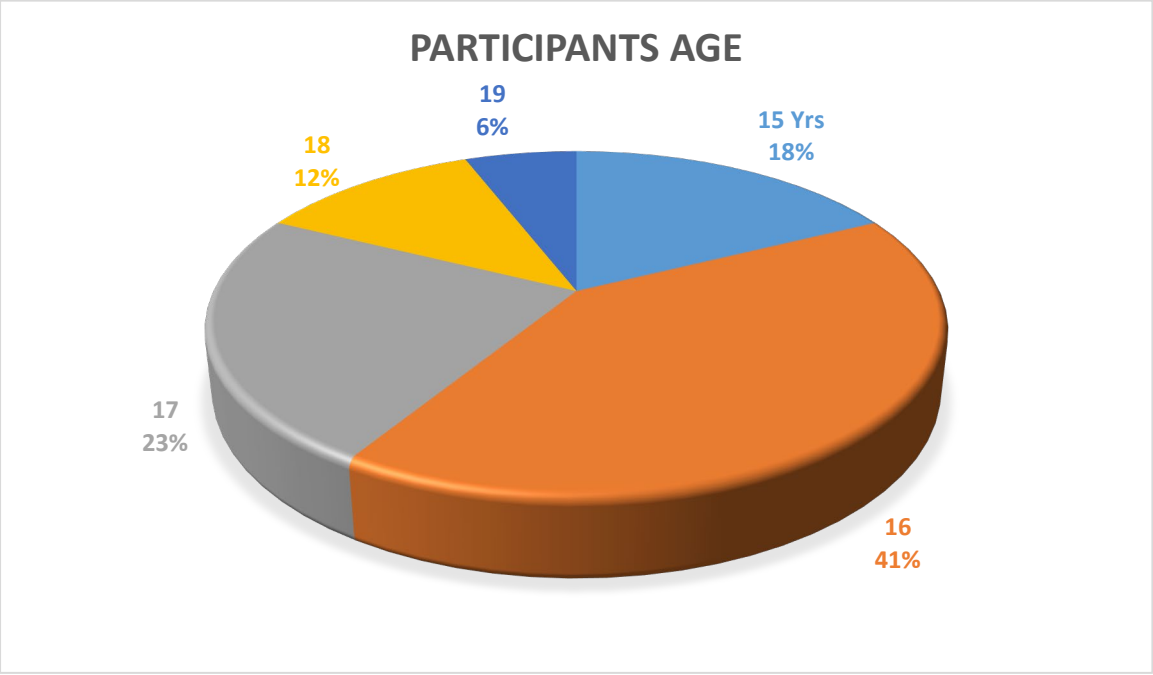


Figure 1: Age distribution of participants

According to (Eyisi, 2016), it is crucial to consider the age of the respondents and have a better grasp their understanding in order to use the appropriate research tools. From figure 1 above, the pie chat shows the proportion of age among respondents who were included in the study. The participants were majorly being students aged 16 years constating of 41% and followed those aged 17 years (23%) and the least responded being aged 19 years. This data suggests that most of the students under study are minors and the use of qualitative approach is useful as one particular area or zone can be reflective of the wider society in terms of samples, contents and patterns and also this approach gives room for the use of control and study groups, giving them the same teaching, but exploiting different teaching methods (Eyisi, 2016).

Table 1: Demographic information of participants

Demographic Data (n=111)		
Gender	**n**	**n (%)**
Male	7	41.18
Female	10	58.82
Gadgets and Devices	**n**	**n (%)**
With gadgets and devices.	9	52.94
Without gadgets and devices	8	47.06
Internet Access	**n**	**n (%)**
With internet access	10	58.82
Without internet access	7	41.18
Background area	**n**	**n (%)**
From urban areas	9	52.94
From rural area	5	29.41
Staying at the school	3	17.65

According to Kuehne (2020), it's crucial to consider the demographics of the respondents and have a better grasp of how they are distributed across each variable including gender, background area availability of resources. In table 1 above, the demographic information of participants is displayed, showing the number of respondents at each and every variable and their percentage to the total population in relation to the research question; the factors affecting students' achievements while using virtual experiment. The females consisted of 10 (58.82%) of the respondents while the male counterparts constituted of 7 (41.18%). This data suggests that females have a high population in middle school and secondary school, this was consistent with research by Reece (2015).

4.2 Relationship between control and experimental group before treatment

H_0: There is no difference between the control and the experimental group before treatment.

H_1: There is a difference between the control and the experimental group before treatment.

```
T-TEST /VARIABLES= Pretest
       /GROUPS=Group(1,2)       /MISSING=ANALYSIS
       /CRITERIA=CI(0.95).
```

Group Statistics

	Group	N	Mean	Std. Deviation	S.E. Mean
Pretest	Control	9	46.00	4.36	1.45
	Experiment	8	42.38	7.27	2.57

Independent Samples Test

		Levene's Test for Equality of Variances		T-Test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pretest	Equal variances assumed	1.38	.259	1.26	15.00	.225	3.63	2.87	-2.48	9.73
	Equal variances not assumed			1.23	11.19	.245	3.63	2.95	-2.86	10.11

Figure 2: The statistical independent t-test of pretest results between the control and experimental group before the treatment.

The p-value from SPSS output of 0.225 which was greater than 0.05, thus we accept the null hypothesis that there was no significant difference between the control and experimental groups before the treatment. The results from the independent t-test were used to validate that there was no statistical difference between the different groups of students before the treatment. According to Cohen, (2018), a pre-test -post-test non-equivalent group design should have no

significant difference between the control and experimental group so as to validate the outcome results of different treatments.

