UNIVERSITY OF KWAZULU-NATAL

The Management of e-Waste in KwaZulu-Natal

By

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As the candidate's supervisor I agree to the submission of this dissertation for examination. To the best of my knowledge, the dissertation is primarily the student's own work and the student has acknowledged all reference sources.

The above student has also satisfied the requirements of English language competency.

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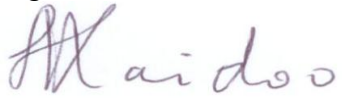

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ABSTRACT

Information Technology is seen as that which makes one's life easier, fun and more comfortable. When a new cellular phone is launched one is eager to see what the new phone has to offer, and often one convinces oneself that the new device is required. This study investigates what happens to redundant or obsolete electronic devices like cellular phones, computers and other electronic devices. Are these devices stored, donated, thrown out with the garbage or are they recycled? Information from academic sources and from all types of media, including television, print and electronic was searched to enhance the survey that was undertaken. Both the informal and formal sectors of recycling were investigated. A questionnaire was used to supplement the information found in different kinds of sources. The collected data was interpreted through the use of SPSS. Descriptive as well as inferential statistics was used to draw conclusions and make inferences. An investigation into legislation controlling the disposal of e-waste is included in this study. International, national, provincial and local government legislation is outlined. The objectives of recycling electronic waste are listed together with the challenges that face the pro-recyclers. The quantitative research methodology approach has been employed for this research. A key technique used in this study is the Research Onion. Data analysis and interpretation are based on the p-value, Pearson's chi-square and Spearman's correlation. The study has really been an eye opener in that it considers the "darker side" of Information Technology. The "darker side" of Information Technology refers to the disposal of obsolete or broken electronic devices in a manner that is harmful to the environment. The cost or lack of profit is the main driving force for incorrect disposal methods. This study has found that the best method of disposal is the take back system, where manufacturers of electronic devices are responsible for the safe disposal of the devices that they manufactured.

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TERMS AND ABBREVIATIONS

TERMS

Cause-and-effect is an action-reaction combination. The cause is the reason something happens, and the effect is the result.

Chi-Square Test is classified as a "goodness-of-fit test" that does a comparison of the observed data and the "expected frequencies in each category" (Dowdy,Weardon and Chilko, 2005).

Data View "is a window in SPSS that consists of a grid of rows and columns. The columns represent variables whilst the rows represent cases. The numerical data from the data instrument example questionnaire are typed in the data view" (SPSS, 2010). See Variable view.

Decommissioning is considered to be a planned shut-down or removal of equipment or a plant.

Descriptive Statistics is the statistics that is used to describe the essential features of the study data.

Eco-efficient the purpose is to maximize efficiency whilst minimising damage to the ecology. This can be done by using less energy, material, and water, more recycling, and the elimination of harmful emissions or by-products.

E-waste "is any refuse created by discarded electronic or electrical devices and components" (eWASA, 2008). This could also be produced "as substances involved in their manufacture or use" (eWASA, 2008).

Inferential statistics is the statistics that is used to draw similarities or differences or inferences about a population from a sample.

Likert Scale is a system uses scores that allows a survey to quantify likes and preferences on a 5-point scale, with 1 being the least important (strongly disagree), 2 being disagree, 3 being neutral, 4 being agree and 5 being the most important (strongly agree).

Meta search engines are a "category of search engine tools that pass queries on to many other search engines and/or directories" (Yourdictionay.com, 2010). The results are summarized in one useful interface.

Nominal in SPSS is a variable that can be treated "as nominal when its values represent categories with no intrinsic ranking" (SPSS, 2010). An example of a nominal variable used in this study is question 1 of the questionnaire, which is part of Addendum 1.

Null hypothesis "represents the hypothesis of no change or no effect" (SPSS, 2010).

Ordinal in SPSS is a variable that can be treated "as ordinal when its values represent categories with some intrinsic ranking" (SPSS, 2010). An example of an ordinal variable used in this study is question 14.1 of the questionnaire, which is part of Addendum 1.

Pearson's chi-square is used to assess tests on relation to goodness of fit and tests of independence.

P-value is a measure of how much evidence there is against the null hypothesis. It is a probability, with a value ranging from zero to one. The smaller the p-value, the more evidence there is against null hypothesis.

Scale in SPSS "is data measured on an interval or ratio scale, where the data values indicate both the order of values and the distance between values" (SPSS, 2010). An example of a scale variable used in this study is question 2.

Spearman's correlation is used to assess how well a function could describe "the relationship between two variables, without making any assumptions about the frequency distribution of the variables" (Dowdy *et al.*, 2005).

True Cost is more than what one pays to purchase an item. True cost includes the cost of manufacture and disposal of the item has to the environment.

Variable View is a window in " that contains a grid of rows and columns. In this window the rows represent the variables in the analysis and the columns are used to define the characteristics of each variable" (SPSS, 2010). See Data view.

ABBREVIATIONS

Acronym	Meaning or Description
ARF	Advance Recycling Fee
BAN	Basel Action Network
CFL	Compact Fluorescent Lamps
CRT	Cathode Ray Tube
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
EPR	Extended Producer Responsibility
eWASA	e-Waste Association of South Africa
e-Waste	Electronic or electrical waste
GWMF	Gauteng Draft Standards for General Waste Management Facilities
ISAP	Index to South African Periodicals
LCD	Liquid Crystal Display
NEMA	National Environmental Management Act
NRF	National Research Foundation
NWIS	National Waste Information Systems
PCs	Personal Computers
PROs	Producer Responsibility Organisations
PWB	Printed Wiring Board
StEP	Solving the e-Waste Problem
RoHS	Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment
SABS	South African Bureau of Standards
SANS	South African National Standard
SA WIS	South African Waste Information Systems
S.EN.S	Stiftung Entsorgung Schweiz
SPSS	Statistical Package for Social Scientists
SWICO	Swiss Association for Information, Communication and Organisational Technology
SVTC	Silicon Valley Toxics Coalition
TCLP	Toxicity Characteristics Leaching Procedure
RFID	Radiofrequency Identification
UPC	Universal Product Code
WEEE	Waste Electrical and Electronic Equipment

Chapter 1

STATEMENT OF PROBLEMS AND RESEARCH DESIGN

1.1. Introduction

Technology is constantly revolutionizing the world, whether we are thinking of how the invention of the bow and arrow must have changed the lives of the ancients, or how the invention of electronics has changed our lives over the past century. For instance, the electronic revolution enables one to communicate with a fellow worker in the office next door or with someone on the other side of the world with just as much ease. Without electronics one cannot perform even a simple task of finding out the correct time. Not surprisingly most suburbanites extensively use electronics in a variety of every-day equipment, for instance in the circuitry used in wristwatches, wall clocks, cell phones, radios, televisions, stoves, microwave ovens, fridges, freezers, computers, let alone the intimidating array of electronic components built into modern motorcars. Computers have become a part of our everyday life.

Limiting our attention to computers alone, in 1998 it was estimated that in excess of 20 million computers became obsolete each year (Kaur, undated). According to Ted Smith (founder of Silicon Valley Toxics Coalition (SVTC)) a study done in 2002 stated that 300 million computers became obsolete in 2004 (Morales, 2008). “The definition of obsolete is based on a user purchasing a replacement computer, after which the old one is stored, resold, sent for waste management (recycled) or sent to a landfill” (Kaur, undated). “Computer components contain lead, mercury, cadmium, chromium and other hazardous materials. Glass screens of cathode ray tubes (CRTs) in monitors could contain as much as 6% lead by mass” (Bridgen, Webster, Labunska, and Santillo, 2007). Morales, (2008) stated that 300 million obsolete computers resulted in “4 billion pounds of plastic, 1 billion pounds of lead, 1.9 million pounds of cadmium, 1.2 million pounds of chromium and 400,000 pounds of mercury” (Morales, 2008).

If one extrapolates the above statements based on current trends in America by the year 2021 the number of obsolete computers will be equal to the number of new computers being sold (Yang & Williams, 2008). This value is based on a minimum household income of $100 000 per year. If the income barrier is removed the values will become much larger.

Disposing of hazardous waste is subject to state and federal regulations and requirements. Since the regulations regarding the recycling of electronic equipment are not in place, many of the countries export the electronic equipment to 3rd world or Developing countries where unsafe methods to extract the different components of the electronic equipment are used (BAN and SVTC, 2002).

1.2. Background and Context

Used electronics is a concern because, aside from taking up valuable space in empty or unused cubicles and storerooms, obsolete electronics pose several challenges regarding the proper disposal and this could pose several potential environmental consequences (WasteWise, 2007). Products that are electrical or electronic in nature are made resources that are valuable. These resources may be metals that are precious, or other materials like glass. All the resources use vast amounts of energy in the sourcing or manufacturing process. (WasteWise, 2007). With little effort many of the electronic components could be refurbished and reused. Some electronic products also contain hazardous materials. According to WasteWise, (2007), a large percentage of electronic equipment is currently being stored or warehoused, as stockpiling continues, there is growing concern about the volume of used or obsolete electronic equipment that will need to be managed responsibly when it emerges from storerooms or attics.

The WasteWise Update, (2007) states that "the most environmentally sound management of solid waste preferred order is:

- Waste prevention first,
- Recycling second, and
- Disposal last" (WasteWise Update, 2007).

The WasteWise Update, (2007) and Osibanjo and Nnorom, (2007) both state that many environmental and societal benefits arise when electronics are re-

used or recycled. With proper end-of-life management of electronics one will find that:

- Materials could be diverted from disposal: electronics reuse and recycling divert bulky equipment from landfills and incinerators.
- Social benefits could be obtained by reuse and donation of electronic products that could extend their useful life and could afford individuals or organizations that could not afford to buy new equipment the opportunity to make use of second hand equipment.
- Natural resources could be conserved and as a result of this, pollution will be reduced.
- When reuse is not an option, recycling electronic products creates a supply of parts and materials that could be used to refurbish other products or manufacture new ones.

The e-waste body in South Africa is called eWASA. This body is currently formulating guidelines that need to be followed for the disposal of e-waste. According to eWASA, Makro and Pavilion are e-waste disposable sites in KwaZulu-Natal (Ecroignard, 2006). Another development for e-waste by eWASA is the launch of an USE-IT TBS (Take Back System) in KwaZulu-Natal during November 2010. The researcher can report from personal observation that Pick n Pay stores collect old batteries and CFLs (compact fluorescent lamps), whilst Woolworths collects CFLs. One should be careful when handling a compact fluorescent lamp because that lamp contains small amounts of mercury (Fact_Sheet_Mercury, 2008). This is very important for us in South Africa because householders are being encouraged by Eskom to use the compact fluorescent lamps but at the same time the public needs to be educated on the correct disposal of these fluorescent lamps.

According to Puckett, Westervelt, Gutierrez, and Takamiya, (2005) much of the growth in developing countries has increased by the imported hand-me-down used equipment from rich developed countries. He goes on to say that this is like a classical win-win situation, but e-waste is proving to be a serious burden on local municipalities as much of the e-waste ends up in landfills.

From the researcher's observations it is found that obsolete computers from 1st world countries that cannot be refurbished are generally sent to 3rd world or Developing countries like India, China, or more recently Nigeria so that the components can be recycled. Sonia Duhan of Earth Sense Recyclers stated in a documentary by Aljazeera that in every 100 computers donated to charity only three computers are in a working condition (Aljazeera, 2010). It was reported at an e-WASA meeting on 3 November 2010 that a container from the United States of America that contained e-waste arrived at the Durban harbour in South Africa. When the container was located it had already been transported to Johannesburg. In this case the container was sent back to its point of departure in America. Another problem that faces South Africa is that the used electronic components and devices use the same import tax numbers as new electronic components and devices. It is therefore extremely difficult to trace the used electronic devices and components that are being imported.

