BINDURA UNIVERSITY OF SCIENCE EDUCATION

DEPARTMENT OF ENVIRONMENTAL SCIENCE

ASSESSING THE STATE OF ELECTRONIC WASTE MANAGEMENT AT A BINDURA UNIVERSITY SCIENCE EDUCATION

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE BACHELOR OF ENVIRONMENTAL SCIENCE HONOURS DEGREE IN SAFETY, HEALTH AND ENVIRONMENTAL MANAGEMENT

Date: 06/2024

DECLARATION

I**, PANASHE NESHAMBA**, I do confirm that this is my own piece of work and has not been submitted before for any academic reason at this institution or any other academic institution for any purpose.

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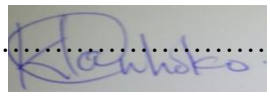
Signature: 

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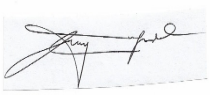
Signature:  ……

Date: 10/10/24…….

DEDICATION

I dedicate this project to my mother Evelyn Govha for her valuable financial assistance and moral support from the start up to the end.To my family, whose unwavering support and encouragement have been the cornerstone of my academic journey. Their belief in me has fueled my determination to pursue this research and achieve my goals. Thank you for your patience, understanding, and constant motivation throughout this challenging yet rewarding endeavor.

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This couldn't have been done without the help, direction, and encouragement of many individuals, for whom I am sincerely grateful. God Almighty, the source of my strength, provides me with both physical and spiritual guidance. Evelyn Govha, my mother, who never stops motivating and supporting me. My academic supervisor Dr L Mabhungu for professionally guiding me and sparing her time even when her schedule was tight, her expert support and vigorous review of all my chapters, her depth and patience made this research possible. I would also like to acknowledge contributions from Mr Nyamugure and Dakarayi Nkomo throughout the course of the project.

I take full responsibility to all errors that may emanate from this research despite all expect guidance from the academic trio.

ABSTRACT

The rapid growth of technology has led to a significant increase in electronic waste (e-waste) generation, posing environmental and health risks. As institutions of higher learning, universities have a critical role to play in promoting sustainable practices and reducing e-waste. The purpose of this study was to investigate the electronic waste stream and generation rate at Bindura University of Science Education, assess the e-waste management practices in place, and evaluate students' knowledge, awareness, and attitudes regarding e-waste management practices according to faculties. A mixed-methods approach was employed, combining both quantitative and qualitative data collection and analysis methods. Questionnaires were used to collect information on students' knowledge and awareness regarding electronic waste management and it was analyzed using SSPS tools. Interviews were conducted to gather detailed information on current practices related to electronic waste management, the rate of electronic waste generation and electronic waste streams which was analyzed and presented by MS Excel tools. The study revealed that the e-waste stream at Bindura University of Science Education is characterized by a high proportion of electronic devices such as desktop computers, printers, and charger cables.

A survey of 61 students from five faculties revealed significant gaps in their knowledge and awareness of e-waste management practices. The findings indicated that students from the Faculty of Agriculture and Environmental Science had higher knowledge levels compared to those from other faculties. However, all students demonstrated positive attitudes towards e-waste management practices. The study recommends the development of an e-waste management policy at the university, education and awareness programs for students and staff, and the establishment of a formal e-waste recycling program. This study contributes to the existing body of knowledge by providing insights into e-waste management practices at a university setting in Zimbabwe. The findings can inform the development of effective e-waste management strategies that can be replicated in other universities in Zimbabwe and beyond.

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LIST OF ACRONYMS AND ABREVIATIONS

WHO	WORLD HEALTH ORGARNISATION
EMF	ELLEN MACARTHUR FOUNDATION
UN	UNITED NATIONS
NEMAS	NATIONAL E-WASTE MANAGEMENT STRATEGY
EMA	ENVIRONMENTAL MANAGEMENT ACT
SSPS	STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES
UNEP	UNITED NATIONS ENVIRONMENTAL PROGRAMME
E-WASTE	ELECTRONIC WASTE
HDMI	HIGH DEFINITION MULTIMEDIA INTERFACE
ICT	INFORMATION COMMUNICATION TECHNOLOGY

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Electronic waste (e-waste) refers to abandoned electrical or electronic equipment which is considered of no use. According to the United Nations Step Initiative (2014), the term E-waste refers to all kinds of electronic and electrical equipment and its components that are no longer in use and are discarded. At the international, regional, and national levels, electronic waste management is required through considering the electronic waste generated, raising awareness of electronic waste management strategies, and implementing practices to deal with its impacts.

In the year 2019, only 17 percent of the total electronic waste produced worldwide was formally collected and recycled (WHO, 2023). This can lead to human exposure to harmful substances which included lead, mercury, cadmium, and dioxins, which may have detrimental effects on neurodevelopment at informal workers in recycling sector (WHO, 2023). To address health problems imposed by electronic waste, the UN is collaborating with several organisations to advance research on e-waste and its health implications (UNEP, 2023).

According to Global Waste Monitor (2020), the total amount of electronic waste produced worldwide had increased from 44.7 million metric tons generated in 2017 to 53.6 metric tons in 2019. The increase was due to the rapid technical developments and a lack of public awareness (Massa et al, 2023). When electronic devices are not disposed of appropriately, the electronic waste can have negative effects on the environment and human health (Massa et al, 2023). The increase in digital work and the demand for electronics are other factors that lead to electronic waste pollution.

Globally, nations are actively addressing the problems associated with electronic waste and enacting legislation, regulations, or other measures at the national level to control it (Heacock, 2016). By October 2019, the number of countries implementing electronic waste regulations and legislation had risen from 66% in 2017 to 71% in 78 nations (Maes et al, 2022).

Many African nations do not have plans in place for the management of electronic waste. According to Machete (2017), there are no management mechanisms in place in South Africa that handle electronic and electrical waste in a way that is safe and sustainable, and the waste ends up in landfills. Rwanda has been the leading country in Africa in managing electronic waste since the opening of its first electronic waste treatment plant in 2020 and it is also one of the few countries to have electronic waste laws (Tetra Tech International Development, 2021). Only a few countries in Africa have made progress in improving electronic waste management.

According to Macherera et al (2023), Zimbabwe has no legislation that helps in the management of electronic waste. This has resulted in electronic waste being treated as municipal waste and ending up in landfills with some toxic elements being leached ending up in underground water (Teta et al, 2017). According to Maphosa (2021), universities are adapting to improve their learning standards by increasing electronic devices that may include projectors and printers, which has increased their electronic waste generation. Bindura University has introduced more degree programs that include software engineering leading to more electronic waste being generated. The innovation hub has been opened recently, increasing chances of electronic waste generation yet there are little or no measures taken to manage electronic waste.

There is a need for more effective policies and legislations to improve electronic waste management in Africa. Implementing strategies to reduce electronic waste discharge into the environment is also necessary to mitigate the negative health effects of poor electronic waste management. Furthermore, there is a need to promote sustainable electronic waste management strategies on universities, which can serve as a model for other institutions and communities. At the Bindura University, there is no communicated policy on electronic waste management that is available to students. Additionally, there are no separate bins for other solid waste and electronic waste. There is a research gap on the implementation of electronic waste management practices in universities, particularly in Africa. Further research is needed to investigate the effectiveness of various strategies and identify best practices for reducing electronic waste generation and promoting sustainable management practices in universities.