4.3 Relationship between the pre-test and post-test scores in both classes

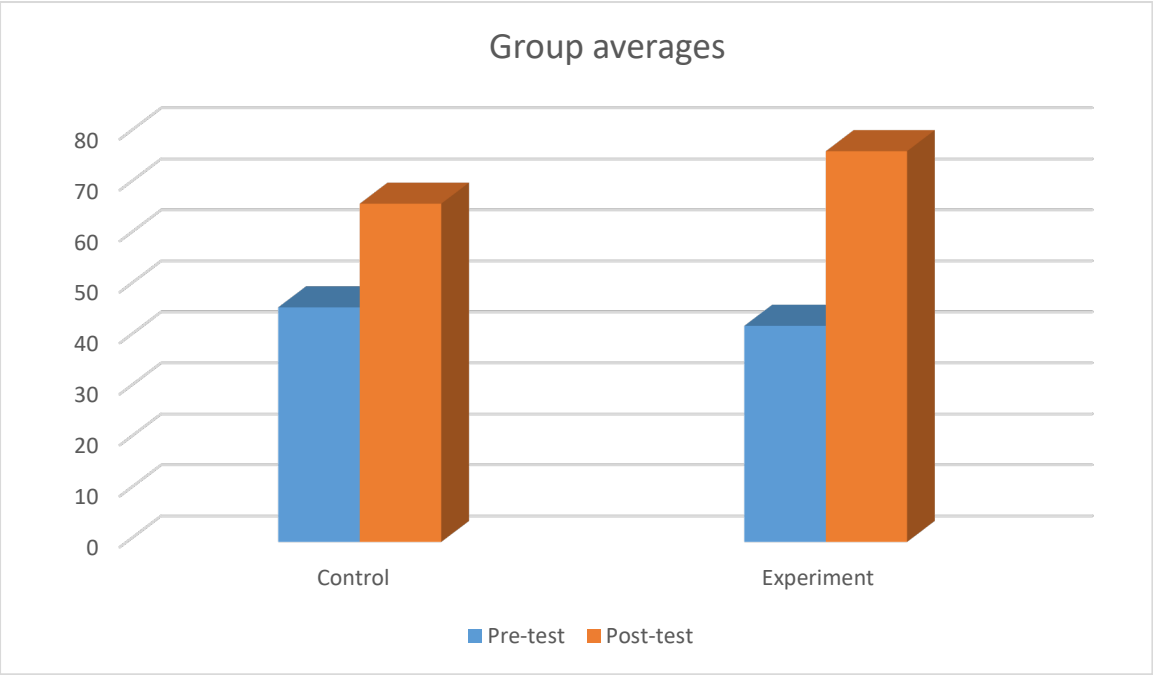


Figure 3: The average scores of respondents on pre-test and post-test

H_0: There is no difference between the pre-test and post-test scores in both classes.

H_1: There is a difference between the pre-test and post-test scores in both classes.

```
T-TEST
        PAIRS =  Pretest WITH  Posttest (PAIRED)
        /MISSING=ANALYSIS
        /CRITERIA=CI(0.95).
```

Paired Sample Statistics

		N	Mean	Std. Deviation	S.E. Mean
Pair 1	Pretest	17	44.29	6.01	1.46
	Posttest	17	68.76	13.64	3.31

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pretest & Posttest	17	.336	.187

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	S.E. Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-24.47	12.92	3.13	-31.12	-17.83	-7.81	16	.000

Figure 4: Paired sample t-test showing the significant difference pre-test and post-test in both classes

The p-value from SPSS output of <0.001 which is less than 0.05, thus we reject the null hypothesis and conclude that there was a highly significant difference between pre-test and the post-test score in both classes.

The Figure 3 above shows percentages of respondent's average passes on both pre and posttest to virtual experiments. An average of mean of 42% and 46% was obtained from the respondents in experimental and control group respectively in the pre-test and an average of 74% and 66% was obtained from respondents in experimental and control group respectively in the post-test from respondents. The difference in the scores obtained can be explained with reference to a study by Tan and Waugh (2013), the students before the treatments had an introductory topic which might have been to abstract to understand without practical exposure thus resulting in poor performance in the pre-test administered. There was a significant increase in post-test scores of the both control and treatment groups of students. There was a notable increased post-test scores of the experimental and control groups. The experimental group was taught using virtually simulated experiments, while the control group was taught with traditional laboratory until a post-test was taken with average. In Figure 4, the paired sample t-test was conducted at 95% level of significance to test the difference between the post-test and pretest for all students. The p-value of <0.001 showed that there was a highly significant difference between pre-test and post-test showing that students despite the method of learning, there was a level of conceptual understanding that led to a certain achievement level. According to Bamu (2020), science subjects require exposure to practical experience in order for a deeper conceptual understanding of the subject. Traditional or virtual experiments are both necessary to motivate, interest and aid in subject development and understanding.

4.4 Relationship between control and experimental group post-test scores

H_0: There is no difference between the control and experimental group post-test scores.

H_1: There is a difference between the control and experimental group post-test scores.

Group Statistics

	Group	N	Mean	Std. Deviation	S.E. Mean
Posttest	Control	9	61.67	7.62	2.54
	Experiment	8	76.75	14.88	5.26

Independent Samples Test

		Levene's Test for Equality of Variances		T-Test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Posttest	Equal variances assumed	1.08	.315	-2.68	15.00	.017	-15.08	5.63	-27.08	-3.08
	Equal variances not assumed			-2.58	10.16	.027	-15.08	5.84	-28.07	-2.10

Figure 5: Statistical independent t-test of post-test results between the control and experimental group post-test scores.

The p-value from SPSS output of 0.017 which was less than 0.05, thus we reject the null hypothesis and conclude that there was significant difference between pre-test and the post-test in both classes.

The box plot above of post-test results obtained in both control and experimental groups. The experimental group had a higher mean average as compared to the control group. In figure 6 above the relationship and level of difference between the learning methods in the study. The significantly low p-value showed quite a significant difference between the control and the experimental group. These results can be related to results by Brinson, (2015), the use of virtual experiments resulted in a higher level of conceptual understanding, motivation, and hypothesis/ model confirmation than in tradition experiments. According to Bamu (2020), virtual experiments are offer an added advantage of unlimited opportunities to re-do and reconduct the same procedures to aid further conceptual understanding and development of subject, thus there was a higher average performance in virtual experiment group and resulting in the significant difference shown by the independent t-test in Figure 5.

4.5 Relationship between gender and post-test scores attained in experimental group

H_0: There is no relationship between the gender and post-test scores attained in experimental group.

H_1: There is a relationship between the gender and post-test scores attained in experimental group.

```
T-TEST /VARIABLES= Posttest
       /GROUPS=Gender(1,2)     /MISSING=ANALYSIS
       /CRITERIA=CI(0.95).
```

Group Statistics

	Group	N	Mean	Std. Deviation	S.E. Mean
Posttest	Female	5	79.60	7.96	3.56
	Male	3	66.33	32.35	18.68

Independent Samples Test

		Levene's Test for Equality of Variances		T-Test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Posttest	Equal variances assumed	9.11	.023	.92	6.00	.394	13.27	14.44	-22.07	48.60
	Equal variances not assumed			.70	2.15	.553	13.27	19.01	-63.41	89.95

Figure 6: Statistical independent t-test results of the relationship between the gender and post-test scores attained in experimental group.

The p-value from SPSS output of 0.394 which was greater than 0.05, thus we fail to reject the null hypothesis and conclude that there was a no statistical relationship between gender and the post-test scored attained.

