

BINDURA UNIVERSITY OF SCIENCE EDUCATION



FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF SCIENCE AND MATHEMATICS EDUCATION

**THE IMPACT OF TECHNOLOGY IN TEACHING AND LEARNING OF BIOLOGY
AT MAUYA ADVENTIST HIGH SCHOOL**

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**A PROJECT SUBMITTED TO THE DEPARTMENT OF SCIENCE AND
MATHEMATICS EDUCATION, BINDURA UNIVERSITY OF SCIENCE
EDUCATION, IN PARTIAL FULLFILMENT OF THE REQUIREMENTS OF THE
DIPLOMA IN SCIENCE EDUCATION (BIOLOGY)**

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Abstract

This study examines the impact of technology on the teaching and learning of biology at Mauya Adventist High School. With the increasing integration of digital tools in education this research explores how technological advancements such as interactive software , multimedia resources and online platform influence student engagement comprehension and academic performance in biology. A mixed method approach was employed interviews and classroom observations involving both students and teachers. Preliminary suggests that technology enhances instructional delivery promotes active learning and improves retention of biological concepts. However challenges such as limited access to devices inadequate technical skills and inconsistent internet connectivity were identified as barriers to effective implementation. The study recommends targeted teacher training, increased investment in technological infrastructure and the development of tailored digital content to maximize the benefits of technology in biology education. The outcomes of this research contributes to the broader discourse on educational technology and provides insights for policy makers and educators seeking to optimize technology intergration in science education

Declaration

I Gora Tariro declare that The impact of technology in teaching and learning of Biology at Mauya Adventist High School is my original work that has not been submitted for any degree or examination in any other university and that all the sources I have used or quoted here have been indicated and acknowledged.

Signature :-

A handwritten signature in blue ink, appearing to read 'Gora Tariro', with a stylized flourish above the first letter 'G'.

Date 24/ 06/2025

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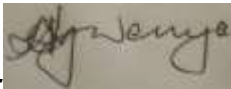
Approval form

The undersigned certify that they have supervised, have read and recommend to the University for acceptance and examination a research project entitled

The impact of technology in teaching and learning of Biology at Mauya Adventist High School.

submitted by Gora Tariro (B226241B) in partial fulfilment of the requirements for the award of the diploma in science education.

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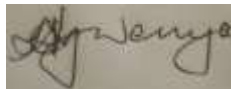
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Date: --07/07/2025

To be completed by the chairperson of the department

I certify to the best of my knowledge that the required procedures have been followed and the preparation criteria have been met for this dissertation

Chairperson 's Signature:-

A handwritten signature in dark ink, appearing to read 'Ngwenya', is written over a light-colored rectangular background.

Date:- 28/08/25

Acknowledgement

I would like to extend my most sincere gratitude to the following, my supervisor Mr Ngwenya for his patience, tolerance and guidance throughout the research and subsequent writing of this thesis.

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The teachers and the learners were pivotal in my research as they provided me with the data that I most needed. Without them, the research would have been a failure. I am really indebted to them for the role they played. May the almighty bless them.

Dedication

This study is dedicated to my parents Jonathan Gora and Agness Gora who were supportive to me, financially and morally during the whole study.

RELEASE FORM



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Chapter 1: Introduction

1.1 Background of the Study

The application of technology in education has revolutionized the teaching and learning process of science subjects, particularly Biology, over the past few decades. Advances in digital software tools, software, and internet-based platforms have provided educators and learners with new means of enhancing the learning process. Teaching and learning Biology, with complex concepts, experiments, and statistical analysis, has particularly benefited from some of the advances such as virtual labs, simulations, interactive multimedia, and online collaboration tools.

The use of technology to teach biology has been driven by the need to enhance learning as being more interactive, accessible, and more effective. Traditional education methods, which normally rely on textbooks and lectures, sometimes fail to capture the experimental and dynamic nature of biology. Technology offers a way of bridging this gap by offering interactive and stimulating learning experiences that can cater to diverse learning styles and capacities. For example, virtual

reality (VR) and augmented reality (AR) can bring abstract biology concepts to life, whereas data analysis programs can facilitate visualization and interpretation of intricate data sets.

In addition, the COVID-19 pandemic opened doors for technology usage in education as schools and universities worldwide shifted towards online learning. This sudden turn of events put on the foreground both the potential and issues of using technology in teaching, particularly in biology involving interactive experimentation and laboratory work. There is therefore a heightened requirement to understand the impacts of technology in teaching and learning biology, its advantages as well as disadvantages.

1.2 Statement of the Problem

Though technology is used universally for learning, there is still limited overall knowledge of how technology influences teaching and learning of biology. Technology can be utilized to enhance learning outcomes but with limitations regarding its effectiveness, accessibility, and equity. All students are not equally equipped with access to technological facilities, and thus it can create disparities in learning opportunities. Additionally, the rate at which technology evolves can make it difficult for teachers to keep up with the latest tools and best practices for integrating technology into teaching.