1.1 PROBLEM STATEMENT

Bindura University has an increase in electronic device use and it has led to the accumulation of electronic waste on the university campus, posing a risk to the environment and public health. The building of new hostels being done by the university has also given room to increase in waste generation also posing the need for electronic waste management. It's essential to assess the current practices and challenges facing electronic waste management at specific institutions, such as Bindura University, to develop effective solutions. Understanding the volume, types and disposal methods of electronic waste generated by the university can provide valuable insights for implementing sustainable electronic waste management practices.

1.3 AIM

To assess the current state of electronic waste management at a Bindura University Science Education

1.4 OBJECTIVES

- Determining the electronic waste stream and generation rate at Bindura University of Science Education
- Determining the current electronic and electrical waste management that is in place at Bindura University of Science Education
- Evaluate students' knowledge, awareness and attitude levels regarding electronics waste management practice.

1.5 JUSTIFICATION

This research will give an insight into the action being taken by the university on managing electronic and electrical waste. Furthermore, it can be used to determine the awareness levels of students regarding electronic waste management practices. This research study can be used to develop a waste management plan or procedure based on the research findings. It can help in understanding the environmental impact of electronic waste generated by the university, including the potential hazards posed by improper disposal. Moreover, evaluating the current electronic waste management practices, the university can identify areas for improvement and implement more

sustainable and environmentally friendly strategies. Additionally, such an assessment can raise awareness among students and staff about the importance of responsible electronic waste disposal and foster a culture of environmental consciousness within the university community.

CHAPTER 2: LITERATURE REVIEW

2.1 ELECTRONIC WASTE MANAGEMENT

Electronic waste management comprises of different processes that start from the disposal area to the recycling and recovery point. Firstly, there is the collection of electronic waste through various programs or events organized by municipalities or recycling organizations from business areas, schools, and households (Jain et al., 2017). Moreover, specialized vehicles are used for the transportation of electronic waste to recycling facilities, with proper handling to prevent pollution or damage (Yu et al., 2020). The breaking down and separation of electronic waste is conducted according to materials such as glass, metals, circuit boards, and plastics using automated machines or manual labor, which aids in proper recycling and treatment of electronic waste (Karadal, 2019). The recycling process involves shredding, refining, and sorting of materials to produce new products (Ravi et al., 2016). Lastly, proper disposal methods like incineration are employed when necessary at facilities that can safely handle hazardous components of electronic waste (Zhou et al., 2018).

2.2 EFFECTS OF ELECTRONIC WASTE ON HUMANS

Improper disposal of electronic waste, open burning, and dismantling of electronic waste in uncontrolled settings can lead to the release of toxic substances into the environment. This can cause soil, water, and air pollution, posing a risk to the environment and communities (Asante et al., 2017). Electronic waste has effects on human health due to the toxic components that include mercury, cadmium, lead, and brominated flame retardants. These toxic elements can have effects on wildlife and humans by accumulating through the food chain (Hopke et al., 2017). Some of these elements, like cadmium and flame retardants, can be carcinogenic and can affect vital organs in the human body, such as the lungs and kidneys. Table 2.1 summarises the elements` found in electronic waste and their effects on humans

Tab 2.1 A summary of elements` found in electronic waste and their effects on humans

Pollutant	Source	Effects on humans	References
Cadium	Rechargeable batteries, semiconductors and circuit boards	Kidney dysfunction, lung damage, reproductive issues	Elzorro, 2019
Brominated flame retardants	Electronic products (They reduce the risk of fire)	Neurological effects, endocrine disruption, potential carcinogenicity	Weiss et al., 2019
Lead	Cathode ray tubes (Old TVs and monitors)	Neurological and developmental effects on children, damage, kidney damage, cardiovascular and kidney damage	Abbasi et al., 2018
Mercury	Fluorescent lamps and batteries	Respiratory issues, neurological damage and kidney damage	Hopke et al., 2017

2.3 CIRCULAR ECONOMY PRINCIPLES IN ELECTRONIC WASTE MANAGEMENT

The circular economy principles are put in place to keep resources in use for a long time through repurposing and recycling, thereby reducing waste (Ellen MacArthur Foundation, 2017). The principles are also applied to conserve natural resources and energy by reusing products to increase the lifespan of the product (Kirchherr et al., 2017). The design and implementation of systems that help in the recovery and repurposing of products are also covered by one of the circular economy principles (EMF, 2017). According to the Ellen MacArthur Foundation (2017), the key principles of the circular economy are: Design out waste and pollution, Regenerate natural systems (practices that prevent the destruction of ecosystems), keep products and

materials in use (application of reuse and repairing), and design for the future (designing a product that can be sustainable). The circular economy is based on waste reduction, which can help manage electronic waste at a university.

One of the principles that can be applied is through electronic waste recycling and collection programs. Discarded electronic waste can be collected at the university by setting up collection points so that it doesn't end up in landfills. Collection points can be installed at university campuses and hostels (Mihai, et al., 2020).

Promoting refurbishment and reuse is essential as application of the circular economic principle. Repairing electronic equipment to reduce the need to purchase new items can decrease electronic waste generation. This can be achieved through buy-back programs and repair workshops. Partnering with refurbishment facilities is also recommended. The application of this principle can help extend the lifespan of electronic equipment (Ardente. et al., 2017).

Procurement policies that supports the purchasing of environmental friendly and electronic equipment that is energy efficient. The application of this principle on electronic can reduce environmental impacts throughout the life span and preventing the release of toxins into the environment disposal. This include the purchasing of latest versions of electronic equipment (Bocken et al., 2016).

One of the major problems faced by universities is a lack of awareness on electronic waste management. One principle that can be applied involves educating the university community. This includes teaching sustainable behavior to students and staff to promote proper electronic waste management. Therefore, workshops and educational campaigns can be conducted (Rehner et al, 2014).

The application of research and innovative technology is also one of the circular economic principles that can be applied. By implementing circular economy strategies and technologies, solutions to the electronic waste problem can be offered. This may involve the construction of recycling facilities (Bakker, C. A. et al., 2014).

By incorporating these circular economy principles into electronic waste management practices at universities, institutions can reduce their environmental footprint, promote resource efficiency, and contribute to a more sustainable future.

2.4 REGULATORY LAWS FOR ELECTRONIC WASTE MANAGEMENT IN ZIMBABWE

Zimbabwe has adopted the Basel Convention, which facilitates the transboundary movement of hazardous waste (UNEP, 2023). In Zimbabwe, electronic waste is classified as hazardous waste and is therefore governed by the Basel Convention (Maphosa et al, 2022). This enables the proper transboundary movement, handling, and disposal of waste. However, electronic waste trafficking continues to occur despite the existence of the convention.

Despite having no laws that govern electronic waste management, Zimbabwe has developed the National E-Waste Management Strategy (NEMAS) (Government of Zimbabwe, 2021). This strategy aims to address the growing challenges caused by e-waste by outlining objectives, targets, and action plans for e-waste collection, recycling, and awareness-raising initiatives. However, there is a massive lack of public awareness, stakeholder coordination, and limited implementation of NEMAS. Additionally, Electronic Waste Regulations are currently in development in Zimbabwe (Government of Zimbabwe, 2021). These regulations will focus on electronic waste management and aim to provide guidance on handling, recycling, and disposing of electronic waste. However, addressing the informal sector may cause a challenge for these regulations, enforcement and alignment with existing legislation may also be difficult.