As shown in the above Figure 6, gender exhibited no statistically significant relationship with the scores of the post-test attained. According to Thompson (2008), gender studies in scientific education are so inconclusive that including the grade level of students in a study's sample might yield more illuminating results. Thompson (2008) suggested in the study that gender inequalities in science subjects are related to variations in self-confidence in learning science rather than intellectual aptitude. This is because males often have higher self-confidence and hence outperform females. It is also conceivable that professors or other educational interventions that tilt the scale in favour of male interest might generate a link between gender and performance. In general, gender has little influence on students' acquisition of science process abilities.

4.6 Summary

This chapter was mainly on the presentation, analysis and discussion of the data collected by the researcher. Data results were presented in the form of graphs and pie charts. The data were analysed to answer the research questions. There was no significant difference between the control and experimental groups before the treatment. However, there was a highly significant difference between pre-test and the post-test scores in both classes. The results were discussed with reference to the literature reviewed. Interpretation of the results was made and the effect of virtual experiments on Cell Biology learning outcomes and achievements at Form 3 was assessed. The next chapter discusses the research summary, conclusions and recommendations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter seeks to present a summary of the whole research on effect of virtual experiments on Cell Biology learning outcomes and achievements at Form 3 at Nyamaropa Secondary School. Conclusions are drawn based on the findings, after which recommendations are made to all those involved in the teaching and learning of Cell Biology at Form 3 level and the nation at large.

5.1 Summary

Laboratory activities are an essential part of Biology curriculum as they provide the practical applications of the theories studied by the learners as well as opportunities to develop practical skills. Limited access to adequate resources in the form of physical laboratory facilities and laboratory consumables is a major problem in the teaching and learning of Biology. The study investigated the effect of virtual experiments on cell biology learning achievements at Form 3 level at Nyamaropa Secondary School. The objectives of the study were to assess the effectiveness of using virtual experiments on students conceptual understanding, and to assess the factors affecting students' outcome achievements on learning cell biology while using virtual experiments. Unified Theory of Acceptance and Use of Technology (UTAUT) as used as the theoretical framework and relevant literature was reviewed to fill the existing gaps in the literature on the teaching and learning of Biology through physical and virtual experiments. A quasi-experimental design was used and the research adopted a quantitative paradigm approach was adopted. A total of 17 learners were selected from 2 classes using purposive sampling technique. The data were collected using pre- and post-tests, and analysed using SPSS and Microsoft Excel. There was no significant difference between the control and experimental

groups before the treatment. However, there was a highly significant difference between pre-test and the post-test scores in both classes hence differences in conceptual understanding as a result of virtual experiments.

5.2 Conclusion

From the findings of the study, it can be concluded that there was a notable general high performance exhibited by students who were using virtual experiments than those performing physical experiments, this was proven statistically that there was a significant difference between the experimental group and the control groups deducing that virtual experiments had a positive effect on cell biology learning achievements. The relationships between students' performance and background were being calculated statistically and from these results in comparison to related studies and literature it can be concluded that virtual experiments are greatly effective but also, they are greatly dependent on students' socio-demographics. The socio-demographics of students and background have a great impact which can either be positive or negative to the students' capacity to perform and effectively understand the concepts of cell biology using

5.3 Recommendations

Based on the research findings, it is recommended that virtual experiments can be used in the teaching and learning of cell Biology at Form 3 level since it achieved good results in terms of scores from the post-tests. However, where resources and consumables are available, teachers are recommended to use physical experiments as they provide practical skills to learners.

The study also recommends that government and the respective School Development Committees (SDCs) should provide proper funding and find ways of raising funds ensure that all necessary laboratory facilities, ICT tools, internet facilities and other resources are available for practical learning of cell biology to be possible, both physically and virtually.

Finally, the researcher recommends for further research on the effect of virtual experiments on other Biology topics learning outcomes and achievements at Form 3 using bigger gender-balanced samples to get more information and come up with valid, reliable and authentic conclusions.

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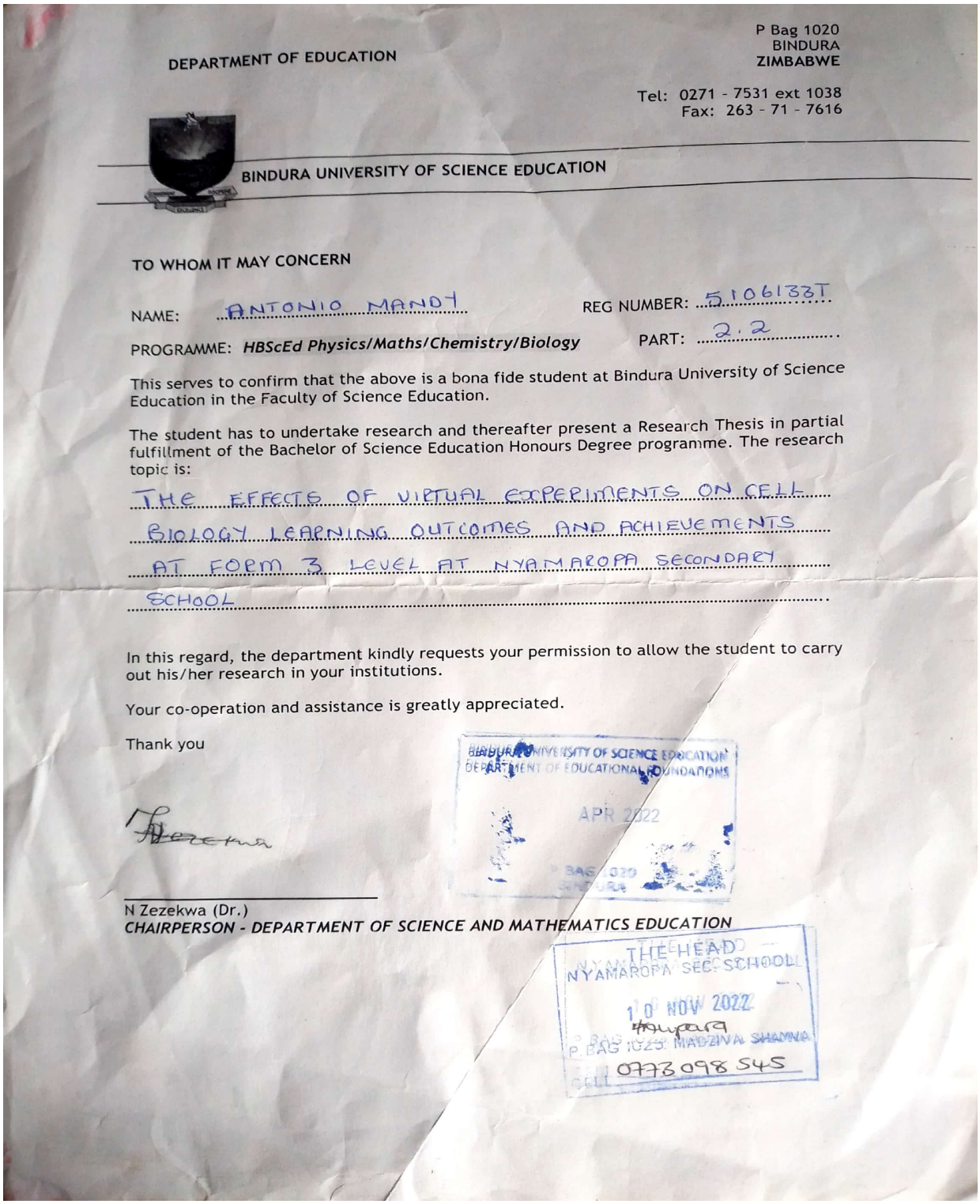
APPENDICES