Further, it is important to explore how technology influences different fields of biology, that is, conceptualization, hands-on competency, and analytical thinking. While some studies have found that technology can be used to boost student motivation and participation, other studies have bemoaned the same for deep learning and the development of critical scientific aptitudes. For instance, while it may be easier for students to conduct experiments in virtual labs, it may also limit their access to experiential, real biology training. This research therefore attempts to bring into focus the impact of technology in teaching and learning of Biology at Mauya Adventist High School

1.3 Research questions

1.3 1. To what extent does incorporation of technology affect the learning achievements of Biology learners?

1.3.2. How does application of technology affect the comprehension and memorization of biological concepts among learners?

1.3.3. What are the challenges to the teacher and learner when they apply technology for the education of Biology?

1.4 Objectives of the Study

1.4.1. To assess the contribution of technology to students' success in Biology.

1.4. 2. To examine the challenges and problems to using technology in Biology.

1.4.3. To ascertain the effectiveness of different technological tools in biology teaching and learning

1.5 Assumptions of the study

It is presumed that

1.5.1 technology is being used in teaching and learning of Biology at Mauya Adventist High School

1.5.2 The teachers and learners will respond honestly and accurately to interviews or any other data collection format.

1.5.3 The students and teachers picked for sampling in this study are indicative of the overall population at Mauya Adventist High School.

1.6 Significance of the study

1.6.1 To teachers. The research will be more informative to instructors regarding the impacts of technology in teaching and learning of biology. It will also enable them to deal with challenges that might be caused with the use of technology in teaching and learning of biology.

1.6.2. to curriculum designers. From the impact of technology in learning and teaching Biology, curriculum designers can come up with guidelines and resources that guide teachers in the application of effective pedagogical practices

1.6.3. to learners. Through research, learners can gain digital skills. With the exploration of technology's role in learning, learners can achieve required digital skills, where they will compete in the current world.

1.6.4. to schools. The study can use the results to inform decisions in the schools on incorporating technology such that it is utilized effectively in making optimal use of resources. Also by embracing technology and improving education, the school will gain its reputation and have an increased number of students enrolling.

1.7 Limitations of the study

The limitations are thought to be the potential weaknesses of the study, and these were

1.7.1 The time was so constrained due to the fact that the researcher was in school for only one term and the researcher needed to limit the participants taking part in the study.

1.7.2 The researcher lacked the finances to buy research materials required and buy bundle to communicate with the supervisor seeking assistance.

1.7.3 The narrow focus of the study on one school and it limited the generalization of the data to other schools

1.8 Delimitations of the study

The research will be conducted in Mashonaland west province in Hurungwe District at Mauya Adventist High School with form three[3] students of biology. The students will be fourteen[14] to sixteen[16] years old. The class will be of mixed abilities and will comprise thirteen [13] females and nine[9] males. The students come from different cultures of families in Zimbabwe. The research will look at on the impact if technology on teaching and learning of biology

1.9 Definitions of terms

1.9.1. The term impact refers to observable or measurable effect, influence, or outcome of intervention, action, technology, or policy on a system, individual, group, or environment (Gremier et al., 2001). It can be negative or positive, intended or unintended and is most often measured by qualitative or quantitative assessment methods (Patton, 2008).

1.9.2. Student Learning Outcomes (SLOs) are statements that describe the knowledge, skills, attitudes, or habits of mind students are supposed to acquire from completing a course, program, or educational experience (Suskie, 2018). Outcomes are typically quantifiable and point to what students can do as a consequence of having completed their learning activities.

1.9.3 Technology refers to the application of scientific knowledge, materials, tools, and procedures to overcome everyday problems, increase efficiency, and enhance human abilities (Volti, 2017). It is both physical devices (e.g., machines, computers) and abstract systems (e.g., algorithms, programs) created to serve specific purposes in various areas, like industry, communication, medicine, and education (Roush, 2005).

1.9.4. Technological tools refer to machinery, software, or systems that are specifically designed to perform specified tasks, enhance productivity, and resolve problems by using science and engineering principles (Jonassen, 2000). These technological tools may be physical (e.g., equipment, sensors, computers) or computer-based (e.g., software programs, algorithms, AI systems) and are utilized in various disciplines from education, health, business, and engineering (Norman, 2013).

1.9.5. Effective use of technology is defined as the strategic, intentional, and pedagogically sound use of technological tools to increase learning, productivity, or performance and align with particular goals and user requirements (Mishra & Koehler, 2006). It is more than simply having

access to technology—it needs thoughtful integration, training for users, and ongoing analysis to support consequential consequences (Puentedura, 2014).