Some products destined for recycling, such as aluminium cans and newspapers, find themselves reborn as like products. Purnell, (2009) and WasteWise Update, (2007) state that tracing the path of recycled electronic products is considerably more complicated than the recycling of cans and newspapers. This is mainly due to the harmful substances that are found in electronic products. Streicher-Porte, Widmer, Jain, Bader, Scheidegger, and Kytzia, (2005) together with WasteWise Update, (2007) suggest the following steps in the recycling of a typical computer:

- **Step 1:** removal of circuit boards and hard drives. Circuit boards and hard drives could be marketed for resale as operational parts. Unusable circuit boards could be broken into a powder and then separated into fibreglass, metals, and precious metals through a process called fire assay.
- **Step 2:** removal of plastic housings. Plastic housings could be separated from the electronic equipment, and materials such as labels and foam insulation could be removed through air classification.
- **Step 3:** small plastic components. The small plastic parts inside computers are typically made from uniform-coloured, high-density polyethylene (HDPE). This makes them easier to remove, grind, and process.

- **Step 4 :** screws, clips, small metal parts. Screws, clips, and small metal components are sorted and separated magnetically into ferrous and non-ferrous groups. The metals are sold as scrap metal.
- **Step 5:** monitors. The plastic housings, metal supports, and circuit boards are separated. The cathode ray tube (CRT) could be crushed, and the glass that contains lead could be separated from the metal. Much of it could be sold to CRT manufacturers for use in new CRT glass or liquid crystal display (LCD) glass. The metal could be sold for its scrap value.

Kathy Hearn a reporter for Aljazeera makes observations in a documentary. She states that the informal sector was more popular than the formal sector for the recycling of old computers. The main reason for this is that start up costs in the informal sector are minimal because people who are bare feet, without any protective clothing or gas masks use open flames on gas stoves to remove components from the electronic boards. As a result of this, the labour cost for recycling in India is $2 compared to $20 in America. The reporter went on to state that in India approximately 75% of the e-waste generated, originated from within the country and that only 25% was generated from outside the country, this was surprising as one would have expected more of the e-waste to have been generated from outside the country. The formal sector was not as popular because of lower profits generated mainly due to safer means of recycling. It was also felt that the formal sector must engage with the informal sector because the expert knowledge about which components and how these components need to be removed lies within the informal sector (Aljazeera, 2010).

The formal sector in South Africa is still in its infancy but the informal sector is recycling electronic devices especially for the metals like copper that can be extracted from the large amounts of electrical wire that is found in the devices. The researcher could not find any formal outlets that collect the lead from computers more especially the computer monitors or CRT's. The formal sector for motor vehicle batteries has been collecting the old motor vehicle batteries for refurbishing. The old motor vehicle battery is taken in as a return when one purchases a new motor vehicle battery (Tsoulfas, Pappis, and Minner, 2002). The motivating factor to return the old motor vehicle battery is that you are required to

pay a deposit on the new motor vehicle battery if you do not return the old one. This practice needs more investigation as it could be used for old obsolete or redundant electronics.

The researcher has found from observation in South Africa that the informal sector is much more inclined to the recycling of e-waste, especially old computers. It then seems interesting to investigate the involvement of the formal sector in the recycling of e-waste together with possible challenges recyclers of e-waste are confronted with and whether this is in line with Green IT. Considering that most of India's e-waste is generated from within its boundaries, it would be interesting to determine what owners of electronic and electric devices/components do with these devices/components when these devices/components reach the end of their usefulness or are replaced in South Africa. To do this the researcher will use problem-based research. A description of problem-based research follows.

1.3. Problem-Based Research

Although many definitions are available for Problem-Based learning, not many definitions are available for Problem-Based Research. The impact on future research and other researchers is what makes research interesting to the reader. This impact may be clearly evidenced by addressing a problem that has some manner of interest to the reader. Kerlinger and Lee, (2000) suggest that if one has a problem that needs to be solved, one must first know what the problem itself is. Leedy and Ormrod, (2005) suggest that the research problem is very similar to a normal problem with the research effort revolving around the research problem. This researcher's understanding is that the problem determines the research and the research helps to solve the problem. This would focus the research such that the research is directed towards solving the problem.

The above definition supports Klopper's, (2008) view that research involves a sequence of research procedures to achieve coherence, alignment, progression and closure. According to Klopper, (2008) a research endeavour might be viewed as a structure that incorporates a number of distinct but interrelated elements including the problem statement that drives the study, the literature review, the research methodology, data analysis, interpretation and conclusions.

The research problem or problem statement serves as the starting point for the research and is a unifying thread that runs throughout all the elements of the research. (Leedy and Ormrod, 2005). Since the research problem or problem statement serves as a starting point, the researcher will now state the problem statement.

1.4. Statement of Problems

1.4.1. Overall problem statement

Although South Africa is a 3rd world country, in many respects it could be considered to be 1st world (South Africa.Info, 2010). An example of this is the speed at which our financial institutions react to changes in currency. They are able to do this because of the computer systems that are in use. These computer systems have to be on the cutting edge of technology and therefore need to be upgraded regularly, *thus creating a major problem with obsolete computers*. Similarly, *many businesses and homes are also probably storing a large number of computers that are obsolete* because it is felt that the computers are still assets. A further problem occurs when these homes and business clean up and dispose of these computers. The worst-case scenario occurs when computers are thrown out with the thrash and become part of a landfill.

1.4.2. Sub-problems

- The cost of decommissioning redundant computers and other electronic equipment is presently unknown. A preliminary literature review has established that the cost of decommissioning redundant computers or even the wider array of other electronic equipment that could be found in most homes today, has not yet been determined.
- Another problem that exists in countries like South Africa where computers are "donated" under the guise of corporate social investment for the "development" of schools. There is uncertainty as to what happens to these computers when they have served their purpose.
- Owners of redundant computers do not know what to do with them. Some computers are not good for current use, but people feel that they are assets and therefore continue storing them.

- It is presently unknown how owners deal with redundant computer equipment.
- The above problem is aggravated when 1st world countries send their obsolete computers to 3rd world countries so that they can be refurbished and have a new lease on life.

1.5. Objectives

The objectives of this research are described below:

- To find the true cost of decommissioning computers and electronic equipment by taking decommissioning of the computers and equipment into account.
- To determine what happens to computers that have been "donated".
- To determine whether owners know what to do with redundant computers.
- To determine whether the stored computers are still considered an asset.
- To determine how owners deal with redundant computer equipment. More specifically, to determine to what extent obsolete computers are:
    - Stored.
    - Resold.
    - Sent for waste management (recycled).
    - Sent to a landfill.
- To determine if South Africa is importing refurbished and obsolete computers from 1st world or other countries.

1.6. Research Questions

Each research question is linked to a sub-problem. The following research questions have been extracted from the sub-problems.

1.6.1. What is the true cost of computers and electronic equipment when the decommissioning of the computers and equipment are taken into account?

1.6.2. What happens to computers that have been "donated" after they are no longer useful?

1.6.3. What does one do with an obsolete computer?

1.6.4. What are the reasons for storing the obsolete computers?

1.6.5. To what extent are obsolete computers:

- Stored?
- Resold?
- Sent for waste management (recycled)?
- Sent to a landfill?

1.6.6. Is South Africa importing refurbished obsolete computers from 1st world countries?

1.7. Alignment Matrix

The alignment matrix below shows the link between the research problems, the research sub-problems and the research questions.

Table 1.1: Problem-research question alignment matrix

RESEARCH PROBLEM	SUB-PROBLEMS	RESEARCH QUESTIONS
For computer systems to be at the cutting edge of technology the computer systems need to be upgraded regularly, thus creating a major problem with obsolete computers.	The cost of decommissioning redundant computers and other electronic equipment is presently unknown. Even a preliminary literature review has established that the cost of decommissioning redundant computers or even the wider array of other electronic equipment that could be found in most homes today, has not yet been determined.	What is the true cost of computers and electronic equipment when the decommissioning of the computers and equipment are taken into account?
	A further problem exists in countries like South Africa where computers are "donated" under the guise of corporate social investment for "development". There is uncertainty as to what happens to these computers when they have served their purpose.	What happens to computers that have been "donated" after they are no longer useful?

RESEARCH PROBLEM	SUB-PROBLEMS	RESEARCH QUE S-TIONS
Many bu sinesses and homes are a lso probably storing a large number of computers that are obs o-lete because it is felt th at the c omputers are s till assets.	Owners of r edundant c om-puters do not know what to do with them. These computers are not good for t he current us e, but t he people feel that they are assets and therefore c ontinue s toring them.	What doe s one do w ith the obs olete computer when one pur chases a new computer? What are the reasons for storing t he obs olete computers?
When hom es a nd bus i-nesses c lean up a nd di s-pose of t hese computers. The w orst-case s cenario occurs w hen t he com-puter is thr own ou t w ith the t hrash a nd be comes part of a landfill.	To t he k nowledge o f the au-thor/researcher, it is pr esently unknown how ow ners deal with r edundant c omputer equipment. The pr oblem i s aggravated when 1st world countries send their obsolete computers to 3rd world c ountries s o t hat they can be r efurbished and ha ve a new lease on life.	To w hat extent ar e o b-solete computers: • Stored? • Resold? • Sent for waste management (re-cycled)? • Sent to a landfill? Is S outh Africa import-ing refurbished obsolete computers from 1st world countries?

Note: A new computer to one person may not necessarily be a previously unused com-puter.

1.8. Research Design

1.8.1. How the literature survey was conducted

South Africa has a population of approximately 50 million people (Worldbank, (2011). The population includes people of different levels of literacy. Due to the nature of the research and the problems that some may have with the terminology being used, it was decided that it would be best to conduct the research amongst people that are computer literate. It was for these reasons that the Tertiary institutions were targeted. Since the University of KwaZulu-Natal is in the province of KwaZulu-Natal it was decided to conduct the study in KwaZulu-Natal. The Province of KwaZulu-Natal, South Africa has four Tertiary contact Institutions that are funded by the Government. The Durban University of Technology and the Mangosuthu University of Technology are the former Technikons, and the remaining two tertiary institutions are the University of KwaZulu-Natal and the University of Zululand (KZN Education, 2010). For completeness it was decided to conduct the survey at all four Tertiary contact Institutions. The Gatekeeper of research from each of the Institutions was contacted and the necessary permission was obtained so that the students from the institution can answer a questionnaire on e-waste.

At the Durban University of Technology (DUT) the researcher was given a time slot that had both 1st year and 2nd year Computer Studies students. The researcher addressed the class of approximately 120 students with the help of a sign language interpreter because DUT also caters for Hearing Impaired students. The group in which the survey was conducted had 1 Hearing Impaired student and one hundred completed questionnaires were collected from these respondents.

At the Mangosuthu University of Technology the researcher was given a time slot with 2nd year Computer Studies students. Sixty six students answered the questionnaire.

At the University of Zululand permission was obtained to conduct the survey with 1st year Human Resources students during a lecture period, the researcher had access to a group of approximately 100 students. Ninety one students answered the questionnaire.

At the University of KwaZulu-Natal permission was obtained to conduct the survey on all 5 campuses. On the Howard College campus the survey was conducted with 1st year engineering students during a tutorial period. The researcher had access to 2 tutorial groups in rooms next to one another. Eighty five students answered the questionnaire. On the Edgewood campus the researcher had access to the 3rd and 4th year education students. Seventy three students in total answered the questionnaire. On the Pietermaritzburg campus the researcher had access to 1st year Information Systems & Technology students. One hundred and four students answered the questionnaire. On the Westville campus the researcher had access to 1st year Information Systems & Technology students. Ninety seven students answered the questionnaire. On the Medical school campus the researcher had access to 1st year Medical students. Ninety three students answered the questionnaire. A total of 709 completed questionnaires were obtained from respondents.

Sekaran and Bougie, (2010) together with a number of other authors like Leedy and Ormrod, (2005) have indicated that a sample size larger than 400 will not significantly add to the conclusions that may be reached, but one must also be aware of Type II errors. Type II errors are errors that occur with large sample sizes, where weak relationships may reach significant levels, and the researcher would be inclined to believe that these significant relationships found in the sample are true of the population, when in reality they may not be so (Sekaran and Bougie, 2010). With this in mind the researcher still chose a large sample size because this would be a possible way of making people aware of e-waste.

The large sample size was also looked at in the context of the research. The population size in KwaZulu-Natal is approximately 10 million and the population of South Africa is approximately 50 million. Due to the fact that the researcher intends to draw inferences about the province of KwaZulu-Natal the sample size is justified. In designing the research instrument the above was taken into account together with the research statement, research objectives and research questions.