Appendix A: Research Approval Form



DEPARTMENT OF EDUCATION

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ZIMBABWE

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BINDURA UNIVERSITY OF SCIENCE EDUCATION

TO WHOM IT MAY CONCERN

NAME: ANTONIO MANDY REG NUMBER: B1061337

PROGRAMME: *HBScEd Physics/Maths/Chemistry/Biology* PART: 2.2

This serves to confirm that the above is a bona fide student at Bindura University of Science Education in the Faculty of Science Education.

The student has to undertake research and thereafter present a Research Thesis in partial fulfillment of the Bachelor of Science Education Honours Degree programme. The research topic is:

THE EFFECTS OF VIRTUAL EXPERIMENTS ON CELL BIOLOGY LEARNING OUTCOMES AND ACHIEVEMENTS AT FORM 3 LEVEL AT NYAMAROPA SECONDARY SCHOOL

In this regard, the department kindly requests your permission to allow the student to carry out his/her research in your institutions.

Your co-operation and assistance is greatly appreciated.

Thank you

BINDURA UNIVERSITY OF SCIENCE EDUCATION
DEPARTMENT OF EDUCATIONAL FOUNDATIONS
APR 2022
P BAG 1020
BINDURA

N Zezekwa (Dr.)
CHAIRPERSON - DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

THE HEAD
NYAMAROPA SEC SCHOOL
10 NOV 2022
P BAG 1025 MADZIVA SHAMVA
0773098545

Appendix B: Lesson Plans

LESSON PLAN 1

NAME OF TEACHER: Ms M. Antonio SCHOOL NAME: Nyamaropa Secondary

DATE : 22 August 2022 TIME (S) 9.10-1020 am

CLASS: 3 A1 NUMBER OF PUPILS 8

TOPIC : Plant and animal cells

LESSON TOPIC: Structure of Plant and animal cell

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i)View plant cell using light microscope
ii)Draw an animal and plant cell
iii)Identify parts of the 2 cells you have drawn on (ii)
iv)Compare the structure of plant and animal cells.

Assumed Knowledge: Learners are able to identify organelles of onion cells

Anticipated difficulties: learners will find difficulties in using microscope and bio viewer

MEDIA

Microscope, bio viewer, scalpel, slides, onion leaves, water

Chalkboard for note writing

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E. (2017). *Step Ahead Biology Book 3*. Pearson Publishers. ISBN: 1776001877, 9781776001873. Pp 24-25

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (5 MINUTES)	-Instructions on the experiment - how to prepare wet mount	-teacher introduce the lesson by teaching learners how to handle the apparatus -teacher write procedure of the experiment on the chalkboard.	-learners listen attentively -learners read the procedure
STEP 1 (20 MINUTES)	- view a cell on a microscope or using bioviewer -draw; plant cell	-teacher instruct learners to get in pairs. -teacher asks learners to prepare wet mount following the procedure written on the chalkboard -teacher ask learners to draw the structures viewed on the microscope or bioviewer .	-learners to get in pairs. -learners to prepare wet mount using onion and water using instructions written on the chalkboard in their groups. - learners draw the structures viewed on their microscope or bioviewers.
STEP 2 (40 MINUTES) FURTHER STUDENT ACTIVITIES (5 MINUTES)	- identify organelles - write test - hand in answer sheets -cleaning	-teacher ask learners to identify organelles of the cell using the drawings they have observed -teacher ask learners questions - teacher write test on the chalkboard and instruct learners to write test - teacher instruct learners to hand in answer sheets for marking - teacher ask learners to clean the apparatus	- learners identify organelles of the cell using diagrams on their drawings Learners write test as instructed by the teacher. -learners hand in answer sheets for marking - learners clean their apparatus

Strengths

All the learners were present for the lesson .Learners managed to do the experiment as per plan. Pairwork was very effective as learners were able to share ideas on how to prepare wet mount and how to focus using microscope.

Weaknesses

There were few microscopes (5) which were functional and the teacher had to use both microscope and bioviewers to view the cells .

Improvement

The learners should be provided with enough apparatus so that they get enough practice for experiment.

LESSON PLAN 2

NAME OF TEACHER: M. Antonio SCHOOL NAME: Nyamaropa Secondary

CLASS: 3 A1 NUMBER OF PUPILS 8

TOPIC: Plant and animal cells DATE 24 August 2022

LESSON TOPIC: Specialised Plant Cell TIME 1055-1235 pm

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i). State at least two specialised plant cell

ii) relate each specialised cell structure to its function

iii) draw and label at least two specialised plant cells.

Assumed Knowledge: Learners are able to view cells using bioviewers

Anticipated difficulties: learners will find difficulties in relating the structure of the cells to their function.

MEDIA

Bio viewer, strips,chart showing structure of the cells

Chalkboard for note writing

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E. (2017). *Step Ahead Biology Book 3*. Pearson Publishers. ISBN: 1776001877, 9781776001873. Pp 24-25

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (5 MINUTES)	what are specialised cells	-teacher explain what are specialised cells -teacher asks learners examples of specialised plant cells	-learners listen attentively -learners state examples of plant specialised cells
STEP 1 (40 MINUTES)	- view root hair cell and palisade cells using bioviewer -draw; root haircell, palisade cell	-teacher instruct learners to get in pairs -teacher write instructions on the chalkboard -teacher ask learners to draw the structures they are observing on the bioviewer .	- learners to get in pairs. -learners read instructions written on the chalkboard in their groups. - learners draw the structures they are observing on their bioviewers.
STEP 2 (20 MINUTES) FURTHER STUDENT ACTIVITIES (5 MINUTES)	- identify organelles -relating structure to function cleaning	-teacher ask learners to identify organelles of the celsl using the drawings they have observed -teacher ask learners to relate the structure of the cells to their function -teacher discuss with the learners the structure of the cells using the chart -teacher ask learners to clean the apparatus	- learners identify organelles of the cell using diagrams on their drawings -learners discuss as a class the relationship of structure to it's function of plant specialised cells they have viewed. - learners clean their apparatus

EVALUATION

Strengths

The use of a chart as media was very effective since both the teacher and learners were able to use it to relate the structure of the specialised cells to their function.All the learners were present for the lesson and the participated well during the lesson.