1.10 Chapters layout

1.10.1 Chapter 1. Introduction and content : State the problem statement, background, research goals, assumptions, importance, limitations, delimitations, most important definitions, and chapter outline

1.10.2 Chapter 2. Literature review: Summarizes pertinent literature on

1.10.3 Chapter 3. Research Methodology: Describes the mixed methods approach, stating the research design, data collection instruments, sampling techniques, and analysis techniques

1.10.4 Chapter 4. Results and findings: Presents qualitative findings data, reflecting on the use of technology in teaching and learning Biology as a subject

1.10.5 Chapter 5. Discussions, conclusion and Recommendations: Interprets results in the context of dominant theories and literature, discusses educational implications and offers recommendations to educators and policy makers. Summarizes study main findings, outlines contributions to knowledge, discusses limitations and offers recommendations for future research and practice

1.11. Chapter summary

In this chapter, the researcher has provided the background of the study, statement of the problem, research questions, purpose, significance of the study, and limitation of the study. Delimitation of the study was also discussed. Definitions of major terms have been provided here. What else researchers have done on the impacts of technology on biology learning and teaching will be discussed in the next chapter.

CHAPTER 2 : LITERATURE REVIEW

Introduction

The chapter provides the existing literature regarding the impact of technology In biology education and learning delving into its benefits, limitations and potential applications.

2.1 The positive impact of technology to the students.

Technology has significantly contributed to the process of learning for biology students by improving accessibility, interaction, and understanding of complex concepts. Tools like virtual dissections e.g BioDigital and Labster allow for exploration of anatomical structures without physical specimens, allowing for greater learning and retention Rutten et al., 2012.

Technology also provides Augmented Reality (AR) & Virtual Reality (VR). AR applications e.g., Complete Anatomy may facilitate interactive 3D explorations of biological systems, advancing spatial sense Kamarainen et al., 2013.

Technology also provides for access to Online Resources and Open Educational Materials. Digital Textbooks & OpenCourseWare e.g Khan Academy, Course provide good-quality, free biology content, balancing the field for education Hilton, 2016. Also YouTube & Educational Videos e.g (Crash Course Biology, Amoeba Sisters) promote engagement and simplify challenging concepts Berk, 2009. Technology also facilitate Collaboration and Communication.

Learning Management Systems (LMS) like Moodle & Google Classroom simplify discussion, makes a teachers' life easy to conduct assignments, and give feedback Means et al., 2010. Moreover, web-based Forums e.g ResearchGate, Biology Stack Exchange enable peer-to-peer learning and expert interactions Dabbagh & Kitsantas, 2012. Tools for Computational Biology and Data Analysis are augmented by technology. Bioinformatics Platforms e.g BLAST, RStudio help analyze DNA sequence and statistical information, bridging theory and real-world application Campbell & Nehm, 2013. Further, simulations e.g PhET Interactive Simulations allow experimentation with biological processes like enzyme kinetics Podolefsky et al., 2010. Technology also enables Personalized and Adaptive Learning. AI-Based Tutors e.g Squirrel AI, ChatGPT provides customized explanations and quizzes based on student performance Luckin et al., 2016. Further, Gamification e.g Foldit, DragonGenetics increases motivation with game-based learning Plass et al., 2015. Technology also favors students as it enabled Remote and Flexible Learning Opportunities. Online Labs such as HHMI BioInteractive, LabXchange allow for experiments to be conducted online, which is crucial for distance education De Jong et al., 2013.

2.2 The impact of technology positively to teachers

Technology has transformed teaching biology not only for the students but also significantly enhancing teaching efficiency, engagement, and professional development for teachers.

Technology provides Improved Teaching Tools & Resources.

Digital Simulations & Virtual Labs e.g Labster, PhET, HHMI BioInteractive enable teachers to demonstrate complex biological processes e.g DNA replication, cellular respiration without the laboratory constraints De Jong et al., 2013. It also reduces the cost of lab materials and dissections Rutten et al., 2012. Also, provision of Interactive Whiteboards & Smart Classrooms enable interactive presentation with real-time markings, increasing student engagement Higgins et al., 2007. Technology helps teachers in Effective Assessment & Feedback by students. Automated Grading & Learning Analytics e.g Google Forms, Kahoot!, LMS sites saves time grading and provides immediate feedback Means et al., 2010. It also track student trend patterns of performance to adjust teaching methods Ifenthaler & Yau, 2020. AI-Powered Tools helps create customized assessments within a limited time Luckin et al., 2016. Technology also offers

access to Open Educational Resources (OER) & Professional Development that offers high quality educational resources to anyone connected to the internet at any place and under any economic circumstances. Also Online Databases & online Journals e.g., PubMed, NCBI, Khan Academy provide lesson planning access to recent scientific research Hilton, 2016 which can be accessed to incorporate numerous categories of topics and allow the users to quickly and easily locate the correct information. Also MOOCs & Webinars offer professional development on an ongoing basis in new subject matters such as CRISPR or bioinformatics Dede, 2010. Technology also Increases Student Engagement & Differentiated Instruction. Gamification e.g Quizlet Live, Foldit, BioMan Biology boosts the motivation and engagement of students Plass et al., 2015. Moreover, adaptive Learning Platforms e.g DreamBox, McGraw-Hill Connect allow teachers to personalize lessons for different learners Pane et al., 2017.