The Environmental Management Act (EMA) also aims to reduce the hazards associated with improper waste disposal and minimize environmental pollution. The EMA Act in Zimbabwe provides guidelines for the proper disposal of waste. Although this Act does not specifically provide guidance on electronic waste, it results in electronic waste being treated as other solid waste. The Act emphasizes the treatment, recycling, and safe disposal of waste in Section 71. According to Masarakufa et al. (2019), challenges still arise in the effective implementation of the EMA Act. These challenges include lack of public awareness and limited resources. Moreover, there is a need for education on the proper disposal of electronic waste and strengthening the implementation of the EMA Act to address the issues related to electronic waste (Chikurunhe et al., 2020).

The Bamako Convention aims to control the transboundary movement of waste by providing a framework for the import and export of waste, thereby reducing the effects of improper waste disposal. In Zimbabwe, it is also used to regulate electronic waste

management practices (Macherera et al., 2023). The Bamako Convention aims to regulate the transboundary movement of hazardous waste in Africa, while the Basel Convention deals with the movement of hazardous waste globally, but both promote environmentally sound disposal of waste (Bakare et al., 2021). However, there is a need for enforcement of the convention regulations and collaboration with relevant stakeholders such as government agencies to ensure compliance (Macherera et al., 2023). Moreover, there is a need to align local policies with the Bamako Convention to ensure its effectiveness (Rehema et al., 2021).

2.5 ELECTRONIC WASTE SOURCES AND GENERATION

Electronic waste is a major concern globally due to technological advancements. Additionally, the replacement of equipment with short life spans is also a significant cause of electronic waste, as highlighted by several studies. According to Alwera et al. (2019), laptops and smartphones were found to contribute to electronic waste generation at a university in Malaysia. The researchers recommended the implementation of sustainable waste disposal practices for electronic waste to reduce environmental impacts. A wide range of batteries, chargers, printers, and monitors were found discarded after a study conducted at a university in Pakistan (Khan et al., 2020). They emphasized the importance of raising awareness and conducting educational campaigns to promote proper waste disposal within the university community.

At universities in Zimbabwe, an increase in the reliance on electronic devices by students for academic purposes, such as smartphones, tablets, and laptops, is leading to the accumulation of electronic waste on campus. This highlights the need for a proper strategy to manage electronic waste (Mawere, 2018). The replacement of IT equipment in university libraries and offices also contributes to electronic waste generation. Additionally, the technological infrastructure used for academic research also poses a risk of electronic waste generation (EMA, 2021). The Environmental Management Agency (EMA, 2021) has suggested the collection of electronic waste within university campuses for proper disposal and recycling.

The use of online resources and the adoption of electronic learning platforms by universities are further contributing to electronic waste generation. This is evident through the use of storage devices, network equipment, and other communication infrastructure as a result of rapid digitalization (Chigwati et al., 2020). Printers,

photocopiers, and scanners found in offices and university departments also generate electronic waste. These equipment have a short lifespan and may require frequent replacement compared to other equipment (Ncube et al., 2019).

2.6 KNOWLEDGE, AWARENESS AND ATTITUDE TOWARDS ELECTRONIC WASTE MANAGEMENT

There are several studies that have gave insight on knowledge and awareness towards electronic waste management at universities globally and regionally (Amhad et al, 2019; Hansen et al, 2019; Mwema et al, 2019).The studies emphasized on the need of awareness campaigns and partnerships with recycling institutes the knowledge and awareness of students towards electronic waste. It was highlighted in the studies that students' knowledge and awareness varied with degree programs they were studying. Table 2.2 summarises some of the findings of studies conducted on knowledge, awareness and attitude towards electronic waste management.

Table 2.2 Knowledge and awareness towards electronic waste management

STUDY	RESULTS	REFERENCES
Awareness and knowledge assessment towards electronic waste management: a case of selected universities in Zimbabwe. (2021)	Recommended the need of awareness campaigns towards electronic waste management There was lack of awareness of electronic waste management among staff and students	Moyo et al.,2021
Assessment of electronic waste management practices in selected universities in South Africa. Waste Management and Research (2019)	There was lack of proper electronic waste collection leading to improper disposal Recommended the need of developing electronic waste management policies at universities	Alabi et al, 2019
E-waste management in universities: A case study of Copperbelt University in Zambia	Poor electronic waste management practices within students because of inadequate infrastructure Recommended the partnership of institutes with recycling of electronic waste facilities	Lwembe et al, 2018

Challenges and prospects of e-waste management practices in higher institutions in Nigeria (2019)	There was low awareness levels on proper electronic waste management for both staff and students at of institutions Awareness programs and training sessions were recommended to give insight on electronic waste management on both staff and students.	Nyokangi et al.,(2019)
Awareness and attitude towards electronic waste management among University Students in India (2018)	The level of awareness towards electronic waste management varied among students although the majority were aware of the practices Offering trainings to improve knowledge of electronic waste among students was recommended	Gupta et al, 2018

CHAPTER 3: METHODOLOGY

3.1 STUDY AREA DESCRIPTION

The study area, Bindura University of Science Education, is located in the Mashonaland Central Province in Zimbabwe (17.3246°S, 31.3327°E) (Fig. 3.1). The university offers various programs which include commercial, arts, and science programs. It comprises four campuses that all engage in the use of computers in offices, libraries, and computer laboratories. The faculty of science and engineering houses the electronic engineering and computer-related programs. An innovation hub has been recently opened to offer the advancement in technology. The university has also engaged in electronic learning making a further step in technological advancement.