Weaknesses

The lens of some of the bioviewers were not clear since learners were not able to view the cells .The teacher had to use the charts for explanation since some the pairs were not able to draw the structure they have observed on the bioviewer since it was not clear.

LESSON PLAN 3

CLASS: 3 A1 NUMBER OF PUPILS 8

TOPIC : Plant and animal cells DATE 28August 2022 TIME 8:35-1020am

LESSON TOPIC: Specialised animal cells

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i). State at least two specialised animal cell

ii) relate each specialised cell structure to it's function

iii) draw and label at least two specialised animal cells.

Assumed Knowledge: learners are able to view cells using bioviewers

Anticipated difficulties: learners will find difficulties in drawing red blood cell

MEDIA

Bio viewer, strips,chart showing structure of the cells

Chalkboard for note writing

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E., (2017). *Step Ahead Biology Book 3*.

Pearson Publishers. ISBN: 1776001877, 9781776001873. Pp 26-7

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (5 MINUTES)	-Identify animal specialised cells	-teacher explain what are specialised cells -teacher asks learners examples of specialised animal cells	-learners listen attentively -learners state examples of animal specialised cells

STEP 1 (40 MINUTES)	- view red blood cell and white blood cells using bioviewer -draw; red blood celle,white blood cell	-teacher instruct learners to get in pairs -teacher write instructions on the chalkboard -teacher ask learners to draw the structures they are observing on the bioviewer .	- learners to get in pairs. -learners read instructions written on the chalkboard in their groups. - learners draw the structures they are observing on their bioviewers.
STEP 2 (20 MINUTES)	- identify organelles -relating structure to function	-teacher ask learners to identify organelles of the celsl using the drawings they have observed -teacher ask learners to relate the structure of the cells to their function -teacher discuss with the learners the structure of the cells using the the diagrams on the chart	- learners identify organelles of the cell using diagrams on their drawings -learners discuss as a class the relationship of structure to it's function of plant specialised cells they have viewed.
FURTHER STUDENT ACTIVITIES (5 MINUTES)	cleaning	-teacher ask learners to clean the apparatus	- learners clean their apparatus

EVALUATION

Strengths

Learners were familiar on how to use microscope and bioviwers and they were able to do the experiment themselves with little assistance from the teacher.

Weaknesses

Learners were not able to view all the animal specialised cells since there were no slides for ovum nerve cell and the sperm.

LESSON PLAN 4

NAME OF TEACHER: Ms M Antonio SCHOOL: Nyamaropa Sec School

DATE :23 August 2022 TIME(S): 10.50- 1200 pm

CLASS: 3 A2 NUMBER OF PUPILS: 9

TOPIC : Plant and animal cells

LESSON TOPIC: Structure of Plant and animal cell (virtual experiment)

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i) View plant cell and animal cell using computers

ii) Draw an animal and plant cell.

iii) Identify parts of both cells.

iv) Compare the structure of plant and animal cells.

Assumed Knowledge: learners have been taught on how to use a computer or a smart phone

Anticipated difficulties: learners will find difficulties in understanding instructions on how to use virtual experiment.

MEDIA

Computers, smart phone

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E., (2017). Step Ahead Biology Book 3. Pearson Publishers. ISBN: 1776001877, 9781776001873. Pp 24-25

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (5 MINUTES)	-instructions on how to use the link	-teacher will introduce the lesson by giving learners link and instructions	-learners listen attentively
STEP 1 (15 MINUTES)	- draw: plant cell and animal cell	-teacher instruct learners to get into their groups -teacher asks learners to draw a plant and animal	-learners to get into their groups -learners to draw and label plant and animal cells in their groups.
STEP 2 (48MINUTES) FURTHER STUDENT ACTIVITIES (2 MINUTES)	- identify organelles - writing a test - hand in answer sheets	-teacher ask learners to identify organelles of the cells they observe during experiment -teacher ask learners questions -teacher write test on the chalkboard and ask learners to write a test - teacher instruct learners to hand in answer sheets for marking	- learners identify organelles of the cell using diagrams on the chart Learners answer questions asked by the teacher. - learners write test in their test exercise books individually -learners hand in answer sheets for marking

EVALUATION

Strengths

The lesson was conducted as planned by the teacher. All the learners were present for the lesson and they managed to do the experiment. Learners were able to view cells using their laptops with the help from their teacher and also the ICT teacher .The lesson was so interesting to the learners since they were able to use the laptop to view cells instead of doing the experiment on their own.

Weaknesses

Most of the learners were not able to do the experiment on their own without the assistant from both the teachers .The teacher had to assist them . The lesson was also affected by power cuts and the teacher had to reschedule the lesson since there was no power backup at school.

Suggestion

The teacher should improve on her computer literacy and also allow learners to get used virtual experiment.

LESSON PLAN 5

NAME OF TEACHER: Ms M Antonio SCHOOL: Nyamaropa Sec School

DATE :25 August 2022 TIME (S): 10.50- 1200 pm

CLASS: 3 A2 NUMBER OF PUPILS: 9

TOPIC : Plant and animal cells

LESSON TOPIC: Virtual Experiment on Specialised plant cells

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i) State at least two Specialised plant cells

ii) Draw an palisade and root hair cell.

iii) Relate the cell's structure to their function

Assumed Knowledge: learners knowledge on the structure of plant and animal cell.

Anticipated difficulties: learners will find difficulties in understanding in operating computers.

MEDIA

Computers, bond paper, pencils

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E., (2017). Step Ahead Biology Book 3. Pearson Publishers. ISBN: 1776001877, 9781776001873. Pp 25-26

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (5 MINUTES)	-instructions on how to use the link	-teacher will introduce the lesson by giving learners link and instructions	-learners listen attentively
STEP 1 (15 MINUTES)	- draw: palisade cell - root hair cell	-teacher instruct learners to get into pairs per each computer. -teacher asks learners to draw a palisade and root hair cell.	-learners to get into their groups -learners to draw and label palisade and root hair cells in pairs using their observations.
STEP 2 (45MINUTES) FURTHER STUDENT ACTIVITIES (5 MINUTES)	- identify organelles - relationship between structure to the function of the cell -question and answer -hand in their drawings for marking	-teacher ask learners to identify organelles of the cells they observe during experiment -teacher ask learners questions on how structure is related to the function of root hair cell and palisade cell. -teacher asks questions as conclusion teacher asks learners to hand in drawing sheets for marking.	- learners identify organelles of the cell using diagrams they have observed. -learners explain how structure is related to the function of root hair cell and palisade cell . -learners answer the questions - learners hand in drawing sheets for marking

EVALUATION

Strenghts

The lesson was conducted and learners were able to observe all the plant specialised cells including the xylem and the phloem which were not included during the planning of the

lesson. During question and answer learners were able to answer the questions correctly showing they have understood the concepts.