1.8.2. The Design and Standardization of the Research Instrument

The researcher considered a number of research instruments including amongst others interviews, observations and questionnaires. It was felt that effec-

tiveness of the research will be influenced by the sample size. The researcher then decided that a questionnaire would be most appropriate for a large sample size. Due to the fact that this study is on e-waste, the research would be more meaningful if the respondents were aware of e-waste or if they were computer literate so that it would facilitate the linking of e-waste to products that they have come across. As a result of this it was decided to target either school pupils or students at tertiary institutions. The added benefit would be that this population would indirectly be made aware of e-waste and the procedures that are available for the disposal of e-waste. The population was further restricted to Students from tertiary institutions because, in this way, the sample population would include respondents from urban, semi-urban and rural areas.

Now that the target population was identified the researcher designed a questionnaire that would help extract information about e-waste from the respondents. As far as possible the Likert scale was used. The questionnaire was sent to a number of people including family and friends for comments and then adjusted accordingly. The final check before adoption of the questionnaire was done with a sample of 5 first year Information Systems & Technology students. All necessary changes were made and 900 copies of the questionnaire were printed. Wherever possible the questionnaire was administered by the researcher after a talk on e-waste was given to possible respondents. Electronic means of filling in the questionnaire was not used as the researcher decided that contact with the population would help in the dissemination of information on e-waste and this would also help in getting the respondents to fill in the questionnaire.

1.8.3. How the collection of valid research data was ensured

The research instrument was answered by respondents from all four Government funded Tertiary Institutions in the province of KwaZulu-Natal. The Gatekeeper of each institution was informed about the nature of the study and where possible 1st year students who had been exposed to some form of computer literacy were chosen. Copies of letters to the gatekeepers can be found in Addendum 2. Within this context the Gatekeeper made groups available to the researcher. The groups had been informed in advance about a talk on e-waste and that the researcher will appreciate them answering the questionnaire. It was emphasised that being at the session was entirely voluntary and would not influence

their marks in any way. It was also emphasised that for the session they were respondents to a survey. This resulted in settling the respondents' minds for a talk on e-waste.

1.8.4. How the data was collected

During the talk on e-waste the researcher motivated the potential respondents in the different groups by explaining what the meaning of the term e-waste is to them. The common thread of the explanations was with the use of examples. The examples that were chosen were such that the potential respondents could relate to them. For example the small amount of mercury found in energy saving bulbs was highlighted to the Medical Students, explaining to them that until now mercury poisoning is considered to be a disease that affects the middle and upper class because of its association with fish, but these bulbs will inadvertently land up in landfills. When broken the mercury, although a small amount, will contaminate anything that it comes into contact with, and this could result in poor people that are sorting out the garbage at landfills to become poisoned with the mercury. Cellular phones were also used as an example.

Since the respondents could relate to cellular phones and energy saving light bulbs, these examples allowed the potential respondents to understand the concept and ask a number of different questions, including questions related to safe disposal. The number of answered questionnaires is an indication of the interest that was created amongst the potential respondents. It was pointed out to the potential respondents that the answering of the questionnaire was on a voluntary basis. The importance of filling in their names and signing the form was brought to the attention of the respondent. It was also emphasized that the responses will not be linked to the respondent. Some potential respondents from the different groups did not take a questionnaire to answer whilst a few others took questionnaires but chose not to answer the questionnaire, no pressure was applied on them to answer or return the questionnaire.

Once the complete batch of questionnaires was collected from the respondents, the questionnaires were numbered consecutively and added to the questionnaires that had already been answered. The researcher did not keep the

answered questionnaires separately because the campus could still be identified by the answer to question one.

1.8.5. How the data was analysed

The data from each question was coded. As an example of the coding a description will be given in relation to question 4. Question 4 "Do you have electricity at home? (Please select one)" has two options, the first being "Yes" and the second being "No". The coding was done such that "Yes" was represented by a "1" and "No" was represented by "2", "no response" was represented by "3". The purpose of the "no response" was a check to see that data was entered for every question. After the coding was done all the data was entered into a spreadsheet.

After all the data was entered, the data was checked with the originals so that errors could be eliminated. Range checks were done electronically to check that the data for each question was within a specified range, for example in question 4 the range was 1, 2 and 3. In this way all invalid data was corrected. The spreadsheet was imported into a Statistical Package for Social Scientists (SPSS) version 15 (SPSS, 2010). Analysis of the data was done by determining the p-value and cross tabbing questions to find relationships. An excel spreadsheet was used to draw graphs so that analysis could be included and displayed graphically.

1.9. Overview of dissertation chapters

Chapter 1 gives the context of the Research together with the General Problem statement, a decomposition of the Problem statement into sub-problems, a set of objectives that have been linked to the sub-problems, and a set of research questions that have being linked to objectives.

Chapter 2 conducts a Literature Survey in order to identify an appropriate theoretical framework together with an appropriate research methodology. Chapter 2 synthesizes the theory and method to problems identified in this Chapter.

Chapter 3 explains the data collection method, problems that were encountered and how these problems were resolved. Chapter 3 also explain the data analysis procedure, sampling techniques and validity tests that will be used.

Chapter 4 uses the methods described in Chapter 2 and 3 to analyse and interpret the data by performing validity tests.

Chapter 5 draws conclusions in relation to the problem statement, and state the limitations and recommendations of the study.

1.10. Conclusion

This Chapter has set the basis of the research in the context of KwaZulu-Natal, clearly showing the manner in which the research sample is linked on a provincial basis to KwaZulu-Natal. The focus of this study is on the management of e-waste in KwaZulu-Natal. KwaZulu-Natal is one on the nine provinces of South Africa. The disposal of e-waste impacts on the environment and has financial implications on various sectors of the society. Disposal techniques have also been discussed. Some companies that are involved with the collection of e-waste have been identified and listed.

The research problem was aligned with the research sub-problems. The research sub-problems were used to derive the research objectives and the research questions. A continuous check with the problem statement was done to make sure that the research questions have been in alignment with the research problem statement.

In addition an outline of the practicalities surrounding the survey has been provided. The standardisation and validation processes were discussed together with a brief description of the data collection methods and data analysis techniques. Finally, an overview of the each of the chapters in this study was given.

Chapter 2

LITERATURE SURVEY

2.1. Introduction

In Chapter 1 the problem statement that this study pursues was discussed showing the alignment of the problem statement with the research sub-problems, the alignment of the sub-problems with the research objectives and the alignment of the research objectives with the research questions. This was done so that the literature review and methodology that is used in this study is relevant to the problem statement.

This chapter presents the results of a more extensive literature survey as a theoretical basis from which to conduct the study. The literature review is targeted and is therefore concept-centric. The searches that have been conducted are described in the next section of this chapter.

2.2. How the literature review was conducted

In terms of literary sources, many of the University's resources had been consulted. The UKZN library's database using the online link (ilink and primo) was used to search for books and printed matter relating to the topic. University databases such as SABINET, Science Direct, EBSCO Host, and ProQuest were used to find journal articles and other literature to aid in this study. Electronic search engines including Google Scholar together with Meta search engines were also used to find articles from the Internet. These articles helped to give the researcher insight into the topic from different global perspectives. The global perspective was enhanced by keeping a close eye on the news (media and Television) especially news from CNN. Online encyclopaedias including Encyclopaedia Britannica were consulted to establish definitions and factual information.

To get a global perspective on e-waste the requirements of articles for StEPs (Solving the e-waste problem) summer school was done.

Useful contact was made with eWASA (e-Waste Association of South Africa). Relevant articles that could not be obtained through the University library database were obtained directly from eWASA. According to eWASA the continued increase in digitalization of products blurs the distinction between electrical and electronic appliances and therefore eWASA's definition of electronic waste includes "white goods, consumer electronics and information technology (IT)" (Ecroignard, 2008). White goods refer to equipment like Fridges, washing machines and microwaves, consumer electronics refers to items like televisions and IT refers to desktop PCs, printers and mobile phones. (eWASA, 2008)

Although the researcher agrees with eWASA that the continued increase in digitalization of products blurs the distinction between electrical and electronic appliances, the researcher would like to limit the focus of electronic products to batteries, mobile phones, computers, printers, decoders, digital cameras, digital watches, energy saver light bulbs, gaming machines, Hi Fi's, TV's, VCR and DVD Players, MP3 players, iPods, USB external hard drives, USB flash memory sticks and secure digital (SD) memory cards because the researcher wants to target the younger generation for the collection of data and the younger generation come across and use these devices fairly commonly.

The reason for targeting the younger generation is that this generation is generally more inclined towards technology and a secondary objective is to educate the population on e-waste. With the population being educated on e-waste and with the harmful substances contained in e-waste, hopefully this will create awareness for the proper disposal of e-waste.

The problem statement, the research sub-problems, the research objectives and the research questions were decomposed such that associated terms could be obtained for the use of searches. The concept matrix in Addendum 3 was used to maintain consistency in the terms and processes being searched for.

The academic searches have been done using keywords such as obsolete/redundant e-waste, obsolete/redundant computers, obsolete/redundant electronics, Green IT on databases including amongst others the Government Gazettes, NRF Nexus, ISAP ("Index to South African Periodicals") by the National Library of South Africa, SAMedia and SA ePublications. The above keywords

were also used to search databases of tertiary institutions such as NDLTD (Thesis and Dissertations), Navtech (SA Technikon research) and UCTD (Theses and Dissertations at South African Universities. These searches did not result in the location of any relevant academic research in the topic area.

2.3. Survey of literature that relates to the theoretical framework of the dissertation

Since the researcher is investigating the disposal of e-waste, a good starting point would be to locate policies or laws that pertain directly to e-waste. These policies or laws may be directed to the proper disposal of e-waste and must therefore be investigated. Although the researcher did not find policies and laws directed directly towards e-waste, the researcher found International, National, Provincial and Local government legislations that could be related to e-waste in some form or the other. These legislations that have been summarised and adapted from Dittke, (2009) are tabulated in the Tables 2.1, 2.2, 2.3 and 2.4 below. In the case of legislations of an International, National and Provincial nature, the legislation and the description have been given, whilst in the case of Local government, legislations, the name of the municipality and the legislation have been given because these legislations will have a bearing only in that municipality. Table 2.1 is based on International Legislation, Table 2.2 is based on National Legislation, Table 2.3 is based on Provincial Legislation and Table 2.4 is based on Local Government Legislation.

Table 2.1: International Legislation (Adapted from Dittke, 2009)

Legislation	Description
"Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)"	Covers several "toxic components found in e-waste". South Africa is a "signatory" to the Convention.
"The EU has the following legislation: • Directive on Waste Electrical and Electronic Equipment (known as WEEE Directive)	Users of equipment in private households must be given the necessary information about: • the requirement not to dispose of WEEE as part of the normal garbage or as unsorted municipal waste and to collect such WEEE separately; • systems that are in place for the return and collection of electronic material; • the individuals role in contributing to reuse, recycling and other forms of recovery of WEEE; • the potential harmful effects on the environment and human health as a result of the presence of hazardous substances in electrical and electronic equipment; • separate collection
• Directive on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (known as RoHS Directive)"	This directive states that all new equipment put on the market must not contain "lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). The Annex to this directive contains exemptions to the use of lead, mercury, cadmium, hexavalent, chromium in certain equipment". This annexure also specifies maximum permissible levels.

Table 2.2: National Legislation (Adapted from Dittke, 2009)

Legislation	**Description**
Constitution	Contains the basic environmental rights. The distribution of powers for different levels of government is given. Provinces indicate the standards of environmental controls within the "national framework" whilst "local authorities" are expected to "administer" the legislation. Where necessary the legislation may be supplemented with by-laws.
"National Environmental Management Act, 107 of 1998 (NEMA)"	The principles on waste management include "avoidance", "minimization", and the "remediation" of pollution. The „polluter pays' and „cradle to grave' principles are emphasized in relation to waste reduction, re-use, recycling and proper disposal.
"Environment Conservation Act, 73 of 1989"	Emphasis of the protection and controlled utilization of the environment. This Act provides for an Environmental Impact Assessment (EIA). The EIA will be "needed for any waste disposal activities". The administration of waste disposal has been delegated to Department of "Environmental Affairs and Tourism (DEAT)". Minimum requirements have been indicated for "waste disposal sites".