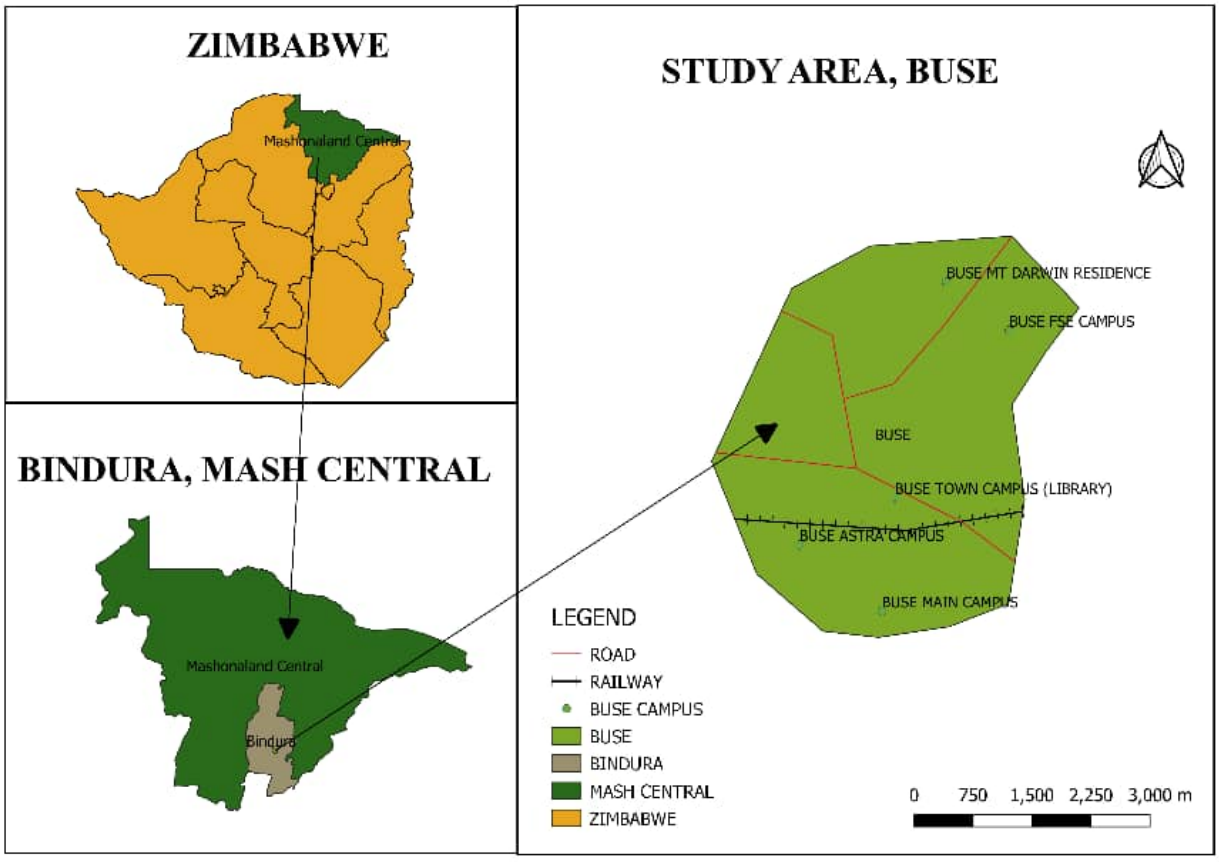

Fig 3.1: location of study area

3.2 RESEARCH DESIGN

The study is based on a cross-sectional study assessing the electronic waste management on Bindura University campuses. Data from questionnaires was used to determine the level of student awareness of electronic waste management practices. Data on electronic waste management practices done at Bindura University of Science Education was gathered through an interview.

3.3 STUDY POPULATION AND SAMPLING FOR THE QUESTIONNAIRE

The target population for the questionnaire comprised 4800 and the population size was 7000. Block-release students, Part 3s (except for those doing optometry) and Part 4s of electronic engineering were not considered because they were not on campus during the time the research was conducted The population was distributed in five faculties, and their populations are shown in Table 3.1.

The sample size for questionnaire respondents was determined using Cochran's formula (Israel, 2009). However, the confidence level was reduced from 95% to 88% due to the large population size and the short time available to conduct the research. The sample size was calculated by Cochran's formula to be 70 members for questionnaire respondents (Israel, 2009). The population was divided into five strata based on faculties. Since the populations of each faculty were slightly different, the number of sample members was equalized across each stratum, resulting in a sample size of 14 questionnaire respondents per faculty. The calculations are presented in Appendix I.

Stratified sampling was done to eliminate bias because the students at the Faculty of Agriculture and Environmental Science might have a more know-how of electronic waste than other campuses

Table 3.1 Sample size for questionnaire

Faculty	Populations	Sample size
Faculty of Science Education	1000	14
Faculty of Agriculture Environmental Sciences	900	14
Faculty of Commerce	1000	14
Faculty of Social Sciences and Humanities	1100	14
Faculty of Science and Engineering	800	14

3.4 TARGET POPULATION FOR INTERVIEW

The target population for the interview included members of staff that are involved in electronic equipment procurement, storage, disposal and maintenance. The population comprised of 7 computer laboratory technicians from the faculties and 1 technician from the IT department. Three computer technicians were randomly selected for the interview.

3.5 DATA COLLECTION

The study employed a combination of questionnaires and an interview that were used to acquire primary data. Interviews were conducted to gather detailed information on current practices related to electronic waste management, the rate of electronic waste generation and electronic waste streams. Additionally, questionnaires were used to collect information on students' knowledge and awareness regarding electronic waste management.

3.5.1 INTERVIEWS

Interviews were held with three of the computer technicians. A discussion was conducted with follow-up questions on the ways and methods used to dispose of electronic waste, using an interview guide (Appendix 3). Future plans on electronic waste management and challenges faced in managing electronic waste were also discussed during the interview session. Furthermore, the interview was used to acquire information on electronic waste generation at computer labs and management practices at Bindura University. Finally, to conclude the interview, the stakeholder was asked to provide recommendations.

3.5.2 QUESTIONNAIRES

Structured questionnaires were used to assess the student's awareness of the electronic waste management system (**Appendix 2**). The questionnaires consisted of closed and open-ended questions. The questionnaires were used to determine the student's knowledge of electronic waste disposal methods, views on recycling, and perceptions of the current electronic waste management practices. The questionnaire had five sections: (A) demographic information of students, (B) knowledge and awareness of electronic waste management, (C) attitudes on electronic waste management, and (D) behavior related to e-waste disposal on campus. The answers to questionnaires were coded and made to suit the data presentation in chapter four. A questionnaire was used because the respondents could answer without hesitation or fear of judgment from the interviewer (Flairclough et al, 2021). In addition, a questionnaire was convenient since a survey was done on a large number of the population.

3.5 DATA ANALYSES

The Statistical Package for the Social Sciences (SPSS) and Microsoft Excel (2014 Version) program were used to examine the information gathered from the electronic waste management questionnaire. The chi-square test was used to determine the relationship between Faculty and electronic waste management using the cross- tabulation on SPSS. Moreover, the frequencies tool in SPSS was used to determine the percentiles and the frequencies of data from questionnaires. Microsoft Excel was used to design graphs of qualitative data. All questions were awarded 1 point for each “yes” response and no point for a “no” response. Awareness had a total of 10 maximum attainable points whereas attitude and practice had 10 maximum attainable points. Awareness points <5 was considered as inadequate whereas behaviour and attitude points <7 were classified as unsatisfactory. The participants' answers to each question were compiled using descriptive statistics, such as frequencies and percentages.

CHAPTER 4: RESULTS

4. 1 ELECTRONIC WASTE MANAGEMENT AT BINDURA UNIVERSTY

The results were the same for all three technicians on electronic waste management practicises. Electronic waste management at Bindura University is partly covered by Section 12 of the ICT Policy of Bindura University. Although the ICT policy is comprehensive, it contains many policies that govern the IT University's work, including proper documentation of procedures. The policy outlines the Maintenance Policy, which provides guidelines on how to maintain equipment, thereby increasing its lifespan. Additionally, the university has a Procurement Policy that ensures the purchase of good electronic equipment that can last long, reducing electronic waste.

When electronic equipment breaks down and is no longer in use, it is put up for auction. In cases where the damage is not severe, the university outsources maintenance to other maintenance companies. However, there is no specific policy in place for the disposal of electronic waste. There were no collaborations with other institutions on sharing electronic waste management practices. Future plans have not yet been discussed for the management of electronic waste at the university. Although other procedures are mentioned in the ICT policy, there is no documented recycling procedure for electronic waste in the policy. Bindura University had only 2 out of 8 expected requirements met for proper electronic waste management practices, according to all three technicians. Tables 4.1 summarize the findings from all three technicians.