Weaknesses

Some of the learners were not able to do the experiment on their own without assistance from the teacher.

Suggestion

Learners should be exposed to methods of teaching and learning that include ICT

LESSON PLAN 6

NAME OF TEACHER: Ms M Antonio SCHOOL: Nyamaropa Sec School

DATE :29 August 2022 TIME (S): 10.50- 1200 pm

CLASS: 3 A2 NUMBER OF PUPILS: 9

TOPIC : Plant and animal cells

LESSON TOPIC: Virtual Experiment on Specialised animal cells

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i) State at least two Specialised animal cells

ii) Draw and red blood and white blood and nerve cell

iii)Relate the cell's structure to their function

Assumed Knowledge: Learners knowledge on the function of red blood cell in the body.

Anticipated difficulties: learners will find difficulties in drawing a nerve cell.

MEDIA

Computers, bond paper, pencils

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E. (2017). *Step Ahead Biology Book 3*.

Pearson Publishers. ISBN: 9781776001873. Pp 24-25

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (5 MINUTES)	-instructions on how to use the link	-teacher will introduce the lesson by giving learners link and instructions	-learners listen attentively
STEP 1 (15 MINUTES)	- draw: red blood cell - nerve cell - white blood cell - ovum Sperm	-teacher instruct learners to get into pairs per each computer. -teacher asks learners to draw at least two of the cell's they have observed during the experiment	-learners to get into their groups - learners to draw and label at least two of the cells they have observed in pairs using their observations.
STEP 2 (45MINUTES)	- identify organelles - relationship between structure to the function of the cell	-teacher ask learners to identify organelles of the cells they observe during experiment -teacher ask learners questions on how structure is related to the function of red blood ,white blood ,sperm and ovum	- learners identify organelles of the cell using diagrams they have drawn -learners explain how structure is related to the function of red blood , white blood celle ,nerve cell ,sperm and ovum
FURTHER STUDENT ACTIVITIES (5 MINUTES)	question and answer hand in their drawings for marking	-teacher asks questions as conclusion teacher asks learners to hand in drawing sheets for marking.	learners answer the questions - learners hand in drawing sheets for marking

EVALUATION

Strenghts

Learners were able to view all the specialised animal cells since they were available online. This enable learners to learn more and grasp more content .

Weaknesses

The time allocated for the lesson was not adequate as compared to the content learners end up learning. Teacher had underestimated the time allocation for the lesson.

Suggestion

Teacher should improve on her planing to allow learners to have more time and adequate content per given lesson.

LESSON PLAN 7

NAME OF TEACHER: Ms M Antonio SCHOOL NAME: Nyamaropa Secondary School

DATE : 2 September 2022 TIME (S) 8:00-9:45am

CLASS: 3 A1 and 3A2 NUMBER OF PUPILS 17

TOPIC : Plant and animal cells

LESSON TOPIC: Post test on Cells

LESSON OBJECTIVES: By the end of the lesson learners should be able to-

i). State at least two specialised plant and animal cells

ii) relate each specialised cell structure to its function

iii) draw and label at least two specialised cells.

Assumed Knowledge: learners have understood the concepts on cells

Anticipated difficulties: learners will find difficulties in drawing diagrams

MEDIA

Test questions papers,test exercise books ,pen ,pencil and ruler

REFERENCES:

Avis, J., Chafanza, E., Madzinga, E, W., Ritchie, E., (2017). Step Ahead Biology Book 3. Pearson Publishers. ISBN: 1776001877, 9781776001873. Pp 24-25

STAGE	CONTENT	TEACHER ACTIVITIES	STUDENT ACTIVITIES
INTRODUCTION (2 MINUTES)	- distribution of question papers - sitting plan	-teacher asks learners to 1 per desk - teacher distributes question papers to the learners.	-learners sit as per instruction from the teacher.
STEP 1 (30MINUTES)	- writing test	-teacher instruct learners to follow instructions and write the test individual	- learners to dit individual -learners read instructions written on the question paper and write test as individual -
Further	teacher instruct learners to hand in books for marking	-teacher instruct learners to stop writing hand in books for marking	learners stop writing and hand in books for marking.

EVALUATION

Strengths

All the learners managed to write the test as planned by the teacher.

Appendix C: Pre-Test

PRE-TEST

INSTRUCTIONS

ANSWER ALL THE QUESTIONS

SECTION A (BIOGRAPHICAL INFORMATION)

1. Name:_____

   _____

2. Class_____

3. Gender

   O Male O Female

4. Where do you stay

   O Rural O Urban O School

5. Do you have a computer/mobile phone/tablet at home

   O Yes O No

6. Do you have Internet access at home?

   o Yes o No

TOPIC PLANT AND ANIMAL CELL

SECTION B

EACH QUESTION CARRY ONE MARK

i) A cell is the ----------

A. basic unit of measurement

B. Unit of life

C. Mitochondria

D. Nucleus.

ii) Organisms which consist only one type of a cell are called

A. Prokaryotic cell

B. eukaryotic cell

C. Cells

D. Plant cell.

3. Eukaryotic cells are classified into ------

A, Root hair cell

B. Prokaryotes

C. Animal and plant cell

D. Plant cell.

4. Root hair cell absorb ---------- from the soil.

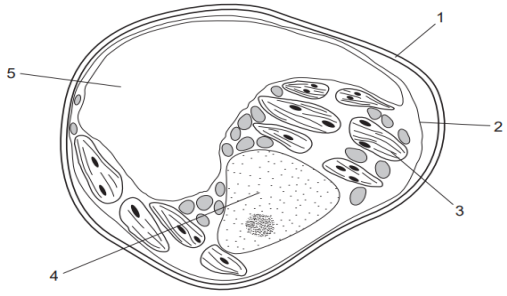
A. Carbon dioxide

B. Oxygen

C. Soil

D. Water and nutrients.

Use the diagram below to answer the question which follows.



5.The difference between an animal and a plant cell

Plant cell have ____ and animal cell does not have _____.

A. 1 and 2

B. 1 and 3

C. 2 and 4

D. 2 and 5

6. which two structures are found in all plant epidermal cells.