Technology is also the benefit of Collaboration & Networking Among Educators. Online Communities facilitate peer support and sharing of resources Dabbagh & Kitsantas, 2012 and may provide a secure site for teachers to share their thoughts and opinions especially for shy or intimidated individuals in face-to-face settings. In addition, Cloud-Based Tools e.g., Google Workspace, Microsoft Teams facilitate collaborative curriculum planning among departments Zheng et al., 2016. Technology provides Remote & Hybrid Teaching Flexibility in the form of Flipped Classroom Models that allow teachers to assign video lectures as homework and use class time for discussion Bishop & Verleger, 2013. There will also be implementation of Virtual Dissections that are ethical and inclusive alternatives to students who object to physical dissections Strauss & Kinzie, 1994. Technology offers teachers Real-World Data Integration & Research Skills like Bioinformatics Tools that enable teachers to introduce students to real genomic data sets Campbell & Nehm, 2013. It offers also Citizen Science Projects that connect classroom learning with global research projects Bonney et al., 2009.

2.3 Impacts of Technology on Teaching and Learning Biology Technology has transformed biology education into a more interactive, engaging, and accessible process. 2.3.1. Technology enables Visualization and Simulation of Biological Processes. Computer-aided models, animation, and simulated labs help students visualize complex processes like DNA replication, cellular respiration, and neural transmission Mayer, 2009, and virtual dissections e.g Froguts, BioDigital reduce ethical concerns while improving anatomy knowledge Strauss & Kinzie, 2017.

2.3.2. Technology Makes Learning More Accessible and Flexible. Online study sites e.g Khan Academy, Coursera provide rural students with access to quality biology resources Means et al., 2010. Additionally, flipped classrooms allow students to learn at their own pace by viewing recorded lessons Bergmann & Sams, 2012.

2.3.3. Technology provides Interactive and Engaging Learning Tools like Gamification that enhances students' motivation and learning retention of biology concepts Deterding et al., 2011. Augmented Reality (AR) and Virtual Reality (VR) also provide immersive experiences, like visualizing human anatomy in 3D Wu et al., 2013.

2.3.4. Technology also facilitates Collaboration and Communication between the students and the instructor. Online collaboration tools and discussion boards e.g Google Classroom, Padlet facilitate peer to peer learning and teacher-student communication Palloff & Pratt, 2013. Besides also provides citizen science activities e.g iNaturalist, Zooniverse which allow students to engage in real biological research for real-world purposes Bonney et al., 2014.

2.3.5. Technology offers and provides Instant Access to Latest Information in teaching and learning of Biology. Open educational resources (OERs) and electronic textbooks provide current biological research, as compared to outdated printed books Hilton, 2016. In addition, AI-based tools e.g ChatGPT, Wolfram Alpha give instant explanations of complicated topics like genetics and ecology Luckin et al., 2016 and thus enables learning better.

2.4 : Challenges of technology to the learning of biology

While technology has facilitated education in numerous ways, its use to learn biology also presents several challenges

2.4.1 Due to the use of technology there will be Reduced Hands-on Laboratory Experience. Over-reliance on simulations and virtual labs may exhaust students' hands-on laboratory experience. Hands-on experiments are critical in biology to acquire skills like dissection, microscopy, and biochemical assays. Virtual labs may fail to precisely replicate the touch and observation skills gained through actual experiments Hofstein & Lunetta, 2004.

2.4.2 Furthermore technology can cause Distraction and Reduced Focus. Digital devices laptops, tablets, and smartphones can lead to multitasking and distractions during learning. Studies show that students using technology for non-academic purposes social media, gaming during lectures perform worse in comprehension and retention Rosen, Carrier, & Cheever, 2013.

2.4.3 Technology leads to Superficial Learning Due to Information Overload. There is ample biological information on the internet, and the students may struggle to distinguish reliable sources. It could lead to superficial knowledge or excessive reliance on oversimplified explanations Kirschner & van Merriënboer, 2013.

2.4.4 Technology also reduces Critical Thinking and Problem-Solving Skills. Computer programs e.g tutoring software using AI can provide quick answers without requiring hard analytical thinking. This demotivates students from exercising hypothesis testing and experimental design, which are fundamental skills in biology Willingham, 2008.

2.4.5 Technology Have Equity and Accessibility Concerns. Not all students similarly use high-speed internet or advanced devices. The digital divide will hamper learners who belong to low-income backgrounds, limiting their online biology resource utilizations Selwyn, 2019.

2.4.6. Excessive use of Technology in Assessments affecting students considerably. Automated graders and computerized tests may not assess the higher-order thinking skills of biology, for example, experimental design or interpreting data Bennett & Dawson, 2020.

2.5 Negative Impacts of Technology in Learning and Teaching Biology

Despite the fact that technology has enriched education in multiple ways, its use in teaching and learning biology also comes with several challenges.

2.5.1. Technology reduces learners Hands-on Laboratory Experience. Over-reliance on computer simulations and virtual labs may reduce the capacity of students to conduct practical lab work Hofstein & Lunetta, 2004. Additionally, students may lose essential skills such as dissection, the use of a microscope, and biochemical assays Ma & Nickerson, 2006.