Table 4.1 Electronic waste management practices available according to Technicians

Requirement	Score	
	Yes	No
Documented recycling procedure		✓
Electronic waste management policy		✓
Collaborations with other institutes		✓
Trainings on disposal methods		✓
Future plans on the management of electronic waste		✓

Documented electronic waste disposal procedure		✓
Methods of reducing electronic waste	✓	
Collaborations with other organizations	✓	

Key

Score	Representation
0	No
1	Yes

4.2 CHALLENGES FACED BY TECHNICIANS IN MANAGING THE ELECTRONIC WASTE

Firstly, data Security risks is also part of the challenges faced by technicians in managing the electronic waste. There is a potential risk of a data breach or unauthorized access to information when handling electronic waste containing personal data. Insufficient resources for managing electronic waste is also a challenge faced by technicians. The lack of recycling facilities and electronic waste management options can interfere with personal budgets and cause financial strain. Complexity of electronic waste is also a form of challenge faced by technicians. The variety of devices, including computers and servers, can be difficult to manage, as they often have many components and require specialized handling. The lack of enforcement of electronic waste laws and regulations, as well as the absence of a comprehensive electronic waste policy, can make it difficult to comply with relevant regulations. Moreover, it is challenging to sustainably manage electronic waste, as it requires aligning daily work with electronic waste management which can be difficult to achieve in a busy work environment. Lastly, there is inadequatepecialized training. Lack of specialized training on electronic waste disposal and handling can leading to mistakes and errors, making it essential to provide employees with the necessary knowledge and skills to manage electronic waste responsibly.

4.3 ELECTRONIC WASTE GENERATION AND STREAM FROM COMPUTER LABORATORIES

Electronics commonly found in the Bindura University ICT department and laboratories include computer system (monitors, mice, keyboards), cables like network cables, HDMI, and power cables, projectors, modems, printers, cartridges, and storage devices such as hard drives and flash drives. These devices were be found in varying quantities, as illustrated in Fig. 4.1. These devices have different lifespans and require different maintenance approaches (**Fig.4.2**). Some devices can be maintained internally, whereas others require outsourcing to maintenance companies depending on the level of damage.