A. cell wall and chloroplast

B. cell wall and nucleus

C. chloroplasts and starch grains

D. nucleus and starch grains

7. In a practical lesson, a student makes the following observations about some organisms.

'They are spherical, unicellular organisms which are visible with a light microscope. Diameter is 0.01mm. Cytoplasm is present and after staining a nucleus can be seen. A vacuole is present.'

What is being described?

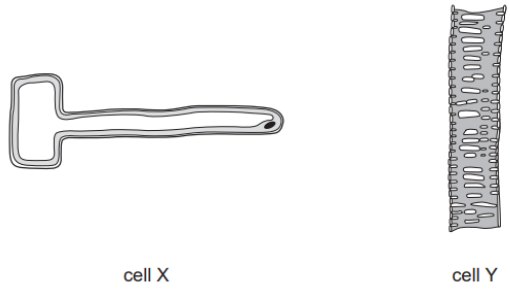
A. Bacterium

B. Fungus

C. Plant

D. Virus

8. The diagram below shows two plant cells.



cell X cell Y

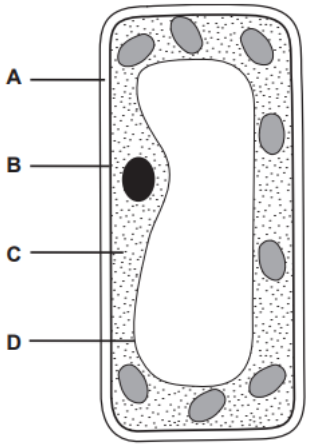
Plant cells become turgid when they take up water by osmoses.

In which of these cells does being turgid provide support

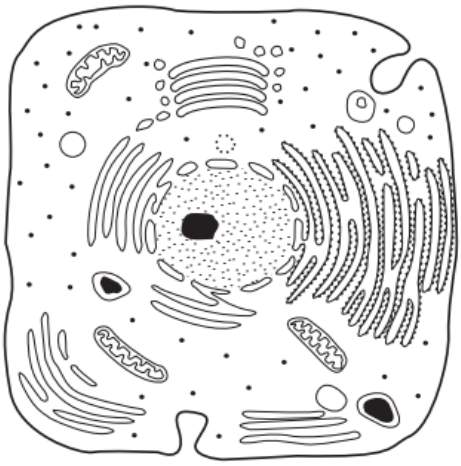
	Cell X	Cell Y
A	No	No
B	No	Yes
C	Yes	No
D	Yes	Yes

9. The diagram shows a plant cell.

Which structure controls the passage of substances into and out of the cell?



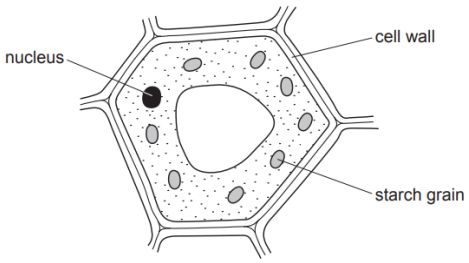
10. The diagram below shows a cell as seen under electron microscope.



What type of cell is this?

	type of cell	reason
A	Animal cell	Outer layer is the cell membrane
B	Bacterium	No chromosome visible
C	Plant cell	Cytoplasm visible
D	Plant Cell	Cell wall is visible

11. The diagram show a plant cell. The cell is stained with iodine solution.



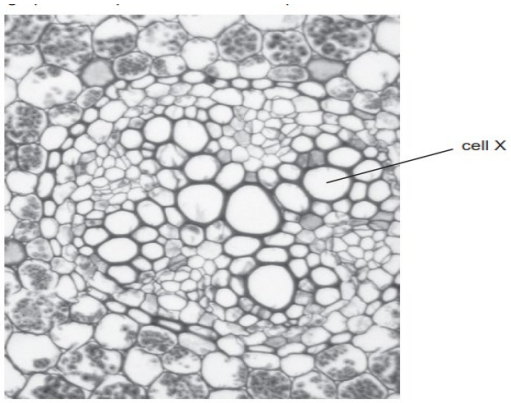
12. which structures are found in a root hair cell.

	Nucleus	Chlo
A	✓	✓
B	✓	x
C	x	✓
D	x	x

13. After staining with iodine solution, what are the colours of the cell wall and the starch grain.

	cell wall	starch grain
A	blue-black	blue-black
B	blue-black	orange-brown
C	orange-brown	blue-black
D	orange-brown	orange-brown

14. The photomicrograph shows part of a section of a plant.

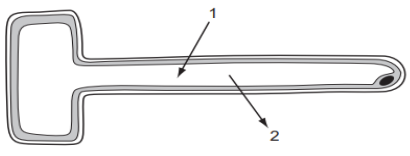


Samples of the contents of cell X were tested

What results are expected?

	Benedict's reagent	**iodine**
A	+	+
B	+	-
C	-	+
D	-	-

15. The diagram shows a root hair



	Nitrate ions	Water molecules
A	1 only	1 and 2
B	1 and 2	1 and 2
C	1 and 2	2 only
D	2 only	1 only

16. Which of the following have both cytoplasm and cell walls?

A. Liver cells

B. Red blood cells

C. Root hair cells

D. Xylem vessels

17. what is the function of each type of plant cell?

	Palisade cells	Phloen cells	Root hair cells
A	Photosynthesis	Sugar transport	Ion uptake
B	Photosynthesis	Sugar transport	Transpiration
C	Transpiration	Photosynthesis	Ion uptake
D	Transpiration	Photosynthesis	Sugar transport

18. Match with the correct shape

Cell	Shape
Muscle	A. Biconcave disc
Root hair	B Elongated and striated
Red blood	C. Long, thin extension

19. Match the correct organelle with its correct function in the cell

ORGANELLE	MAIN FUNCTION
Nucleus	**A**. Provides medium which organelles are suspended
Mitochondria	**B.** Store water and maintains pressure in the cell
Vacuole	**C**. Supply energy through the process of cellular respiration

Cytoplasm	**D**. Controls cellular activities
Cell membrane	**E.** Site of lipid synthesis and transport proteins.
Endoplasmic reticulum	**F**. Controls movement of materials into and out of the cell.