2.5.2. Use of technology may cause distraction and reduced attention. Mobiles laptops, tablets, smartphones are the source of multitasking, which reduces the attention of students in biology classes Sana, Weston, & Cepeda, 2013. Social media and other learning apps divert attention from learning complex biological details Rosen, Carrier, & Cheever, 2013.

2.5.3. Technological overdependence. Overuse of technology may lead to technology overdependence. Students may excessively use online resources e.g Google, AI tools instead of critical thinking and problem-solving Wheeler, 2015.

This may lead to surface learning of biological mechanisms e.g (DNA replication, metabolic pathways) without deep conceptual understanding Clark et al., 2016.

2.5.4. Technology reduces Teacher-Student Interaction. Excessive use of digital tools has the potential to slow down human processes, decreasing individualized comments and advisement Barker & Gossman, 2013. Even automated grading systems may overlook individual student struggles with understanding biological principles Selwyn, 2016.

2.5.5. Technology may lead to misinformation and unreliable sources. There is inaccurate or simplified biological information on the internet which leads to misconceptions Kirschner & van Merriënboer, 2013. Also, content generated through AI e.g ChatGPT provides inaccurate descriptions of complex topics like evolution or genetic engineering Mollick & Mollick, 2023.

2.5.6. Technology is responsible for Health-Related Issues. Prolonged use of screens results in eye strain, headaches, and bad posture Arora et al., 2014. Also reduced physical activity due to excessive dependence on e-learning can lead to sedentary living Straker et al., 2018.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

In this chapter, the researcher outlines how the research was conducted. The researcher gives an overview of the research design and give its justification. The researcher also gives the procedures used in this project and justify them. The chapter also deals with the population, sampling procedure, and research instruments.

3.2 Research design

In this research the researcher used qualitative research method, qualitative research method is an exploratory research methodology used to acquire understanding of human behaviour, experiences, attitudes, and social phenomena through non numerical data. According to Patton, M. Q (2025) According to Robson 2016 a research design is the overall plan of how you will go about tackling your research question(s). A case study was used in this research. As stated by Robert K. Yin, a case study is an empirical inquiry that investigates a contemporary phenomenon

(the 'case') within its real-life context, especially when the phenomenon's and context's boundaries are not evidently clear. In this research, a case study is relevant as both the researcher and the participants are directly engaged in this research. The impacts of technology on biology teaching and learning can be verified by the observer only. There the teaching session will be the right moment to conduct this research since that will be the only time the researcher will have contact with the participants.

3.3 Sample and sampling procedure

A sample is a subset of individuals, items, or events drawn from a population to make statistical inferences about the population. A sample, Kothari (2004) says, is a subset of the population drawn from it to represent the whole. The sample for this study was twenty learners. Participants will be chosen through stratified random sampling. Random stratified sampling according to Cochran 1977 is a probability sampling technique where the population is divided into subgroups (strata) based on shared traits. This ensures that "each subgroup of the population will be properly represented in the sample. This is the most suitable technique because participants will be drawn from different background, age sex and academic abilities."

3.4 Research instruments

3.4.1 Observation is an organized data collection method in research whereby the researcher records behaviors, events, or phenomena during their natural or controlled setting. It involves watching, listening, and noting the particulars without interfering directly, which renders it a basic tool in qualitative and quantitative research.

3.4.2. Interview schedules were conducted on biology teachers, head of department sciences, and biology students in order to gather data on the positive and negative impacts of technology on teaching and learning of biology.

3.5 Data collection procedures

Data as defined by Babbie 2010 Is the unprocessed material collected from observations, measures, or investigations that can be refined to produce useful information. The researcher collected data from her teaching practice at Mauya Adventist High School in Hurungwe District. The headmaster of the school permitted the researcher to conduct the research.

Observations were used by the researcher as she remained in the school because it was a boarding school. It was to see how teachers and students use technology so as to describe the impacts of technology in biology teaching and learning.

The interviews were conducted during free periods to avoid disrupting the lessons. There were 2 free periods in a week. The individuals being interviewed were interviewed one at a time.

Interviews allowed immediate feedback. Data was recorded and collected manually. The data created is shown in the appendix.

3.6 Data analysis techniques used

Data analysis technique according to Creswell is a step-by-step procedures used to organize, interpret and give meaning to collected data to address research questions. The researcher used tables, pie charts, and bar graphs to present her findings since it gave clearer analysis for the results.

3.7 Ethical considerations

As Dierner & Crandall 1978 defined, ethical concerns are the regulations and standards that ensure the protection of participants' rights, welfare and dignity during a study. The researcher explained the purpose of the interview and maintains confidentiality of the data. Written data were kept in a locked cabinet with no access other than the researcher. Data were encrypted in devices with passcodes. Participant names were removed while transcribing data.