Legislation	Description
"Department of Water Affairs and Forestry (DWAF)"	Clearly specifies minimum requirements that deal with "waste disposal at landfill, handling, classification and disposal of hazardous waste together with water monitoring". Specification of the "storage of hazardous waste".
"National Water Act, 36 of 1998"	This Act includes a reference to "Disposing of waste in a manner which may detrimentally impact on a water resource (section 21(g)), which could have implications for e-waste management".
"Health Act, 63 of 1977"	Substantially repealed by the "National Health Act, 61 of 2003". Local authorities must carry out reasonable measures to maintain their districts in a hygienic and clean condition and in so doing to prevent any condition which could be harmful or dangerous to the health of people. Prevent pollution of water intended for human use.
"National Health Act, 61 of 2003"	The object is to "protect, respect, promote and fulfil the rights of the people of South Africa such that the environment is not harmful to the health or well-being of all".
"Atmospheric Pollution Prevention Act, 45 of 1965"	Registration certificates are required for some processes. This includes the processing of "lead, copper, waste incineration, cadmium, metal recovery, mercury, and glass".

Legislation	Description
"Air Quality Act, 39 of 2004"	This Act is only "partially in force". The purpose is to "improve air quality", although "standards" and controls are still being "formulated". This would most likely affect smelters. This licensing will "replace the registration certificates" currently being issued in terms of the "Atmospheric Pollution Prevention Act".
"Hazardous Substances Act, 15 of 1973"	Regulates the management of hazardous substances and hazardous waste. Deals with the "handling", "selling", and use of "hazardous substances".
"Chapter VIII (Transportation of Dangerous Goods and Substances by Road) of the Regulations in terms of the National Road Traffic Act, GN R 225 of 17 March 2000"	Incorporate various SABS now (SANS) standards that cover the road transportation of dangerous and hazardous goods – does not really apply to e-waste since transportation does not pose a danger. As a result transportation of e-waste will be governed by the „ordinary' traffic rules.

Legislation	Description
"Occupational Health and Safety Act, 85 of 1993, and Regulations"	Health and safety in the workplace. Specifies the regulations in relation to the "health and safety of employees and the public in general". Employers will be obliged to "perform risk and hazard assessments on a regular basis to determine any dangers posed by the work environment or materials being used".
"Framework for the National Waste Management Strategy, (2009)"; "White Paper on Integrated Pollution and Waste Management (2000)"; "National Waste Management Strategy and Action Plans (1999)"	Deals with environmental issues and "waste management functions and powers". The development of "the National Waste Management Strategy" is included. The prominence is on "holistic waste and pollution management". The following "waste management hierarchy" is laid down "for policy and legislative development": (a) Waste avoidance, minimisation and prevention; (b) Recycling and reuse (c) Treatment and handling (d) Storage and final disposal. "Recycling" is one of the "short-term" priority areas that have been "identified".

Legislation	Description
"Waste Management Act, 59 of 2008"	According to this act no person may "import", "manufacture", "process", "sell or export" a "priority" (harmful) "waste or product" that is likely to "result in the generation" of a "priority" (harmful) waste unless that "waste or product" complies with: (a) The management measures contemplated in this Act; (b) An industrial waste management plan; or (c) Any other requirement in terms of the Act.
"List of Waste Management Activities which have, or are likely to have a Detrimental Effect on the Environment, GN 718 of 2009"	No person may "commence, undertake or conduct a waste management activity" listed in the "schedule" unless a "licence is issued" in respect of that "activity". Two categories are used – category A only requires basic assessment whist category B requires a scoping followed by a "full" environmental impact assessment as per GN R 387.
"Changes to the Environmental Impact Assessment (EIA)Regulations"	The "second and third" of the "three EIA regulations" were "amended" on 3 July 2009. Depending on the "nature and size" of the "waste activities" carried out either a "category" A or B "licence" will still be required if the "minimum waste volumes" are reached. This then requires basic assessment or a scoping followed by a "full" EIA which is the same as before the changes.

Legislation	Description
Precious Metals legislation	Legislation was "considered" to be in a state of "flux". Governs "gold, silver, platinum and other platinum group metals, namely palladium, rhodium, iridium, ruthenium and osmium".
Second-Hand Goods legislation	"Second-Hand Goods Act, 6 of 2009" still not implemented. "Every dealer" must "register" with the "National Commissioner of the South African Police Service". This will include e-waste because according to Schedule 2 of the Act the metals being controlled are: "Copper, aluminium, zinc, chrome, lead, white metal, nickel, tungsten, tin, ferrovanadium, ferrosilicon, ferro-chrome, brass, bronze, cobalt and precious metals" as defined in the "Precious Metals Act, 2005 (Act No. 27 of 2005)", or any item consisting "wholly or principally" of any of the above mentioned metals.
"Consumer Protection Act, 68 of 2008"	This act will only be applied from 24 October 2010. This act prohibits the disposal into a common collection system. The supplier will need to accept the return of the product – it would seem that this would include e-waste.

Table 2.3: Provincial Legislation (Adapted from Dittke, 2009)

Legislation	**Description**
"Gauteng Draft Standards for General Waste Management Facilities (GWMF), March 2009"	Only province that has such standards. e-Waste containing "ozone-depleting substances" may not be "accepted or treated" at General Waste Management Facilities (GWMF's)

Table 2.4: Local (Municipality) Legislations (Adapted from Dittke, 2009)

Municipality	Legislation
Cape Town	"Integrated Waste Management By-law, PG 6651 of 21 August 2009"
	"Water By-law, LA 18366 of 1 September 2006"
	"Wastewater and Industrial Effluent By-law, LA 18367 of 1 September 2006"
	"Storm water Management By-law, PG 6300 of 23 September 2005"
	"Environmental Health By-law, LA 13333 of 30 June 2003"
	"Air Pollution Control By-law, LA 12649 of 4 February 2003"
	Draft Air Quality Management By-law
	Policies

Municipality	Legislation
Johannesburg	"Waste Management By-laws, 2003"
	"Water Services By-laws, PN 179 of 21 May 2004"
	"Public Health By-law, PN 830 of 21 May 2004"
	Policies
Durban / eThekwini Metropolitan Municipality	"Refuse Removal By-law, PN 47 of 2002"
	"Water Supply By-law, MN 104 of 26 September 1996"
	"Scheduled Trades and Occupations By-laws, PN 134 of 22 March 1979"
	Draft by-laws
	Policies
Pretoria (Tshwane Municipality)	"Solid Waste By-laws, 2005"
	"Sanitation By-laws, 2003"
	"Water Supply By-laws, 2003"
	Policies
Ekurhuleni	"Solid Waste By-law, PG 51 of 6 March 2002"
	"Wastewater By-laws, PN 274 of 6 March 2002"
	"Water Supply By-law, PN 276 of 6 March 2002"
	Policies

Since there are a number of legislations that can be applied to e-waste, the researcher will not attempt to draw up guidelines or legislation that applies to e-waste. EWASA is currently drawing up legislation for South Africa. It must also be noted that although it is important to have legislation in place, it is yet another issue when it comes to the enforcement of the legislation especially in a country

like South Africa. The problem of e-waste recycling becomes worse when one considers that a number of recyclers of e-waste are in fact in the informal sector. One of the problems with recyclers in the informal sector is that they do not follow safe methods of extraction of materials from e-waste (Aljazeera, 2010). The reason for this may be that the cost of the safety equipment is too high when one considers the rewards from recycling e-waste.

Since April 2010, "South Africa's National Air Quality Act", that watches and records emissions from business, is in fully operational. The Department of Environmental Affairs in a statement at the beginning of April 2010 stated that the Act "requires the national or one of the provincial environment ministers to identify and publish activities which result in atmospheric emissions that require an atmospheric emission licence before they can operate" (Enviroadmin, 2010). According to a list in the Government Gazette, activities such as "mineral, metallurgical, chemical processing and certain types of waste disposal" will fall within the scrutiny of the Air Quality Act (New Air Quality, 2004). This means that South Africans now have legislation on air quality management, and this legislation is comparable to international finest outcome driven practices (Enviroadmin, 2010). Although this law is in place, many informal recyclers still burn the mother boards of computers, emitting large amount of toxic material into the atmosphere. This is an example of where the legislation is in place but the enforcement of the legislation to say the least is difficult.

2.4. Survey of literature that relates to the management of e-waste

Since the researcher is investigating the Management of e-Waste in KwaZulu-Natal, South Africa this section will examine and report on the Management of e-Waste in a Switzerland, India, Europe, Japan, South Korea, United States of America, China, Nigeria and South Africa. A range of countries have been chosen for comparison of the organization or control of e-waste in developed and developing countries. Countries that import e-waste and countries that export e-waste have also been included in this section.

2.4.1. Management of e-Waste in Switzerland

According to the Environmental Sustainability Index Report of 2005 on world environment protection, Switzerland ranks amongst the top ten countries (Esty, Levy, Srebotnjak, de Sherbinin, 2005). The "Swiss law" on "waste management" stresses the principle of polluters pay. This principle has resulted in the encouragement of the "reduction, reuse and recycling of waste". Several systems are in place in Switzerland for the separation and gathering of dissimilar types of waste such as "glass, paper, plastic bottles and aluminium, among others, to facilitate better recycling". It is therefore not surprising that the first country in the world to set up a formal system to manage e-waste was Switzerland (Sinha-Khetriwala, Kraeuchib & Schwaningerc, 2005).

Sinha-Khetriwala *et al.,* (2005) states that two (2) Producer Responsibility Organisations or (PROs) was largely the reason for the successful collection of e-waste in Switzerland. SWICO ("The Swiss Association for Information, Communication and Organisational Technology") manages "brown goods" which include "electronic equipment" such as "computers", "TVs", "radios", etc., and the Stiftung Entsorgung Schweiz (S.EN.S) that handles "white goods" such as "washing machines, refrigerators, and ovens". Both SWICO and S.EN.S have years of practice in overseeing the successful management of e-waste. The managing of e-waste was started with the principle of Extended Producer Responsibility (EPR). A fee called ARF (Advance Recycling Fee) is charged on all produced appliances, this fee is not charged for repurchased appliances. By funding the collection and recycling, the ARF forms one of the strengths of the recycling system (Sinha-Khetriwala *et al*., 2005).

2.4.2. Management of e-Waste in India

The Indian system for recycling of e-waste was developed from the established scrap industry, the scrap industry sources include old or disused ships, old or end-of-life vehicles and waste from buildings. The e-waste organization in India is a case of "successful industrial symbiosis", which is organised by itself and driven by the market (Sinha-Khetriwala *et al.,* 2005).

Dwivedy & Mittal, (2010) conducted a study in which an approach together with a methodology was constructed to predict an estimate of the potential out-

flows of electronic waste (e-waste) in India. The study shows that the major factor that influenced the "European Union's Waste Electrical and Electronics Equipment" (WEEE) estimate for e-waste is the inflow value, the inflow value is calculated with the use of sales data and the decisions taken by the first owner or user. The correctness of the results is reliant on the accuracy of the data that was available together with postulation or guess of the average life span of the electronic items. The outflow estimates predicted with the use of this study may be used to divert waste from landfills by the creation of appropriate formal recovery and recycling infrastructure of electronic waste. However, one needs to keep in mind that illegal exports from other countries including developed countries into India cannot be reliably estimated, this will result in difficulty in the prediction and estimation of the outflows. This outflow estimate is even further compounded or blurred when one takes into account the informal sector.

2.4.3. Management of e-Waste in Europe

According to the European Commission - WEEE Directive, 2003 twenty five (25) "Member States of the European Union have been adopting a number of community level regulations related to e-waste". The intention is to safeguard, protect and improve environmental quality, look after human health and make use of natural resources carefully and sensibly. In 2003, the European Commission-WEEE Directive (2003) accepted regulations associated to EEE merchandise design, e-waste gathering, e-waste recovery, dealing with e-waste financing and user knowledge (European Commission - WEEE Directive, 2003).