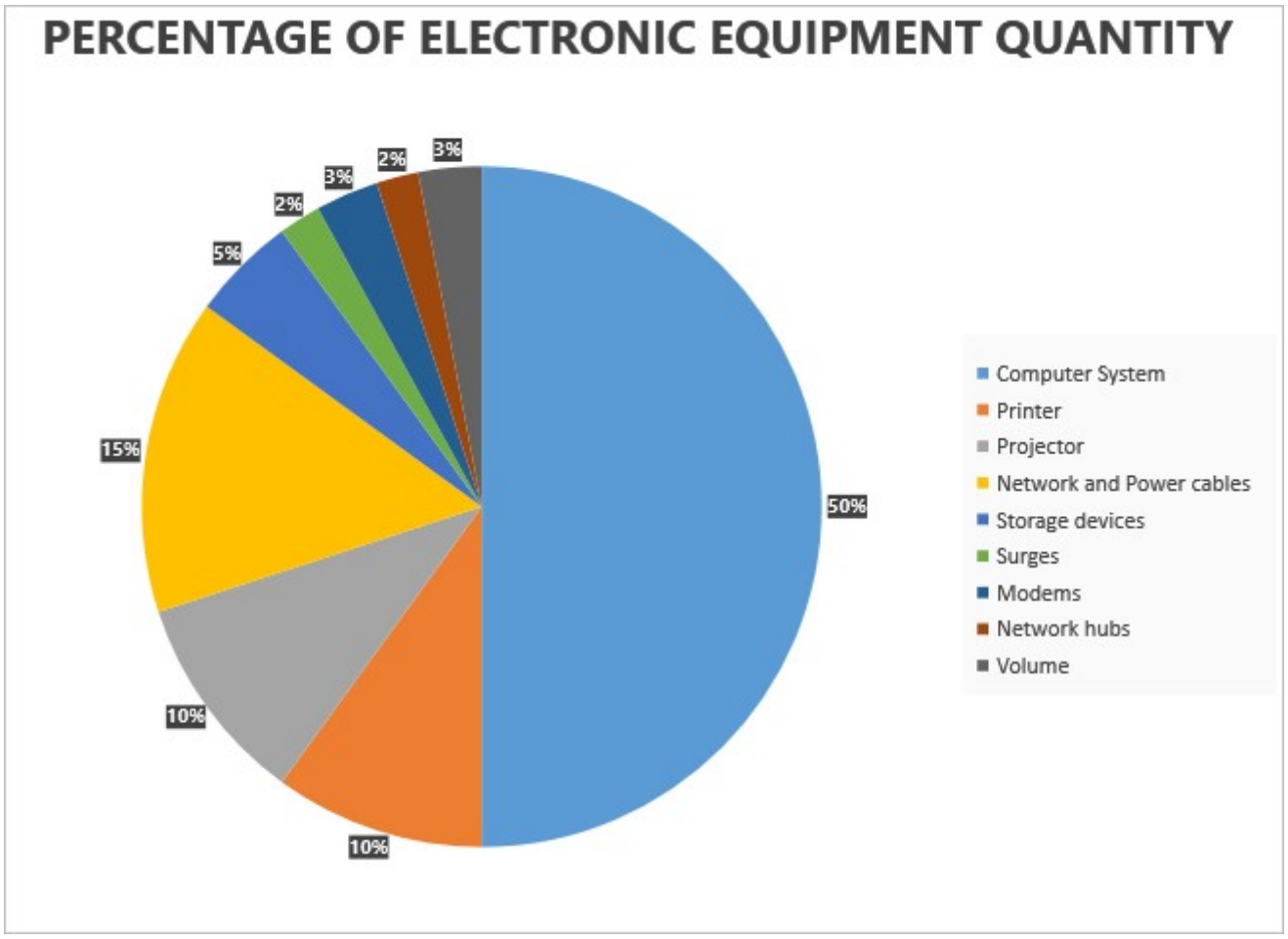

Fig 4.1 Percentage of Electronic Equipment Quantity in Computer laboratories

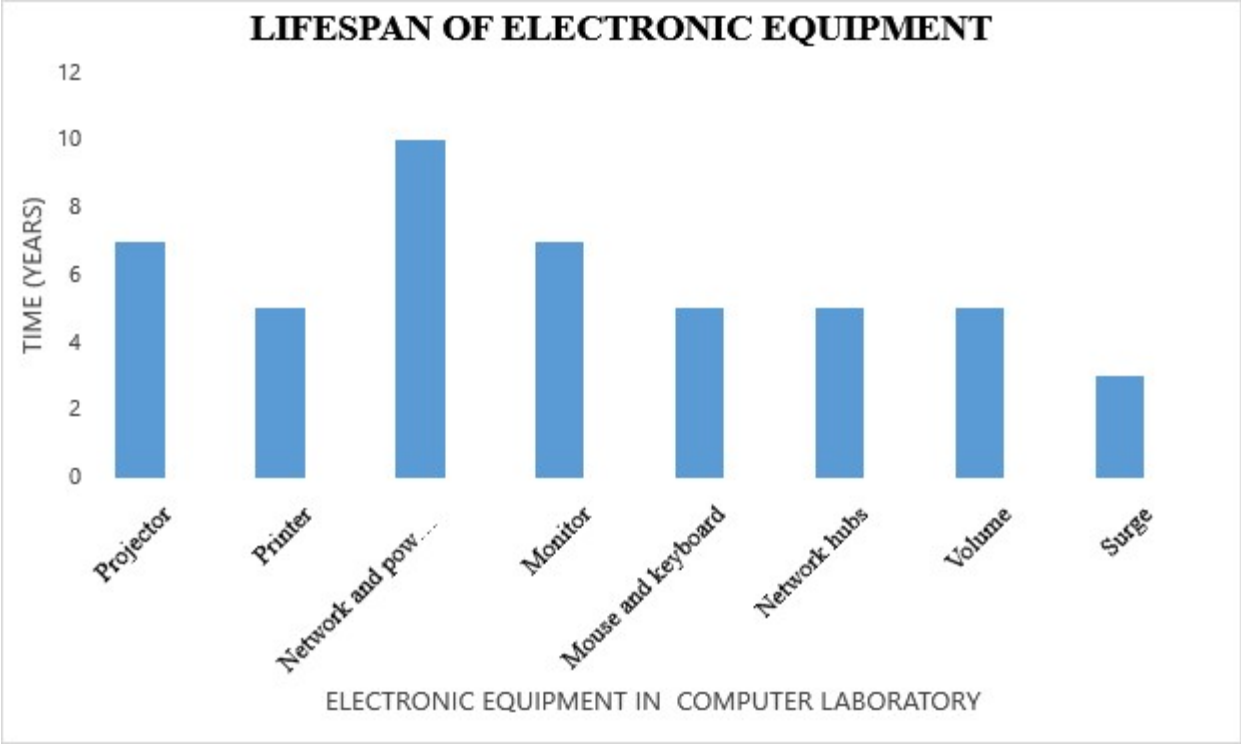

Fig 4.2 Life spans and maintained of electronic equipment found in Bindura University

4.4 ELECTRONIC WASTE GENERATION AND STREAMS STUDENTS

Over 60% of the students admitted that they were not aware of proper disposal of electronic waste management. This suggests that improved awareness campaigns can have a significant impact on electronic waste management practices on campus. Moreover, the study found that 40% of students reported disposing of cellphone chargers cables as the most common examples of their electronic waste. The remaining percentage was comprised of devices such as handheld fans, charger cables, electric jugs, and irons (Fig 4.3).

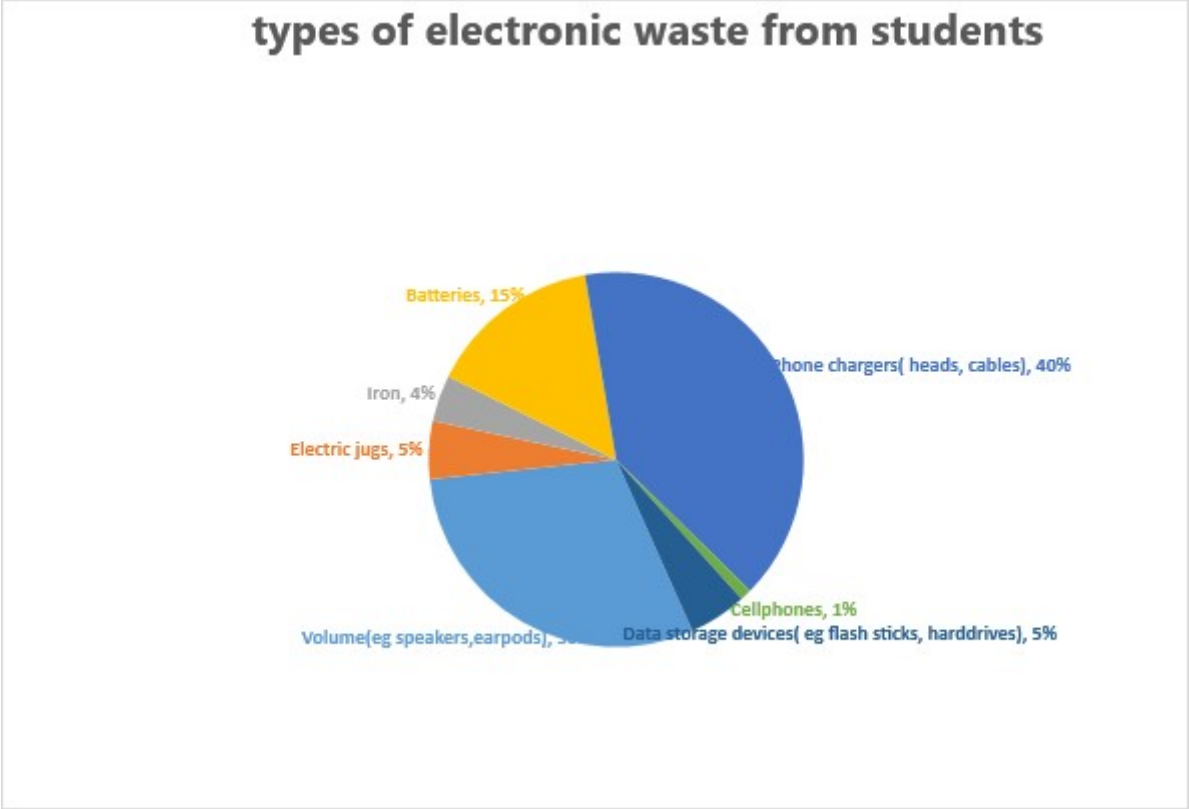

Fig 4.3 Types of electronic waste produced by students

4.5 STUDENTS KNOWLEDGE AND ATTITUDE ON ELECTRONIC WASTE MANAGEMENT

A total of 61 respondents out of 70 students sampled managed to respond to the questionnaire, comprising both males and females. Only undergraduate students participated in the questionnaire, and nearly half of the respondents were in their fourth year (Part 4). The age range of the respondents was between 18 and 26 years old. The distribution of respondents by faculty was as follows: 13 from the Faculty of Science, 12 from the Faculty of Humanities and Social Sciences, 13 from the Faculty of Agriculture and Environmental Science, 12 from the Faculty of Commerce, and 11 from the Faculty of Science and Engineering.

The faculty of agriculture and environmental sciences had the highest number of respondents who knew about electronic waste, with 61% admitting they were aware of it. Only students from the faculties of science and engineering, and agriculture and environmental sciences, had nearly the same percentage of people who knew about electronic waste, which was better compared to the rest of the faculties. Students seemed to be unfamiliar with recycling programs and facilities in the university community.

Students from the Faculty of Agriculture and Environmental Sciences had 38.4% of students who were aware of recycling programs, while those from the Faculty of Science had 38.5%. Knowing the harmful effects of improper electronic waste disposal was also a major challenge. The Faculty of Agriculture and Environmental Sciences had a leading number of students who were aware of the harmful effects of improper electronic waste disposal, with 38.4%, while the Faculty of Commerce had only 16.7%. However, it remained a challenge on awareness in these areas.