3.8 Conclusion

The researcher utilized formal interviews and observations to collect information from the learners and teachers. Utilization of methods that are above and cautious sampling assisted a lot in achieving the answers that are as much rational as possible. The topic area also catered for the research population.

Chapter 4: Data Presentation, Analysis, and Discussion

4.1 Introduction

This chapter presents and discusses the data collected on the impact of technology on the teaching and learning of Biology at Mauya Adventist High School. Results are presented in conformity with the research questions on student learning outcomes, challenges of integrating technology, and best practices for effective implementation. The data is presented in tables, graphs, and descriptive analysis, and followed by discussion of key findings.

4.2 Data Analysis and Presentation

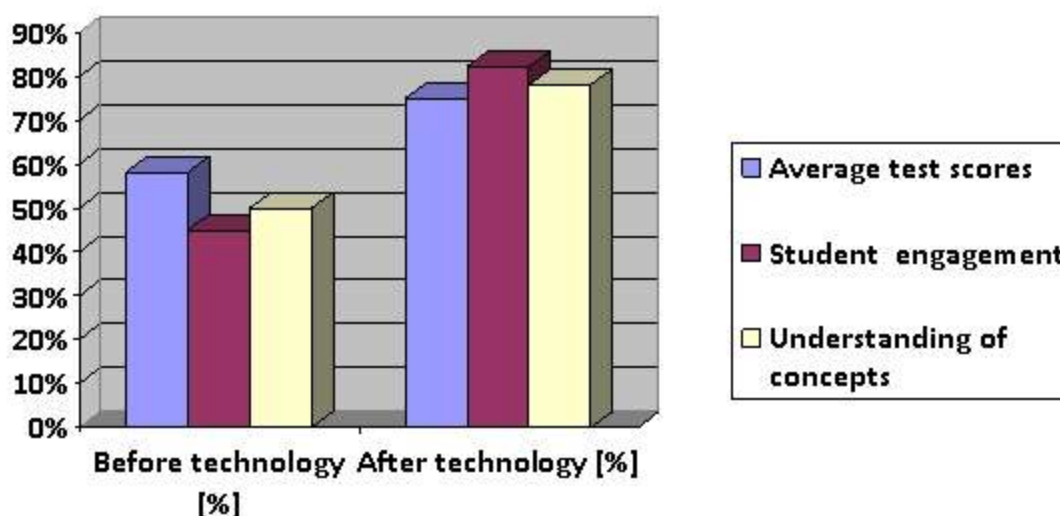
This sub-section gives and analyzes data collected research by research question

4.2.1 Impact of Technology on Student Performance

To analyze the impact of technology integration on student performance, data were collected from students and teachers through questionnaires and tests. The results are given below:

Table 4.1: Student Performance Before and After Technology Integration

Performance Indicator	Before technology [%]	After technology [%]
Average test scores	58%	75%
Student engagement	45%	82%
Understanding of concepts	50%	78%



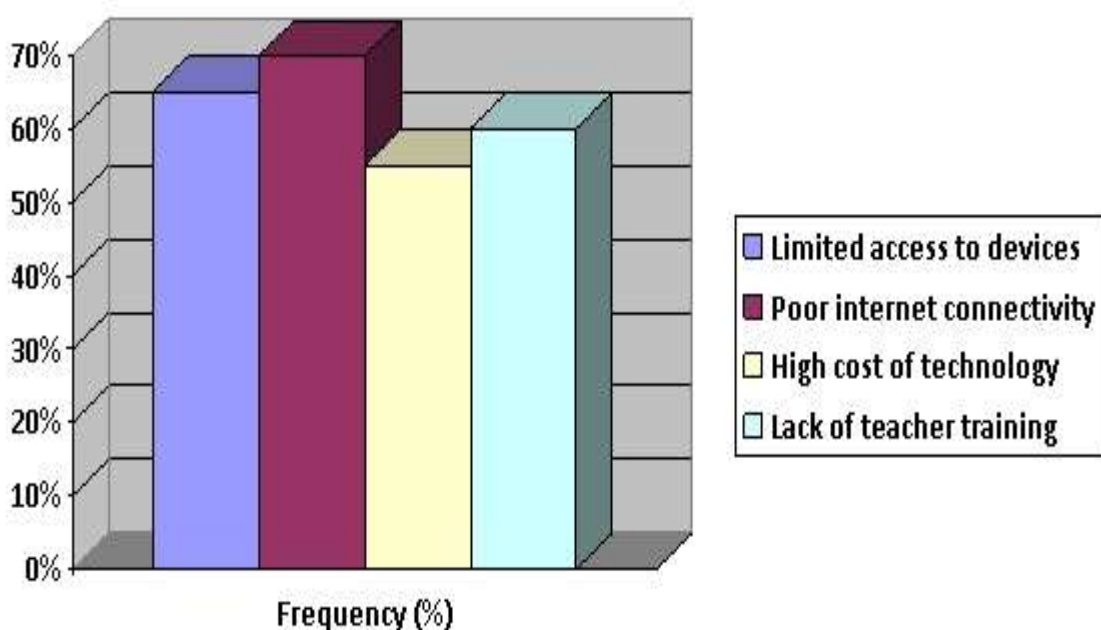
The data show a dramatic improvement in students' performance after integrating technology into Biology lessons. Teachers, during interviews, also attested that interactive simulations, virtual labs, and multimedia tools enhanced understanding and recall of complex biological concepts.