The main aspects of this Directive was to include the "recovery, recycle and reuse" of e-waste. The directive aims to raise knowledge and awareness of end-of-life circumstances at the beginning and during the design of the merchandise or product.

Some on the countries from Europe that belong to the European Union are already implementing the regulation whilst other countries that do not have any previous system to manage e-waste, have requested extensions so that they can comply with the regulations. In addition, the two main factors that are delaying the directive are the reassigning of past regulations and the dialogue with stake-

holders in relation to the responsibilities in the process (Kahhat, Kim, Xua, Allenby, Williams, and Zhang, 2008).

2.4.4. Management of e-Waste in Japan

Kahhat *et al*., (2008) states that according to the e-waste laws in Japan manufacturers and importers must recall end-of-life electronics for effective management or recycling of e-waste. In particular, the Japanese "Home Appliance Recycling Law", enacted in 1998 and put into effect fully as of 2001. This law requires producers or importers of household produce to recycle household produce whether it is a television, a refrigerator or a washing machine. In addition, customers will have to pay an "end-of-life fee" that covers the cost or a part thereof associated with the end-of-life recycling and transportation. Through this system, the collection and transfer discarded merchandise from consumers is the responsibility of the retailer. In addition, it was found that Japan began the compulsory recycling of business personal computers (PCs) in April 2001. This was expanded to residential personal computers in 2003 with the "Law for Promotion of Effective Resource Utilization."

Local authorities initially managed the system, but for PCs sold after October 2003, manufactures are responsible for collection and recycling/reuse of computers. Computers under the PC recycling program have a "PC Recycling Mark" and include an invisible non-refundable recycling fee in the sale price, so no additional charges are required at the time of disposal. However, customers or consumers are required to pay a fee comprising collection and recycling for products or merchandise that was purchased before October 2003. These products will not have an identification mark (Kahhat *et al*., 2008).

2.4.5. Management of e-Waste in South Korea

The "Extended Producer Responsibility" (EPR) Law came into effect in 2003 in South Korea. Official targets for recycling of purchaser/consumer goods have been set by the government. If these targets are not met the local manufacturers of consumer goods, the importers of consumer goods and the distributors of consumer goods will face financial consequences. Typical consumer goods are TVs and PCs. In addition a condition is that a government account must be set up

so that recycling funds can be deposited into this account. A portion of these funds are refunded in a ratio to the actual volumes of waste that has been recycled.

In order to meet the EPR requirements, the recycling can be done in house or outsourced to recycling companies. The cost of the collection and transport of used equipment is to be borne by Retailers and suppliers resulting in no additional cost to the customer, the provision are that a similar product is purchased by the customer. In South Korea the responsibility of colleting e-waste products lies with the local governments, producers and/or retailers. If the consumer buys a new replacement product, the consumer does not pay a collection fee. Upon the sale of the new replacement product, the retailer becomes responsible for the collection of the e-waste, or as an alternate the retailer can pay a collection fee, this fess is made available to the local government collection system (Kahhat *et al*., 2008).

2.4.6. Management of e-Waste in the United States of America (USA)

The management of e-waste the USA focuses on e-waste disposal in the landfills and the exportation of e-waste. According to the "USA Environmental Protection Agency (EPA)", between 2003 and 2005, "about 80 - 85% of the e-waste ready for end-of-life management ended up in USA landfills". The solder in "circuit boards and in cathode ray tube (CRT) glass" are most commonly lead. The results for lead in different electronic equipment (such as "circuit boards, CRTs, mobile phones, computers") showed that "lead" exceeded the Toxicity Characteristics Leaching Procedure (TCLP) federal limits. These results were compared with results for electronic equipment such as "circuit boards and CRTs" that had been collected from eleven (11) Florida landfill sites. The landfill sites are referred to as leachates. A significant difference in "lead concentrations" was found, this resulted in the conclusion that TCLP can be overestimating "lead" leach ability in "real landfill" conditions. Even if e-waste disposal at landfill sites is not a danger to the surroundings and human beings health, it must be remembered that a number of advantages can still be realized from reuse and "recycling of e-waste" (Kahhat *et al*., 2008).

E-waste is disposed of by developed nations by exportation; this includes the USA, to developing countries, which in some cases is in "contravention of the

Basel Convention Agreement". The "Basel Convention is an international treaty that was created in 1989 in an effort to counteract the unsustainable and unjust effects of free trade in toxic wastes". The free trade in toxic wastes of all types including toxic electronic waste resulted in the Basel Convention of 1994 adopting a total ban on the export of all hazardous or toxic wastes from rich to poor countries for any reason at all, and this included recycling. The Basel Convention encourages countries to reduce their hazardous wastes and as far as possible to arrange for the hazardous waste to be disposed of within the country. A consequence of this would be that less hazard waste will be exported (BAN and SVTC, 2002).

Although the USA does not have any law that will be violated by the exportation of e-waste, a prior notification between the USA and the importing country is needed to comply with the "Basel Convention Agreement". The Basel Action Network (BAN) and the Silicon Valley Toxics Coalition (SVTC), are two non-governmental organizations (NGOs). Both these NGO's are in agreement when they oppose the export of e-waste to other countries especially developing countries. 80% as an estimate, of e-waste from USA, which is initially collected for recycling purposes, is actually being discarded by being exported to developing countries; in addition this is for informal recycling procedures in the developing countries (BAN and SVTC, 2002). BAN and SVTC have both indicated that the USA is not handling the e-waste issue directly and they are using escape routes with one of these being where the e-waste is shipped to developing countries, especially in Asia (BAN and SVTC, 2002).

2.4.7. Management of e-Waste in China

The government of Chinese has been aware of the dangers associated with e-waste to the environment for a number of years. This awareness has resulted in the issuing of a larger number of varying environmental laws, policies, principles, technical guidance and norms that relate to the manufacture of electronic goods and the management of e-waste (Yu, Williams, Jua, and Shao, 2010). A number of laws are related to e-waste by a varying degree, but are not specifically for the management of e-waste. Yu *et al.,* (2010) state that a "Circular on Strengthening the Environmental Management of Waste Electrical and Electronic Equipment

(WEEE) aims to prohibit the environmentally harmful processing of WEEE" (Yu *et al.,* 2010). The circular states that environmental or ecological protection departments issue licenses to enterprises for waste processing. This is done in accordance with the Law. The purpose is to encourage electronic product manufacturers to uphold or support cleaner manufacture and design that are eco-friendly (Yu *et al.*, 2010). Yu *et al*., (2010) also state that China does not have a specific licensing system or regulation for the recycling and treatment of WEEE.

2.4.8. Management of e-Waste in Developing Countries

Nnorom and Osibanjo, (2008) found that the majority of "developing countries do not have formal government or private industry-driven extended producer responsibility (EPR) programs for the management of waste electrical and electronic equipment". This problem is aggravated by the attitude of these governments' especially towards trans-boundary movement of electronic waste. This would not have been a problem or could have even been an opportunity, if these countries had formal activities for recycling, but instead these developing countries have low-end "crude" or informal recycling activities that are not controlled. An urgent need for the introduction of an EPR programme in developing countries exists, this would need to be driven by both government and industry. The establishment of "state-of-the-art" formal recycling facilities ought to facilitate the execution of successful reuse of components and modules whilst the remanufacture or reuse of electrical and electronic equipment will be a way forward.

As far as the author is aware developing countries do not have "legislation" dealing with specific toxic waste such as e-waste and the "enforcement of existing laws" dealing that are for "general waste management" is generally difficult to enforce. Formal "recycling of e-waste" using current, "efficient technologies" and safe, "state-of-the-art recycling facilities" is not common. Due to this e-waste tends to be managed by a number of low-end cheaper or more cost effective alternatives that amongst others involves disposal in open dumps, in backyards or informal recycling which at times also involves the disposal onto surface water bodies. Limited funding or no funding has also resulted in noteworthy impediments to the useful control and organization or management of toxic wastes. Even though financial resources have been scarce, the "development of technologies"

that is “appropriate” for the minimization of toxic waste like e-waste has been slow.

Uncontrolled, crude recycling of e-waste is takes place in a number of developing countries. These ‚backyard’ or informal recycling processes are used to decrease the volume of waste or remove “copper wires” by using open fires and leaching with the use of strong acid on printed wiring board (PWB) to recover precious metals. Often individuals/recyclers involved in the actual process give little or no consideration for personal protection of themselves or protection of equipment or pollution control measures that are being used in these recycling processes Aljazeera, (2010).

In burning of materials in open fires, toxic materials including heavy metals are generally emitted as fly ash particulates. These toxic fly ash particles or materials are generally inhaled; contaminate food, soil and surface water or anything in the surrounding area. These unprotected material recoveries from e-waste processes have resulted in pollution to the environment while exposing millions of people to toxic materials (Nnorom and Osibanjo, 2008).

2.4.9. Management of e-Waste in South Africa

Ecroignard, (2008) states that the Swiss government together with the KwaZulu-Natal Department of Agriculture have set up a “Dismantling and Recycling” facility at its “Head Office” in Cedara. The site at Cedara was to be used as a pilot project that would then be expanded to other parts of South Africa. The intention of this facility was to collect and dismantle e-waste (Ecroignard, 2008). According to eWasa, (2010) the site at Cedara is currently not functioning. eWasa, (2011) is currently investigating different methods that could be implemented for the proper disposal of e-waste in the entire country. Pilot committees have been set up in KwaZulu-Natal. Should these committees be successful then similar committees will be set up in Gauteng and Cape Town.

The table below lists four approaches of extended producer responsibility (EPR) together with examples of the manner in which the EPR ought to be implemented.

Table 2.5: Possible approaches to EPR and examples (OECD, 2001)

Type of EPR approach	Examples
Product take-back programs	• Mandatory take-back • Voluntary or negotiated take-back programs
Regulatory approaches	• Minimum product standards • Prohibitions of certain hazardous materials or products. • Disposal bans • Mandated recycling
Voluntary industry practices	• Voluntary codes of practice • Public/private partnerships • Leasing and servicing • Labelling
Economic instruments	• Deposit–refund schemes • Advance recycling fees • Fees on disposal • Material taxes/ Subsidies

2.4.10. Different methods used in the Management of e-Waste

Considering both India and Switzerland, it can be seen that more than one solution exists for e-waste recycling systems. The best or optimal solution is dependant to a large extent on the "economic and cultural context within which the system" is expected to operate or operates. A number of factors that include labour costs, the formal economic structures including the configuration and functioning of the informal sector, the existing framework for regulations together with the possibilities and limits of enforcement of the law must be considered when suggesting alternatives as solutions. The advantage of this would be that the current situation, in relation to environmental impacts, occupational hazards and economic revenue, could improve (Sinha-Khetriwala *et al.,* 2005).

In Switzerland, consumers pay a "recycling fee". In contrast, in India the "waste collectors pay a fee" to consumers when colleting their obsolete appliances. Traders who "aggregate" and "sort different kinds" of waste purchase the waste from the small collectors. The aggregated waste is then sold to larger recyclers, who recover the materials including metals, which have value from the waste. The waste industry adds "value" and creates "jobs at every point" in the value chain whether it is at the collector level, the trader level or the recycler

level. Due to the volume of e-waste increasing, specialization has occurred amongst waste processors (collectors, traders & recyclers) in that some of the waste processors are focusing only on "e-waste". The initial investment that is required so that a collection can be started, or to dismantle, to sort, or to recover materials is low in the e-waste industry, this results in a small entrepreneurs joining the industry (Sinha-Khetriwala *et al.,* 2005).

Nnorom and Osibanjo, (2008) discuss product take-back and product self-management as the two "issues in e-waste management". "Product take-back" occurs with "extended producer responsibility" (EPR) where the producer has a responsibility for the product from manufacture to disposal. As a result of this the producer is provided with incentives for redesigning products so that environmental impact is minimised. This would include the use of materials that are environmentally and the design of products in a manner in such that product can be more efficiently recycled or reused. The "principle of polluter pay" was one of the factors that were used in the development of EPR together with the acknowledgment of waste management and recycling. EPR requires that the people who use electronic equipment pay the true cost of the electronic equipment. The true cost takes into account the cost for recycling; it is also assumed that the cost of transport together with disposal cost is taken into account in the determination of the true cost of the product. The result of this is that the user of the "electronic equipment" will pay their "share of recycling" in the cost of the electronic equipment.