Appendix D: Post Test

PRE-TEST

INSTRUCTIONS

ANSWER ALL THE QUESTIONS

TOPIC PLANT AND ANIMAL CELL

SECTION A

EACH QUESTION CARRY ONE MARK

1. Organisms which consist only one type of a cell are called

A. Prokaryotic cell

B. eukaryotic cell

C. Cells

D. Plant cell.

2. Root hair cell absorb ---------- from the soil.

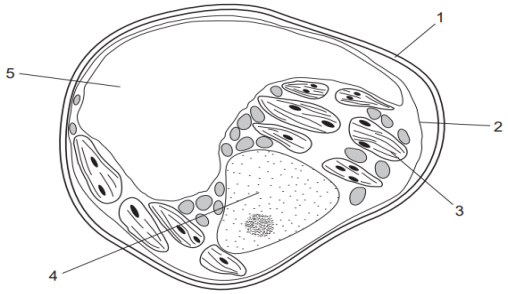
A. Carbon dioxide

B. Oxygen

C. Soil

D. Water and nutrients.

Use the diagram below to answer the question which follow.



3.The difference between an animal and a plant cell

Plant cell have --------- and animal cell does not have.

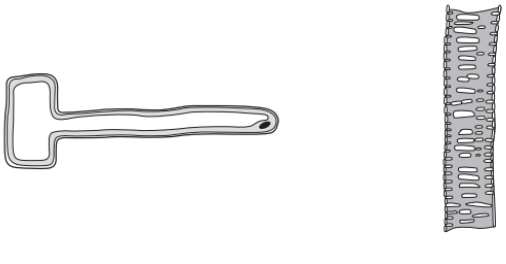
A. 1 and 2

B. 1 and 3

C. 2 and 4

D. 2 and 5

4. The diagram below shows two plant cells.



cell X cell Y

Plant cells become turgid when they take up water by osmoses.

In which of these cells does being turgid provide support

	Cell X	Cell Y
A	No	No
B	No	Yes
C	Yes	No
D	Yes	Yes

5. Which two structures are found in all plant epidermal cells.

A. cell wall and chloroplast

B. cell wall and nucleus

C. chloroplasts and starch grains

D. nucleus and starch grains

6. In a practical lesson, a student makes the following observations about some organisms.

'They are spherical, unicellular organisms which are visible with a light microscope. Diameter is 0.01mm. Cytoplasm is present and after staining a nucleus can be seen. A vacuole is present.'

What is being described?

E. Bacterium

F. Fungus

G. Plant

H. Virus

7. What is the function of each type of plant cell?

	Palisade cells	Phloen cells	Root hair cells
A	Photosynthesis	Sugar transport	Ion uptake
B	Photosynthesis	Sugar transport	Transpiration
C	Transpiration	Photosynthesis	Ion uptake
D	Transpiration	Photosynthesis	Sugar transport

8. Eukaryotic cells are grouped into --------

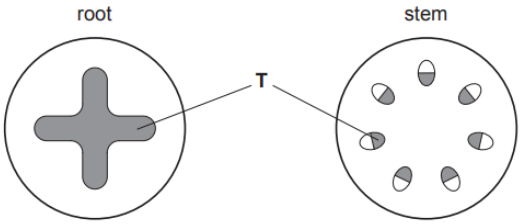
A, Root hair cell

B. Prokaryotes

C. Animal and plant cell

D. Plant cell.

9. The diagram shows cross section through the root and stem of the same plant.



What is tissue T?

A. epidermis

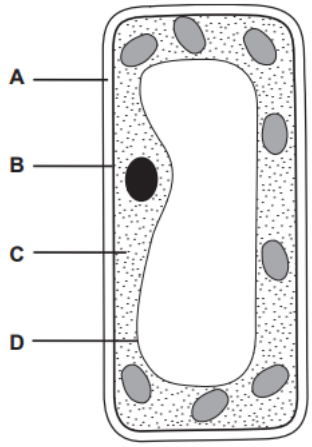
B. mesophyll

C. phloem

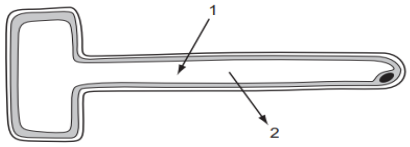
D. xylem

10. The diagram shows a plant cell.

Which structure controls the passage of substances into and out of the cell?

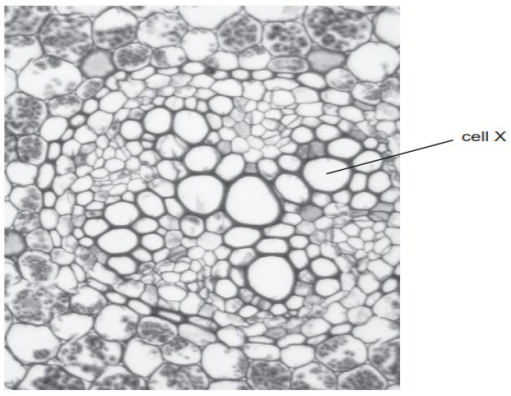


11. The diagram shows a root hair



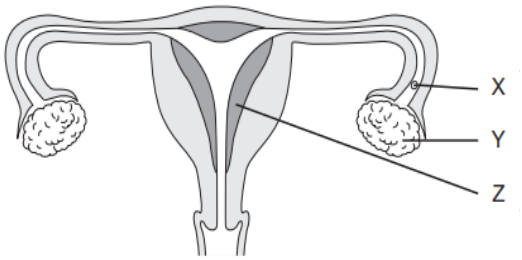
	Nitrate ions	Water molecules
A	1 only	1 and 2
B	1 and 2	1 and 2
C	1 and 2	2 only
D	2 only	1 only

12. The photomicrograph shows part of a section of a plant.



Samples of the contents of cell X were tested

13. The diagram shows the female reproductive system.



Which level of organization are the structures W, X, Y and Z?

	cell	tissue	organ	organ systen
A	W	X	Y	Z
B	X	Z	Y	Z
C	Y	Y	Z	W
D	Z	W	Y	X

14 After staining with iodine solution, what are the colours of the cell wall and the starch grain.

	cell wall	starch grain
A	blue-black	blue-black
B	blue-black	orange-brown
C	orange-brown	blue-black
D	orange-brown	orange-brown

15. What results are expected?

	Benedict's reagent	**iodine**
A	+	+
B	+	-
C	-	+
D	-	-

SECTION B

16. What is a cell? {3}

17. Draw the palisade leaf cells and describe the function of each of the organelles that are found in the cells. {8}

18. . Is the following statement is correct? If it is wrong, correct the statement

    Statement: “Unicellular organisms do not respire, only multicellular organisms respire. {2}

19. Read the following statements and write the appropriate term against each statement.

    A. I control the functions of a cell. Who am I? .....

    B. I am like a policeman. I do not allow anything and everything to get in and out of the cell. Who am I? .....

    C. I transfer characters from parents to off springs. Who am I? ..... {3}

20. State 2 differences between a plant nad animal cell. {2}

21. What is the difference between resolution and magnification? {2}

22. Explain how a palisade cell is specialised to perfom its function. {3}

22. How are xylem and phloem cells adapted to their function? {2}