4.2.2 Challenges and Barriers to Effective Technology Use

In spite of advantages, some challenges impede the optimal application of technology in the teaching of Biology. The major challenges outlined are:

Table 4.2:

Challenges	Frequency (%)
Limited access to devices	65%
Poor internet connectivity	70%
High cost of technology	55%
Lack of teacher training	60%



The biggest concern was inadequate internet connection, followed by the lack of devices and the need for better teacher training. A few teachers were not willing to use new teaching techniques but instead favored conventional methods.

4.2.3 Best Practices in Using Technology to Teach Biology

Teachers and students indicated some best practices that can enhance technology integration: In the feedback, teachers emphasized the need for continual professional development and access to excellent-quality digital content. Students proposed further interactive and game-based learning tools in order to keep them interested.

4.3 Discussion of Findings

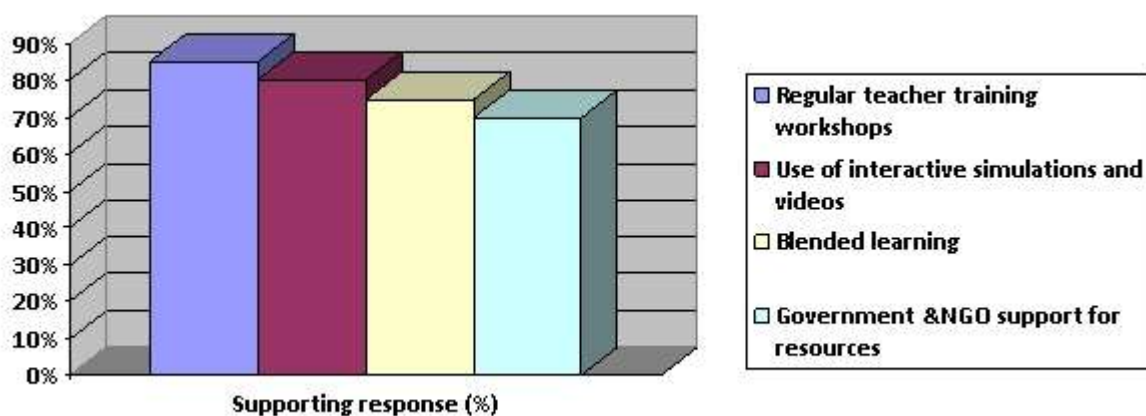
This discussion is discussing the data which is obtained through research questions

4.3.1 Technology Enhances Learning Outcomes

The findings support that technology positively impacts Biology learning at Mauya Adventist High School. Improved test scores and engagement are in alignment with worldwide studies suggesting that computation tools facilitate active learning (Higgins et al., 2012). The virtual dissections and 3D models were particularly valuable in facilitating concise concepts like what happens inside cells.

Table 4.3: Recommended Best Practices

Best practices	Supporting response (%)
Regular teacher training workshops	85%
Use of interactive simulations and videos	80%
Blended learning	75%
Government &NGO support for resources	70%



While technology is beneficial, infrastructural and financial constraints hinder its best realization. Similar studies on rural schools (Selwyn, 2017) highlight that resources and training are limited, which negatively affects implementation. These need to be addressed by policy interventions and stakeholder collaboration.

4.3.3 Adopting Best Practices for Sustainable Integration

Successful technology integration depends on teachers being ready and resources being available. Blended learning emphasis fits with UNESCO's (2021) recommendation for striking a balance between digital and face-to-face modalities. Partnerships with technology companies and NGOs may provide solutions of long duration to the problem of resource inadequacy.

4.4 Conclusion

This chapter explored how technology affects Biology learning at Mauya Adventist High School. Despite that it aids learning, inadequate infrastructure and untrained teachers pose problems that have to be addressed. Adoptions such as teacher workshops and blended learning can optimize utilization of technology. The next chapter will provide conclusions and recommendations on these findings.

Chapter 5: Conclusion, Summary, and Recommendations

5.1 Introduction

The chapter gives the summary of the research on the impact of technology in teaching and learning Biology at Mauya Adventist High School. The chapter provides conclusions based on the findings and offers recommendations to learners, policymakers, and researchers.

5.2 Summary of Findings

The study explored the effect of technology on Biology teaching in Mauya Adventist High School. The results were:

5.2.1. Improved Student Engagement: Projectors, learning apps, and online resources improved student engagement and motivation towards Biology.

5.2.2. Improved Understanding of Complicated Concepts: Graphics, simulation, and virtual laboratories made understanding complex biological phenomena easier (e.g., cellular respiration, DNA replication).