Product self-management is an alternative to EPR and the expectation is that it would make the management of end of life products "more efficient and less expensive". One of the EPR requirements is that manufacturers are to package fundamental information about the product disposal, both as a written label and as a tag with the product. The purpose of the tag on the "electronic equipment" would be to "link to websites", the website will have information on how product can be dismantled. "Universal Product Code" (UPC) bar code or "Radiofrequency Identification" (RFID) tags are possibilities of tags that could be used. A potential recycling application would be the dismantling of computers or other electronic products (Nnorom and Osibanjo, 2008).

Deng, Wen, and Zhao, (2008) conducted a study on discarded refrigerators. They state that for a short lifespan (a lifespan less than 8 years) of a refrigerator, the best option was to refurbish and resell the refrigerator. Whilst the best option for a long lifespan (a lifespan more than 15 years) a refrigerator was "Pre-treatment" and complete disassembly together with the shredding of the main body of the refrigerator in an open environment or in areas that have strict control standards for greenhouse gases. To control greenhouse gases the shredding must be done in an airtight environment. It was also found that the main factors that affect the chosen option of discarding is influenced by the cost of purchasing and disassembling and the sale price of plastics, condensers and copper.

Although the refrigerator does not fall in the exact category being investigated, it was found that these different disposal methods could be applied to e-waste.

Sinha-Khetriwala *et al.,* (2005) and Nnorom and Osibanjo, (2008) suggest government action is strongly recommended for an EPR program to be effective, government action will assist in gaining public confidence. Sinha-Khetriwala *et al.,* (2005) and Nnorom and Osibanjo, (2008) further stated that elements of an effective EPR program should include:

- Technical standards that are promulgated,
- Incentives for participation;
- Manufacturing and material processes to be continually re-evaluated,
- Information disseminated "to consumers and treatment facilities",
- Accountability for "end products" and performance must be maintained, and,
- Effective evaluation and monitoring of the program.

Systematic commitment is required by the government for the maintenance and sustainable development of an EPR program. "Resource conservation and re-use, material recovery and energy efficiency" are aspects that are encompassed by sound environmental management of e-waste (Nnorom and Osibanjo, 2008).

2.4.11. Lower level Management of e-Waste

Van Schaik & Reuter, (2010) in their article entitled "Dynamic modelling of e-waste recycling system performance based on product design", based the article on product design and liberation modelling. The creation of multi-material substances is determined by liberation or detachment of the associated materials during the shredding or dismantling process.

The repetition of a simple random pattern in the recycling stream results in a liberation model. Van Schaik & Reuter, (2010) state that a design table must be defined prior to "product design characteristics" in relation to "material masses and material connections" are captured into the design table. Their paper illustrates the manner in which the definition of a design table could be linked to the redirecting of the dynamic flows of materials. Van Schaik & Reuter, (2010) further suggest that a possibility for adding value throughout the recycling chain is done by incorporating "their quality as a function of liberation and separation efficiency".

Chen *et al*., (2006) present an "e-commerce simulation" that uses "a case e-commerce system" referred to as "Webfill". In Hong Kong Webfill is integrated with other systems for the management of construction and demolition waste disposal. The Webfill system functions by providing an online waste exchange platform to amongst others construction "contractors, property managers, construction material manufacturers and recyclers, and landfill managers".

Robinson, (2009) considers e-waste recycling that was conducted in Guiyu, China. According to Robinson, (2009) the e-waste recycling contaminated the entire region and pervaded into water, air, soil and the ecology of the region. "A small fraction or portion of the global e-waste stream would contribute very large volume of lead (Pb) and many tonnes of Cadmium (Cd), Mercury (Hg) and polychlorinated biphenyls (PCBs) being deposited into the water, air, soil and ecological systems" (Robinson, 2009). Figure 2.1 below shows the flow of "contaminants associated with e-waste". The components of e-waste are not being investigated in this study.

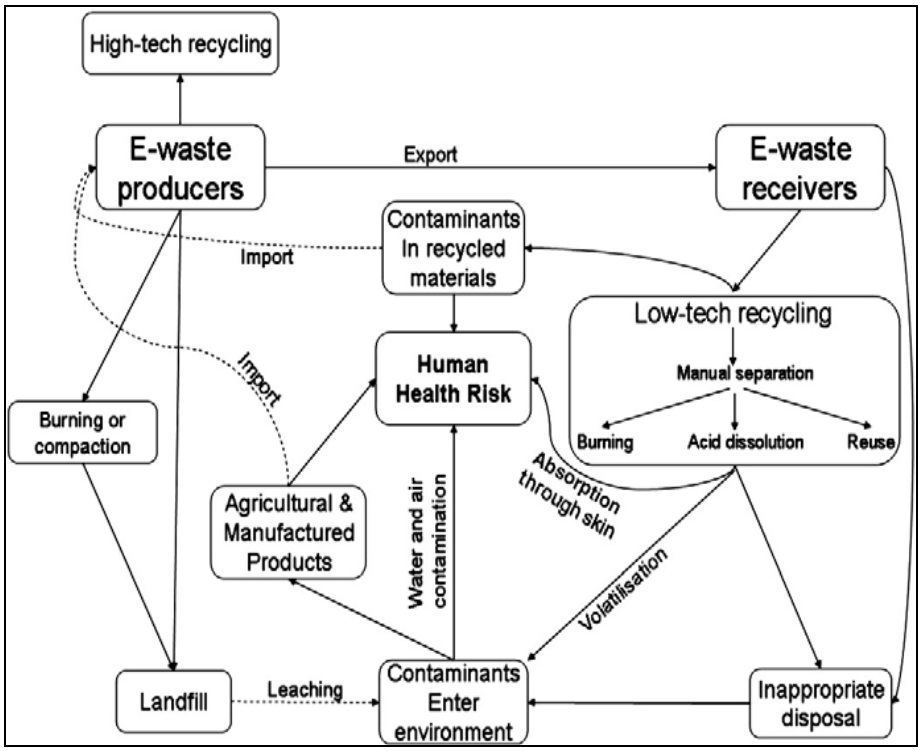

Figure 2.1: Fluxes of contaminants associated with E-waste from producers to receivers and ultimately to humans. (Robinson, 2009)

2.5. Survey of literature that relates to the research methodology used in the dissertation

StEP (Solving the e-Waste Problem) developed and reviewed a study that deals with "Recycle".

The focus of the study that was done for StEP by Schluep, Hagelueken, Kuehr, Magalini, Maurer, Meskers, Mueller, and Wang, (2009) lies on a consistent set of differing metals ("ferrous and non-ferrous metals") that included metals like "aluminium (Al), copper (Cu), palladium (Pd) and gold (Au)". Phenomena that are drivers for the execution of successful gathering and treatment processes of e-waste can be attributed to the fact that toxic and hazardous substances are present in different forms of electronic waste. In order to prevent environmental or health impacts the recycling of electronic waste requires proper handling and treatment. Schluep *et al*., (2009) in the report to StEP state that "the appropriate handling of e-waste can prevent serious environmental damage and also recover valuable materials". Schluep *et al*., (2009) classify "the recycling chain for e-waste into three consecutive steps: The first being collection, the second being

sorting/dismantling and pre-processing that also includes any mechanical treatment that may or may not occur. The third step would be the end-processing. They emphasise that "all three steps should operate and interact in a cyclic manner so that the overall recycling objectives can be achieved". Deng *et al*., (2008), Chen *et al*., (2009), Schluep *et al*., (2009) and Aljazeera, (2010) have shown that the common thread or the main objectives of e-waste recycling are:

- "To treat the hazardous fractions in an environmentally sound manner",
- "To recover the maximum valuable material",
- "To create eco-efficient and sustainable business",
- "To consider the social impact and the local context".

South Africa is also mentioned in the report by Schluep *et al*., (2009). The report places South Africa in Group C as a potential market for recycling and also classifies South Africa "as having a significant potential to adapt pre- processing and, to some extent, end-processing technologies to our own needs" with a requirement being that South Africa is involved in a technology and knowledge exchange. "Policy and legislation, technology and skills, as well as business and financing" have been identified as the three barriers that exist for the "transfer" of formal "sustainable e-waste recycling technologies" (Schluep *et al*., 2009).

Purnell, (2009) is instrumental in developing a National Waste Quantification and the Waste Information System. The purpose of formulating the "National Waste Quantification and Waste Information system" was to present the baseline data and to highlight issues that could be used in the main waste categories. Although e-waste can fit into a number of categories, this researcher felt that the most important category applicable to e-waste is the e-Waste and National Waste Information Systems (NWIS). Purnell, (2009) states that the "National Waste Quantification, and the Waste Information System" recognises that the "actual size of the e-waste stream is unknown" although "a survey was undertaken by eWASA in November 2008" to establish an estimate of the e-waste stream. eWASA found "that approximately 136 000 tons of white goods" including commercial and household goods, "consumer electronics and IT products were distributed in 2007"(eWASA, 2008). However, the survey could not determine

the actual size of the e-waste stream because the survey did not show how many of the distributed electronics and white goods reached their end of life or how much e-waste came from other sources. This also indicates that the quantities of recycled materials that arise in the form of e-waste are unknown and "very little information" is available on the "quantities" of e-waste that actually enter South African landfills. The reason for this is that there is "no systematic or formal monitoring of e-waste" quantities entering the waste stream, as e-waste is a relatively new recognised waste stream.

The assessment of the National Waste Information System found that "Chapter 6 of the Waste Act, 2008", needs the Minister to "establish a national waste information system (NWIS)" that will record, collect, manage and analyse data and information (Dittke, 2009). The current South African Waste Information Systems (SA WIS) does not, currently, meet some aspects of the Waste Act. However, the SA WIS design allows for the incremental expansion to include the required data and information, and would, therefore be able to comply with "Chapter 6" of the Waste Act. (Purnell, 2009). NWIS may also be adapted so that data or information could include the level of services that are provided by the different municipalities and this could in turn be related to the "information on compliance with the Waste Act".

From the above it can be seen that e-waste in South Africa requires research that will help to determine the volume and categories of e-waste. Another area that requires attention when considering recycling is the informal sector. There are many news reports that show the harmful ways in which recycling occurs in the informal sector. It is for these reasons that common grounds between the formal and informal sector requires investigation.

The above literature initiated a theoretical framework that is represented in the form of a diagram in Chapter 3, Figure 3.2.

When considering the Management of e-waste in South Africa an additional theoretical framework that can be used as an assessment indicator system that measures and compares "waste electrical and electronic equipment (WEEE)" management systems is extended producer responsibility which is represented in Chapter 2, Table 2.5.

2.6. Survey of literature that relates to the elimination of problems already solved by other researchers

The determination of substances that could be used in the recycling process has been identified by a number of researchers including Streicher-Porte *et al*., (2005). According to Streicher-Porte *et al*., (2005) the precious metal flow which can be easily converted into revenue "flow is one of the key economic drivers" of the informal recycling system. The high monetary value associated with gold and the fact that "concentrations of up to 4g" per personal computers can be obtained creates strong incentives to recover gold from personal computers. Studies have shown that the main separation of material flows for the recycling processes split into glass, plastic and metal fractions (Whyte, 2010 and Streicher-Porte *et al*., 2005). Little economic incentive is created by the glass fraction because the material is inexpensive and cannot be used for products of high quality without separation techniques that are elaborate. The volume of "glass fraction outweighs all other flows". Whyte, (2010) in a presentation to eWASA stated that the glass could be crushed to a fine form and used in tar for the surfacing of roads or even in the place of river sand when pipes are being laid. The problem is that it would cost more than the sand that it would replace. Also, people would need to be educated on the fact that the glass would be fine so that it does not cause any harm.