The levels of attitude towards electronic waste management were better than the awareness levels. Students who thought that manufacturers should be more responsible for the disposal of electronic products they produce were 76.9% from the Faculty of Science and Engineering, which was the highest. The lowest was from the Faculty of Social Sciences and Humanities, with 58.3%.

Over 50% of students at all faculties admitted that they recycled their electronic waste. Students who actively sought information on electronic waste management were very few, and only a few students admitted that they sought information. None of the students admitted that they sought information at the Faculty of Commerce, and overall, there were fewer than 40% at all faculties.

However, there were low results in awareness of students towards electronic waste management, which was lower than the level of attitude towards electronic waste management. Overall, the Faculty of Agriculture and Environmental Sciences had better results than all faculties.

Table 4.2 A summary some of the key findings on electronic waste management awareness and attitude levels according to faculties

Variables	Faculty of Agriculture and environmental science Characteristic (n=13)		Faculty of Science Characteristic (n=13)		Faculty of Science and Engineering Characteristic (n=11)		Faculty of social sciences and humanities Characteristic (n=12)		Faculty of commerce Characteristic (n=12)	
	Frequency (%)		Frequency (%)		Frequency (%)		Frequency (%)		Frequency (%)	
Are you aware of what electronic waste (e-waste) is?	Yes 8(61.5)	No 5(38.4)	Yes 7(53.8)	No 6(46.2)	Yes 7(63.6)	No 4(36.3)	Yes 5(41.6)	No 7(58.3)	Yes 4(33.3)	No 8(66.6)
Are you familiar with e-waste recycling programs or facilities in your community?	Yes 5(38.4)	No 7(53.8)	Yes 5(38.5)	No 8(61.5)	Yes 4(36.3)	No 7(63.6)	Yes 4(33.3)	No 8(66.6)	Yes 4(33.3)	No 6(66.6)

Do you know the harmful effects of improper disposal of e-waste on the environment?	Yes 5(38.4)	No 8(61.5)	Yes 3(23.1)	No 10(76.9)	Yes 3(27.3)	No 8(72.7)	Yes 1(8.3)	No 11(91.7)	Yes 2(16.7)	No 10(83.3)
Do you actively seek out information on how to recycle or dispose of electronic waste properly?	Yes 5 (38.5)	No 8(61.5)	Yes 4(30.8)	No 9(69.2)	Yes 4(36.4)	No 7(63.6)	Yes 1(8.3)	No 11(91.7)	Yes 0	No 12(100)
Do you think that manufacturers should be more responsible for the disposal of electronic products they produce?	Yes 10(76.9)	No 3(23.1)	Yes 9(69.2)	No 4(30.8)	Yes 9(81.8)	No 2(18.1)	Yes 7(58.3)	No 5(41.7)	Yes 8(66.7)	No 4(33.3)
Do you typically recycle electronic devices that are no longer in use?	Yes 9(69.2)	No 4(30.7)	Yes 8(61.5)	No 5(38.5)	Yes 7(63.6)	No 4(36.4)	Yes 6(50.5)	No 6(50.0)	Yes 7(58.3)	No 5(41.6)

Table 4.6 shows that the relationship between all faculties was not significantly influenced, except for the knowledge and awareness towards electronic waste management of the Faculty of Agriculture and Environmental Science. The faculty attained the highest knowledge and score (4.83±0.72) and also had the highest attitude score (7.33 ± 0.62)

Table 4.3 The relationship between faculty knowledge and awareness towards electronic waste management

Characteristic (*n*=61)		Knowledge and Awareness			Attitude		
		Score Mean(SD)	Range	X^2	Score Mean(SD)	Range	X^2
Faculty	Agriculture and Environmental Science	4.83±0.72	3-7	11.34 (p<0.05)	7.33±0.62	6-9	14.11 (p>0.05)
	Science and Engineering	4.54± 0.83	2-8	13.43 (p>0.05)	7.18±0.61	6-9	13.23 (p>0.05)
	Science	4.45±0.79	3-7	10.33 (p>0.05)	6.92±0.58	5-9	12.56 (p>0.05)
	Social sciences and humanities	3.17±0.62	2-5	6.56 (p>0.05)	6.33±0.53	5-8	8.85 (p>0.05)
	Commerce	3.38± 0.67	2-5	6.56 (p>0.05)	6.51±0.51	5-8	9.35 (p>0.05)

*significantly different (p < 0.05)

CHAPTER 5: DISCUSSION

5.1 ELECTRONIC WASTE MANAGEMENT AT BINDURA UNIVERSTY

The findings reveal that Bindura University is not fully prepared to manage electronic waste. Despite having a comprehensive ICT policy, there is no specific policy in place for the disposal of electronic waste. This lack of a documented recycling procedure and electronic waste management policy poses significant challenges for technicians in managing electronic waste. Moreover, the university's failure to collaborate with other institutions on sharing electronic waste management practices and lack of future plans for electronic waste management indicate that the issue is not being prioritized. The results were similar to those of Ogbomo et al (2012), who observed that the lack of national and institutional policies negatively affected the management of e-waste at a university in Nigeria.

The challenges faced by technicians in managing electronic waste are numerous, including data security risks, insufficient resources, and complexity of electronic waste, regulatory compliance challenges, sustainability challenges, and inadequate specialized training concurring with Ghulam & Abushammala, (2023). The lack of a documented recycling procedure and electronic waste disposal procedure also increases the risk of mistakes and errors in handling electronic waste.

5. 2 ELECTRONIC WASTE GENERATION AND STREAMS

The study highlights the prevalence of electronic waste generation in the Bindura University computer laboratories. The findings indicate that a wide range of electronic devices, including computer systems, projectors, printers, and storage devices, are present in varying quantities concurring with (Ncube et al., 2019). These devices have different lifespans and maintenance requirements, with some being repairable internally while others require outsourcing to maintenance companies.

The study also reveals a concerning lack of awareness among students regarding proper electronic waste disposal. Over 60% of students admitted to not knowing how to properly

dispose of electronic waste, suggesting that targeted awareness campaigns could significantly impact electronic waste management practices on campus. Furthermore, the study found that the things that influenced communication like cell phone chargers and cables are the most common examples of electronic waste generated by students, followed by other devices such as handheld fans, irons, and electric jugs. This was similar to the findings of Jahan, (2023).

5.3 ELECTRONIC WASTE MANAGEMENT AWARENESS AND ATTITUDE AMONG UNIVERSITY STUDENTS

The survey results reveal a mixed picture of awareness and attitude towards electronic waste management among university students. The Faculty of Agriculture and Environmental Sciences showed a high level of awareness on the term electronic waste (61%), while other faculties trailed behind with only 53.8% – 33.3 % of students aware of electronic waste. However, they failed to know the problems associated improper electronic waste disposal tallying with Singh et al, (2018).

Attitudes towards electronic waste management were more positive, with over 50% of students from all faculties admitting to recycling their electronic waste despite having no recycling facilities in the area. The Faculty of Science and Engineering had the most supportive attitude, with 81.8% believing that manufacturers should be more responsible for disposing of electronic products they produce. However, there was a significant gap in awareness levels, with students from the Faculty of Commerce showing the lowest levels of awareness and attitude towards electronic waste management, unlike Jahan, (2023) who found that student did not care about electronic waste management despite being aware of improper disposal. Additionally, only a few students actively sought information on electronic waste management, with none from the Faculty of Commerce and fewer than 40% from other faculties. This suggests that the curriculum and educational programs within the faculties may be playing a crucial role in promoting environmental awareness and sustainability among its students, which could have a positive impact on their future careers and communities.