5.2.3. Technology Integration Challenges: Technical difficulties, limited access to technology devices, and poor internet connectivity hampered maximum use of technology.

5.2.4. Positive Perceptions by Teachers: The majority of Biology teachers admitted technology benefits but noted increased need for professional development and infrastructure support.

5.2.5. Performance of Students: Students who had technology-supported learning demonstrated better test scores and retention rates than those taught conventionally.

5.3 Conclusion

The study concludes that technology has a very high positive impact on teaching and learning Biology in Mauya Adventist High School. It enhances participation, simplifies complex material, and raises performance. Lack of adequate access to enough resources and proper training for the instructors, however, deems its maximum potential. Eliminating such barriers is necessary to maximize use of technology in teaching Biology.

5.4 Recommendations

Based on the results, the following recommendations are made:

5.4.1 For School Administration

Invest in modern technology resources (smartboards, tablets, reliable internet).

Organize regular teacher workshops on integrating technology into class.

Establish a computer lab or virtual resource room dedicated to science studies.

5.4.2 For Biology Teachers

Integrate multimedia presentations, animation, and virtual labs into lessons.

Implement blended learning approaches (combining traditional and new approaches).

Collaborate with fellow teachers to share best practices regarding the application of technology.

5.4.3 For Policymakers

Offer financial support to schools to upgrade technological infrastructure.

Implement policies aimed at facilitating teachers' and learners' digital literacy.

Call for collaboration with technology companies to provide affordable learning platforms.

5.4.4 For Future Research

Conduct a longitudinal study of the long-term impact of technology on Biology performance.

Investigate the impact of some technologies (e.g., VR, AI) in science education.

Investigate student and teacher attitudes towards new educational technologies.

5.5 Final Remarks

Technology has transformed Biology education at Mauya Adventist High School, making learning more efficient and engaging. Irrespective of the setbacks, strategic investment and teacher empowerment will even further increase its effectiveness. With the implementation of digital innovation, the school can provide an enhanced stimulating and productive learning environment for students of Biology.

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APPENDIX I

QUESTIONARE FOR LEARNERS

My name is Gora Tariro. I am a student at Bindura University of Science Education pursuing a Diploma in Science Education. I am required to carry out a research project in partial fulfilment of the requirements for diploma. I am carrying out a research on The impact of technology in teaching and learning of Biology at Mauya Adventist High School. I am respectfully requesting your co-operation as research participants to the research understudy by completing the questionnaire. Your answers will be handled as confidential as possible and used only for academic purposes. Your co-operation will be greatly appreciated

Answer the questions below to the best of your knowledge. Do not put your name on the question.

Questionnaire for Students

Personal Information

1.

Gender

☐ Male ☐ Female

2.

Age

☐ Under 13 ☐ 13–15 ☐ 16–18 ☐ Over 18

3.\\tGrade

☐ Form 1 ☐ Form 2 ☐ Form 3 ☐ Form 4

Use of Technology in Biology lessons

5. Which of the following technologies do you use in your lessons?

☐ Computers/laptops

☐ Smartphones or tablets

☐ Projectors or smartboards

☐ Internet or online resources

☐ Biology apps or educational games

☐ Virtual labs/simulations

☐ None

6. How often is technology used in your lessons?

☐ Every lesson

☐ Once a week

☐ Occasionally

☐ Rarely

☐ Never

7. Who usually utilizes the technology during class?

☐ Teacher only

☐ Both teacher and students

☐ Students only

☐ Nobody uses it

Effectiveness of Technology in Learning Biology

8. Technology helps me more to learn Biology concepts.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

9. Videos, diagrams, and animations make Biology easier.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

10. I am more engaged and motivated towards Biology when technology is used.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

11. Technology has helped me improve my performance in Biology.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

12. I prefer to use textbooks and technology when learning Biology.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Challenges and Recommendations

13. What are the challenges you face while using technology for Biology lessons?

(Choose all that apply)

☐ No access to devices

☐ Poor internet connection

☐ Electricity problems

☐ The lessons proceed too fast using technology

☐ I don't know how to operate the tools

☐ Teachers rarely utilize technology

How could technology be utilized more effectively in studying Biology?

(Short answer)

APPENDIX II

QUESTIONERES FOR TEACHERS

Questionnaire for Teachers

Personal Information

1. Gender

☐ Male ☐ Female

2. Which of the following technologies do you use in your lessons?

☐ Computers/laptops

☐ Smartphones or tablets

☐ P

rojectors or smartboards

☐ Internet or online resources

☐ Biology apps or educational games

☐ Virtual labs/simulations

☐ None

3. How often do you use technology when conducting your lessons?

☐ Every lesson

☐ Once a week

☐ Occasionally

☐ Rarely

☐ Never

4. Does Technology helps you understand and teach Biology topics better.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

5. Videos, diagrams, and animations make Biology easier to teach .

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

APPENDIX III

Observation Checklist

Item	Number in place at the school
ICT tools	
Learners who are able to use Technological tools	
Biology teachers who are computer literacy	