The plastic that can be obtained from monitors and other components of the personal computer contain flame retardants. Plastic recycling creates raw materials for other industries. Streicher-Porte *et al*., (2005) reveal in their study that effective recycling of plastic are available for several different plastic fractions, the downside being that the price is very low. In South-Africa we have a company that manufactures roof tiles from the plastic that can be obtained from obsolete or redundant computers; the problem yet again is that the tiles after manufacture cost more than conventional tiles. If the manufacture of the tiles is subsidized, the benefit of the subsidy could reach the recycler; in this way recycling can be encouraged. Australia has built an entire cycle track with the plastic from recycled printer cartridges (Whyte, 2010).

Studies like the one done for StEP by Schluep *et al*., (2009) have shown that although many metals are contained in e-waste, only iron, copper and alumin-

ium are sent to smelters. The recovery of these "contributes less than 10% to the value" that is added to e-waste.

Chen *et al*., (2009) describe the effect of the "detoxification and reutilization of lead-contained in funnel glass" of Cathode Ray Tubes. It was found that "Lead with purity level of 99.3%, was successfully separated and recovered from the funnel glass" of a Cathode Ray Tube. It was found that "the maximum lead removal rate reached 98.6%" under certain fixed conditions. The article from Chen et.al, 2009 did not state whether this process was profitable or not. Currently in South Africa the recycling on Cathode Ray Tubes (CRT) in the Formal sector is not profitable (Whyte, 2010).

It was also stated in the broadcast by Aljazeera, (2010) that the cost in India of dismantling a computer is $2 whilst the cost in America is $20. Aljazeera, (2010) did not indicate whether the cost was calculated in the informal or the formal sector, or a mixture of both. This shows that the cost of dismantling a computer is not constant from country to country, and it is therefore difficult to predict what the cost of dismantling of a computer in South Africa is. Since decommissioning involves the proper removal of the data and software on the computer, dismantling and recycling of components that can be used for other purposes, the extraction of materials that can be used elsewhere and finally the safe discarding of material that cannot be used, it becomes even more difficult to predict the cost of decommissioning a computer. As a result of this it is difficult to predict the cost of a computer that includes the cost of decommissioning. In this dissertation, the cost of a computer that includes the cost of decommissioning is referred to as the true cost of the computer.

The research question "Is South Africa importing refurbished obsolete computers from 1st world countries?" cannot really be determined because imported new and used electronic goods cannot be separated as both new and used electronic goods share a common import tax number. Resulting from the use of a common tax number, it is difficult to ascertain how much used electronic goods are being imported into South Africa. Aljazeera, (2010) states that 75% of India's e-waste is generated from within the country; eWASA has stated "that the amount of e-waste generated" in South Africa has not been determined.

Given that a 3rd world country like India generates such a high percentage of its own e-waste, it would seem that South Africa will also be generating a large percentage of its own e-waste.

2.7. Conclusion

The literature review involved searches on various electronic databases and meta-search engines. Global media sources were also consulted. Due to the limited material available from academic sources, a section 21 Company, eWASA proved to be very useful for the location of information relating to the local e-waste situation. International, National, Provincial as well as municipal legislation that relate to e-waste have been listed. The level and depth of the application of the legislation have been discussed. Finance and the lack of knowledge or disregard of the laws governing the safe disposal of e-waste, are major drawbacks to the safe disposal of e-waste. A further aggravating factor is the capacity or policing that is required to implement these laws.

Various studies that relate to the disposal of e-waste and the technologies that are required have been discussed. e-Waste management in European, Asian, American and developing countries was investigated. In comparison South Africa still has a long way to go in terms of e-waste management. South African law-makers and advocates of e-waste have come a long way in the establishment of laws that positively affect the proper or safe disposal of e-waste. Much more work and education is still required.

The true cost (cost that includes the decommissioning) of computers and importing computers was investigated. Problems and possible solutions specifically relating to processes involved in e-waste disposal and recycling were discussed. South Africa is still in its infancy when one considers safe e-waste disposal in the form of reuse and recycling. It would seem that education would be a key driver in the application of safe the disposal of e-waste.

Chapter 3 uses the literature from Chapter 2 together with the elaboration of the problem statement from Chapter 1 to discuss the research methodology that is being used in this dissertation.

Chapter 3

RESEARCH METHODOLOGY

3.1. Introduction

Sekaran and Bougie, (2010) define research "as simply the process of finding solutions to a problem after a thorough study and analysis of the situational factors". Whilst considering the definition one has to consider the different types of research. Miller, (1983) states that "methodology is a body of knowledge that enables researchers to explain and analyse methods" whilst indicating their limitations and "resources and consequences and then relate the potential to advancing other research". Another way of looking at research methodology would be that "it underpins the types of questions" that one can address directly and the "nature of the evidence that is generated" (Clark, Lotto, and Astuto, 1984). It is for these reasons that the "issue of research methodology is important to any study" (Clark *et.al*.,1984). The definitions that have been listed will be used initially in the design of the questionnaire and then in the analysis data that will be obtained from the respondents.

Methodological procedures that are of a lower-level such as sampling and statistical packages are influenced by the decisions about the priority that is being given in the design of the methodology. The methodology is similar to a blue print that researchers can follow so that responses to questions being studied can be analyzed to obtain answers for the research project. Together with a well outlined research plan, the methodology provides the limitations, constraints and issues of an ethical nature that a study will certainly encounter (Saunders, Lewis, and Thornill, 2009). In order to get a holistic view of research the researcher looked closely at the research „Onion' as described by Saunders *et al*., (2009). The terms associated with the research „Onion' will be described in conjunction with Figure 3.1.

3.2. The Research Onion

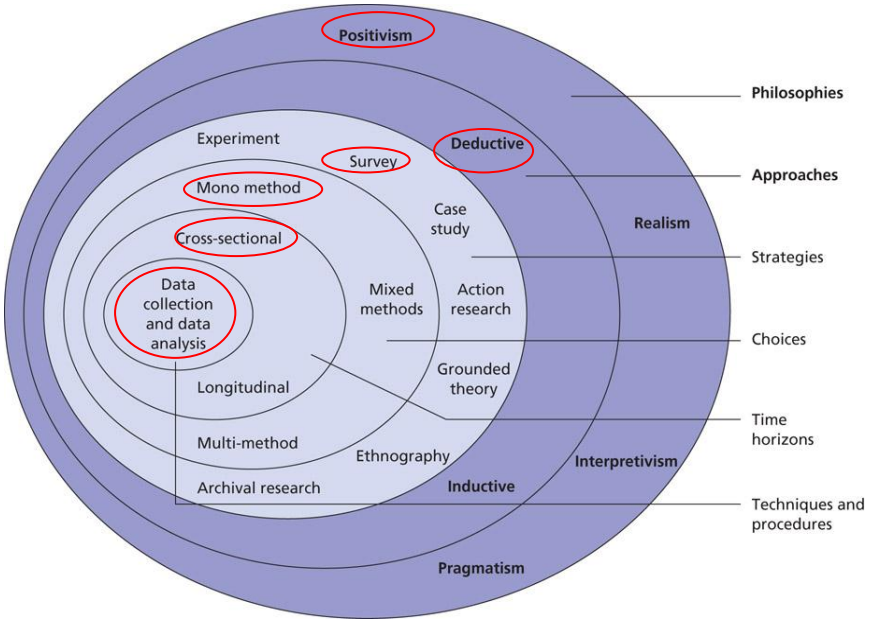

Figure 3.1: The Research Onion, Source: (Saunders *et al*., 2009)

Figure 3.1, the research onion, extracted from Saunders *et al*., (2009) shows the different layers with each layer associated with an approach, each of the layers needs to be constantly considered and engaged in order for one to conduct research. In association with the research onion, techniques for data collection and analysis can be obtained, however considerations must be given to the other layers of the onion (Saunders *et al*., 2009). The researcher will now discuss the research onion beginning with the outermost layer and then proceed from layer to layer until finally discussing the inner most layers which are symbolic of peeling an onion. The layers that would be described are the philosophical, research approaches, strategies, choices, time horizon and lastly the techniques and procedures layers. In each layer the approach that will be used in this study will be elaborated on. The approaches used in this research for each layer is circled in red in Figure 3.1.

3.2.1. Research Philosophy

Many different philosophies exist that influence the manner in which an event is interpreted; an event may appear to be problematic under certain conditions (May, 1997). In order to deduce and recognize aspects with the world we are living in, we require „ways of viewing' and „ways of interpreting' in order to clutch the evidence, ideas, and procedures that surround us (Thanawut, 2009). This would then imply that many schools of thoughts can be used to interpret and understood the social world. For this research the researcher would choose to use the philosophical positivism research over the categories realism, interpretivism and pragmatism of philosophical research. The reason for this is that positivism is considered to be "a philosophy that asserts the only authentic knowledge is that which is based on sense experience and positive verification" (Thanawut, 2009).

3.2.2. Approaches

The Deductive is an approach that begins with wide-ranging ideas such as a theory, laws or principles. A specific hypothesis or problem statement is based on these general ideas. A specific hypotheses or problem statement is formulated. This specific hypothesis or problem statement can be tested in order to support or reject the general ideas. The initial or general idea is indeed correct if the hypothesis is supported. If the hypothesis is rejected, it would imply that the initial or general idea was in fact incorrect (Sekaran and Bougie, 2010).

An inductive approach begins with specific occurrence or observations of an individual case. The inductive approach is based on the accumulation of an observation where a general idea on that observation may be derived. The Inductive approach may be compared to detectives solving a crime they are involved with; they gather small bits of evidence and information around the criminal scene and derive a general idea that would be able to point in a specific direction leading to the arrest of the culprit or criminal (Sekaran and Bougie, 2010).

The researcher chose to use the deductive approach because "e-waste" is a general perception that is in existence and the researcher is concerned about a specific aspect of e-waste.

3.2.3. Strategies

In this layer the strategies have been broken down into seven types of design being "the experimental, the survey, a case study, action research, grounded theory, ethnography and archival research" (Sekaran and Bougie, 2010). Experimental design is a design approach in which the researcher may organise a simulated setting, with some variables that may be controlled, and the independent variable may be changed by the researcher. This will create a cause-and-effect relationship (Sekaran and Bougie, 2010).

Survey research will encompass any measurement methods that would involve the asking of questions of the respondents or participants. A survey may in different forms, it can be a simple pen or paper-and-pencil feedback or it can be interview on a one-on-one basis (Mouton, 2003). In the study design, the researcher uses case studies as the primary data in the study (Glatthorn, 1998). "Action research is a method of initiating or starting change processes", with "an incremental focus, for reducing the gap between the desired and actual states" (Sekaran and Bougie, 2010). Grounded theory is a systematic set of procedures to develop an inductively derived theory from the data (Mouton, 2003). Ethnography can be considered as the "fundamental research method of cultural anthropology, and also as the written text produced to report ethnographic research results. Ethnography design seeks to answer central anthropological questions concerning the ways of life of living human beings". Generally questions in ethnographic design are the links between culture and behaviour of the subjects being studied, or how cultural processes develop over time. (Glatthorn, 1998).

Archival research is at times referred to as secondary research. In this kind of research the majority of references and knowledge is not from the primary source but rather from sources that have been based on other sources (Blanche, Durrheim, and Painter, 2007). Some examples of secondary data are data from census surveys, clippings from newspapers, certificates of birth and past records from different sectors (Blanche *et.al,* 2007). After careful consideration of each of the different strategies the research of choice for the researcher is survey research because the researcher wants to obtain feedback to

questions from a large number of respondents with the questionnaire being used as a survey tool.

3.2.4. Choices

A "mono method approach is one in which the researcher collects the data, analyzes the data, and integrates quantitative or qualitative data in a single study or in multiple studies" (Sekaran and Bougie, 2010). "A mixed method approach is one in which the researcher collects the data, analyzes the data, and integrates both quantitative and qualitative data in a single study or in multiple studies" (Mouton, 2003). The researcher's understanding is that multi-method research attempts to join different research methods so that a specific research problem can be isolated and addressed. It would typically include a range of research strategies that may be assigned strategically. It may also be used over the course or duration of the research project whist breaching the divide between qualitative and quantitative divide (McKendric, 1999). From the researcher's point of view multi-method research occurs when one "method is applied" with reference to another method to satisfy or "address a research agenda" (McKendric, 1999).

This research will be restricted to the mono method because the researcher wants to get a large number of respondents to answer the questionnaire, and thereafter use the Statistical Package for Social Scientists (SPSS) to analysis the data.