The students achieved the lower scores in knowledge and awareness towards electronic waste management than in attitude towards electronic waste management, suggesting a

more positive disposition towards electronic waste management. Unlike, Maphosa, (2021) who found that while students were aware of the environmental impact of electronic waste, they did not practice proper electronic waste management.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

In conclusion, Bindura University of Science Education faces challenges in effectively managing electronic waste, despite having basic some other solid waste disposal mechanisms in place. The university generates substantial electronic waste annually, predominantly from computers, printers, and mobile devices, influenced by frequent equipment upgrades and replacements.

While students show a low level of understanding of electronic waste issues, there is a clear need for enhanced education on proper disposal methods and environmental impacts. The study revealed that students' understanding and attitudes toward electronic waste management could be improved through better education and awareness programs. To address these issues, we recommend enhancing recycling efforts, improving collection logistics, and integrating educational initiatives into the curriculum to promote responsible electronic waste practices across the university community.

These findings highlight the need for a coordinated approach to e-waste management at Bindura University. By implementing these recommendations, the university can reduce environmental risks associated with improper electronic waste disposal, align with regulatory requirements, and contribute to sustainable practices. Future research could explore the broader socio-economic impacts of improved e-waste management in educational settings, providing further insights for sustainable development initiatives.

6.2 RECOMMENDATIONS

I recommend future studies to focus on:

- Collection and recycling of electronic waste
- Electronic waste reduction and prevention
- Electronic waste management policy and regulation

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APPENDICES

APPENDIX I: SAMPLE SIZE CALCULATIONS

$$n = \frac{N}{1 + N(e)^2}$$

Where *N* is the population size, *e* is the standard deviation and *n* is the sample size

$$n = \frac{4800}{1 + 4800(0.12)^2}$$

The sample size is 67.6056 to nearest tenth = 70

Then the sample size was divided by the number of 5 strata to give 14

A number of 14 respondents in each strata

APPENDIX II: BINDURA UNIVERSITY SURVEY QUESTIONNAIRE

Good day. I am a Student called Panashe Neshamba in the Department of Environmental Science (Registration No.B202092B) at Bindura University. I am doing a research study on *"Assessing the electronic waste management at Bindura University"*. I am inviting you to participate in the study by answering a few questions on the topic. The study findings will be used to make recommendations on electronic waste management at the university. This survey aims to gather information on your perceptions and understanding of electronic waste management. Your responses will remain confidential and will be used for research purposes only. Your feedback is greatly appreciated. Thank you for taking the time to complete this questionnaire.

Section A: Demography

1. Age_____

2. Sex_____

3. Faculty _____Department_____

4. Academic year _____

Section B: Awareness and knowledge on electronic waste management

Please tick appropriate answer

1. Are you aware of what electronic waste (e-waste) is? Yes☐/no☐

2. Do you know the harmful effects of improper disposal of e-waste on the environment? Yes☐/no☐

3. Have you ever recycled or properly disposed of electronic devices such as phones, laptops, or tablets? Yes☐ /no☐

4. Are you familiar with e-waste recycling programs or facilities in your community? Yes ☐/no☐ If tick yes list the programs or facilities_____

5. Have you ever considered the environmental impact of upgrading or replacing your electronic devices? Yes☐ /no☐

6. Do you know how to safely dispose of batteries from electronic devices? Yes☐/no☐

7. Have you ever participated in a community clean-up event focused on collecting e-waste? Yes☐/ no☐

8. Do you think there is a need for more education and awareness about e-waste among students and the general public? Yes☐ /no☐

9. Have you heard of any initiatives or campaigns aimed at reducing e-waste in your area? Yes☐ /no☐

Section C: Attitude towards electronic waste management

Please tick appropriate answer

1. Do you believe that proper management of electronic waste is important for the environment? Yes☐ /no☐

2. Are you willing to take steps to ensure that your electronic devices are disposed of responsibly? Yes☐ /no☐

3. Do you actively seek out information on how to recycle or dispose of electronic waste properly? Yes☐ /no☐

4. Do you think that manufacturers should be more responsible for the disposal of electronic products they produce? Yes☐ /no☐

5. Do you believe that individuals have a role to play in reducing the amount of e-waste generated? Yes☐ /no☐

6. Are you open to buying refurbished electronic devices as a way to reduce e-waste? Yes☐ /no☐

7. Do you think that education on e-waste management should be included in school curriculums? Yes☐ /no☐

8. Would you be willing to participate in a community initiative focused on collecting and recycling e-waste? Yes ☐/no☐

9. Do you think that government policies should be put in place to regulate the disposal of electronic waste? Yes☐ /no☐

10. Do you feel personally responsible for the impact of your electronic consumption on the environment? Yes☐/no☐

Section D: Behaviour towards electronic waste management

Please tick appropriate answer

1. How often do you properly dispose of electronic devices when upgrading or replacing them? Monthly☐/ Yearly☐/ 2 or more years ☐ Give examples of electronic waste dispose_____

2. Do you typically recycle electronic devices that are no longer in use? Yes ☐/no☐

3. Have you ever donated or sold your old electronic devices instead of throwing them away? Yes☐ /no☐

4. Do you make an effort to repair or maintain your electronic devices rather than replacing them? Yes ☐/no☐

5. Have you ever participated in an e-waste collection event or program? Yes☐ /no☐

6. Do you separate electronic waste from regular household waste when disposing of it? Yes☐ /no☐

7. Are you aware of the impact of electronic waste on the environment when making purchasing decisions? Yes☐ /no☐

8. Do you encourage friends or family members to recycle or properly dispose of their electronic devices? Yes☐ /no☐

9. Have you ever taken steps to extend the lifespan of your electronic devices to reduce e-waste? Yes☐ /no☐

10. Do you actively seek out information on how to reduce, reuse, and recycle electronic waste in your daily life? Yes☐ /no☐

APPENDIX III: INTERVIEW GUIDE

Preamble: First ask for permission to record

Electronic waste stream, generation and disposal methods

1. **Electronic Waste sources**

i. What are the different types of electronic equipment used in the department

ii. How often are they replaced and their typical lifespan

2. **Electronic Waste Management**

i. What are the current methods used for disposing electronic waste in the university.

ii. What are the guidelines or regulation that follows in regards proper electronic waste disposal

iii. What are the recycling programs that are in place for electronic waste management

3. **Electronic Waste generation rate**

i. What is estimated the amount of electronic waste (kg) generated by the university on a monthly or yearly basis.

ii. What are the trends or changes in electronic waste generation rates over the past few year (is it increasing or decreasing)

4. **Recycling Methods**

i. What are the methods used for recycling electronic waste at the university.

ii. Are they any partnerships with external agencies or companies for electronic waste recycling

5. **Challenges and Opportunities**

i. What are the challenges faced in managing electronic waste

ii. Inquire about any opportunities for improvement in electronic waste management practices.

6. Future Plans

i. What are the future plans or initiatives for improving electronic waste management at the university

ii. What the goals set on recycling and reduction of electronic waste at the university