3.2.5. Time Horizons

People from different groups, who differ in interest, but share some of the characteristics like socioeconomic status or educational background or ethnicity are utilized in a cross-section (Blanche *et al*., 2007). Research of a longitudinal nature is a research method that is used to find a relationship or relationships between variable or variables that are not related to other background variables. The technique of studying or observing or researching the same group of individuals over an extended or long period of time is referred to as observational research. Data is collected at the beginning of the study this data is referred to as initial data, and then at specified intervals data is gathered repeatedly throughout

the timeline of the study (Blanche *et al*., 2007). This study uses cross-sectional research because the respondents of this study are university students that are computer literate and this study is a snap shot at a particular time, for the duration of this study the researcher will not go back to the respondents for the collection of any more data.

3.2.6. Techniques and procedures

Quantitative research involves the collection of data that is unconditional, an example would be data on a numerical nature. The purpose of using the numerical data is to minimize bias when the data is being examined. With this idea in mind it would imply that one of the main ideas concerning quantitative research would be the ability to separate things, so that they can be counted in categories so that they can be modelled statistically. An important advantage of this would be that factors that may distract one from the research or the intent of the research can be removed. In order to do this the researcher must have an in-depth understanding what is being measured prior to one actually performing the measuring process. Controls are used in the set up of the study with a very clear blueprint in the form of a theoretical framework. The theoretical framework will be elaborated on later in this chapter. Quantitative research may also be considered as a collection of numbers, which can be subjected analysis of a statistical nature (Sekaran and Bougie, 2010). In the case of this research SPSS is being used as the tool to analysis quantitative data.

Another important consideration or aspect in removing researcher bias in favour of Quantitative research is that the researcher or data collector can easily remain emotionally separate from the research. For research areas that involve obtaining sociological data as in the case of this research, the majority of bias if there is any would be limited to bias that may be introduced by the respondents of the survey (Sekaran and Bougie, 2010).

Qualitative Research is considered to be a more subjective form of research because the research in its nature allows the researcher or participants or respondents to introduce bias. This occurs mainly when one wants a more complete picture. Qualitative research may be more suitable for situations where what is being

looked at in the study is unclear and the researcher needs to filter the data to obtain or extract the relevant data. Qualitative research "generally examines words or actions in narrative or descriptive ways more closely where these represent the experiences of the people" or respondents involved. This focus of the research is on understandings and meanings. It takes lay accounts and concepts seriously and will involve more than just a description of other, from a quantitative questionnaire. Due to the nature of qualitative research the focus of the study or research may become clearer as the research progresses (Mouton, 2003).

In quantitative research the observations are generally converted into discrete units, the purpose of the conversion is so that the units can be compared to other units by performing statistical analysis. The focus of quantitative research is on explanations, predictions and proof. In this research the questionnaire was converted into discrete numbers that represented the alternatives of each question.

Generally the data that is presented from qualitative research is less tangible than pure numbers that one may obtain from quantitative research. The outcomes of qualitative research may in fact yield a story or stories, or a picture or pictures, or a depiction of feelings or emotions. In qualitative research the emotion of the researcher may play a significant role, and this may result in the researchers own bias influencing the results.

3.3. Choice of Methodology

Based on the descriptions given above and the research problem the research methodologies being used in this research (from the outer most layer of the onion to the inner most layers) are:

- Philosophy - Positivism,
- Approach – Deductive,
- Strategy – Survey,
- Choice – Mono-Method,
- Time Horizon – Cross-sectional and
- Techniques and procedures – Quantitative

In addition to the reasoning in the above paragraphs, the researcher also took into account that:

- Answers to questions involving the research lends itself to be quantified in terms of numbers,
- It would be best to collect data that does not have a bias from the researcher,
- A large sample size will be looked at to accommodate the different Government Funded Tertiary institutions so that the sample can include both Rural and Urban areas,
- Due to the large sample size open ended questions would be avoided so that SPSS can be used for the analysis,
- The questionnaire could be administered to a large group of students at a single setting, in this way the answers from one participant would not really be influenced by another participant.

This resulted in the following theoretical framework.

3.4. Theoretical Frameworks

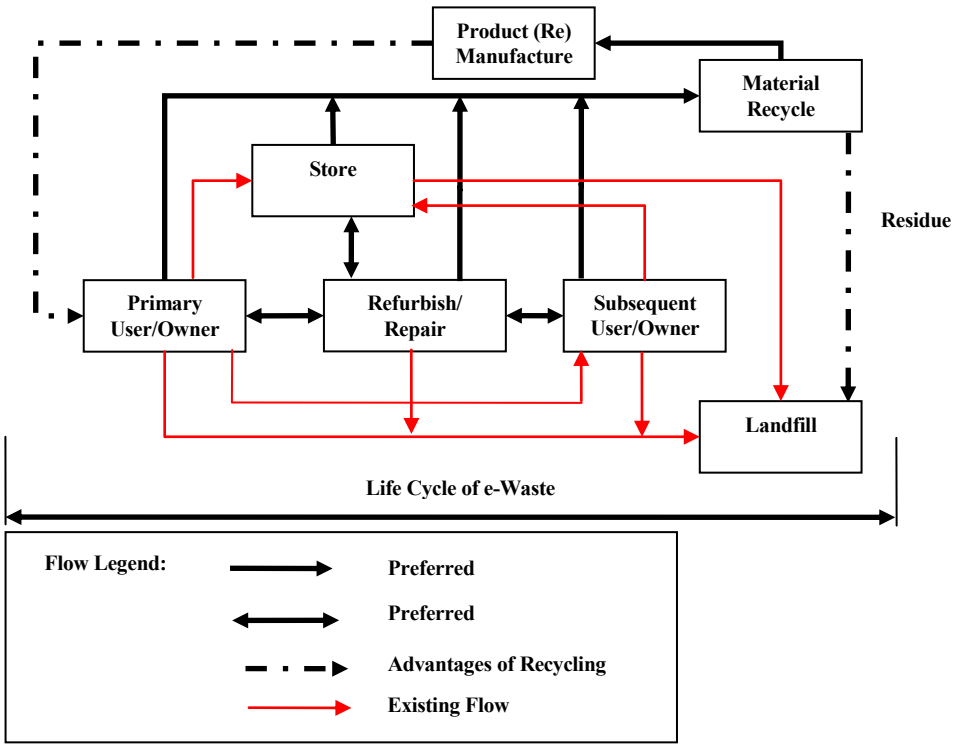

Figure 3.1: Life-cycle of e-Waste, Adapted from Life-cycle of e-Waste Ahluwalia and Nema, 2007.

Figure 3.2 shows the flow of electronic or electrical components/device from the manufacture until it ends up in a landfill site. Each aspect in the diagram is explained below. Each box represents a significant step in the life-cycle of the electronic/electrical components/device. The Flows are showing the possible movement of electronic/electrical components/device from one step in the life-cycle to the next. The different types of flows are considered as:

- The narrow (Red) line shows the possible existing flow from the Primary user until it finally lands up in a landfill,
- The broad dark line with the single and double shows the preferred flow as this would be in keeping with the Global ideological belief of going Green,
- The broken line shows the advantages of recycling.

The researcher will now explain what happens when the electronic or electrical component or device has served its purpose within each box or step; to do this each box or step will be considered on its own:

- Primary User/Owner and Subsequent User/Owner Box/step
    - Placed into storage because the primary user/owner may feel that the component or device is still an asset,
    - Sold or donated to a subsequent user/owner,
    - Sent out with the garbage until it ends up in a landfill.
    - Sent out for Material recycling – this may be at specific collection points that may include manufacture recollection points,
    - Sent to be repaired or refurbished so that its life span can be increased.
- Refurbish/Repair Box/step
    - Broken components/device is repaired and sent back to the primary user/owner or sold to a subsequent user/owner.
    - Broken components/device that cannot be repaired are sent back to the primary user/owner or sold to a subsequent user/owner or sent to storage or sent for material recycling or sent to a landfill,
    - Working components/device that is not meeting the user's requirements are sent to be refurbished. After refurbishment if it does meet the user's requirements then components/devices are returned to the user/owner. After refurbishment if the components/devices do not meet the user's requirements the components/devices are sent back to the user/owner or sold to a subsequent user/owner or sent to storage or sent for material recycling or sent to a landfill.
- Store Box/Step
    - Kept in storage until cleanup when it can either land up in a landfill or sent for recycling.
- Material Recycle

- Broken down into constituent parts usable parts sent for remanufacture whilst unusable parts are sent to Landfill.

- Product (Re) Manufacture
  - The materials could be used to manufacture new components/devices and sent back to the market or the materials can be used in the assembly of new components/devices.

Although some manufactures are now taking back used electronic or electrical components it is not common practice and therefore is combined with the material recycle. The perception of the participants will be investigated in this research.

3.5. Conclusion

The different research strategies used to facilitate this study has been discussed. The Research onion was considered important to this study. Each layer of the research onion from the outermost to the inner most was described. After the description of each layer the approach being used in this research was indicated. The purpose for this was to show the manner in which this researcher linked the theories of research to the research problem. The methodology being used from innermost to outermost of the research onion is data collection and data analysis, a cross-sectional, mono-method, survey, deductive approach and a positivism philosophy. The statistical package of choice is SPSS because of the quantitative data.

A theoretical framework adapted from the Life-cycle of e-waste was explained in the context of this study.

Chapter 4 employs use the research methodology from Chapter 3, with literature from Chapter 2 and the elaboration of the problem statement from Chapter 1 to analyse and interpret the data that has been collected.

Chapter 4

DATA ANALYSIS AND INTERPRETATION

4.1. Introduction

Lieberman, (1971) and Sekaran and Bougie, (2010) state that the purpose of using statistics is to extrapolate from the data one has collected so that general conclusions can be made. According to Levin, (1999) and Sekaran and Bougie, (2010) analysis is done on the sample so that inferences can be made about the population. South Africa has a population of approximately 50 million people of which approximately 10 million reside in KwaZulu-Natal (Population Estimates, 2010). The population includes people of different levels of literacy.

Due to the nature of the research and the problems that some may have with the terminology being used, it was decided that it would be best to conduct the research amongst people that are computer literate. It was for these reasons that the Tertiary institutions were targeted. It was decided to conduct the study in all four government funded Tertiary Institutions in the province. The Gatekeeper of research from each of the Institutions was contacted and the necessary permission to conduct the research was obtained. After analysis of the questionnaires inferences will be drawn about the population of KwaZulu-Natal, South Africa.

This Chapter will analyse and interpret the data collected from the questionnaires, designed with the use of the theoretical framework which was described in Chapter 3. In total 709 completed unspoilt questionnaires were obtained from respondents. Questionnaires that did not have signatures granting the researcher permission to use the questionnaire was not used. The questionnaires were divided into batches of approximately 20 and the data from all 19 questions of the questionnaires were entered into an Excel spreadsheet. After the data from all the questionnaires were captured into the spreadsheet, the data was verified by checking the spreadsheet with the data from the questionnaire. This enabled the researcher to correct all incorrect entries. The reason that the data was entered into

a spreadsheet and not directly into SPSS was to check the range of data for each question with the use of formulae. Thereafter the data was imported into SPSS. The questions from the questionnaire were entered into SPSS with the use of the variable view, the terms scale, nominal and ordinal was used to describe the measure (SPSS, 2010).

Due to the nature of the data that was obtained from the questionnaires, both "descriptive and inferential statistics" will be "used to analyse" and interpret the data (SPSS, 2010). The analysis of each part of the data will be done with an immediate interpretation, so that a link to the data and interpretation can be maintained. The next section shows the relevance on the data in relation to the demographics.

4.2. Demographics

Figure 4.1 below shows the number of respondents per tertiary institution. Data from 709 respondents was used, by taking the 8 different campuses into account the mean or average number of respondents per campus should be 88.6 if an equal number of respondents per campus were required. The study had a varying number of respondents per campus, the lowest number of respondents was from MUT which was 22.6 lower than the mean and the highest was from UKZN PMB which was 15.4 more than the mean. In relation to percentages the percentage difference is 5.4%. The Frequency Table for the pie graphs are in Addendum 4.

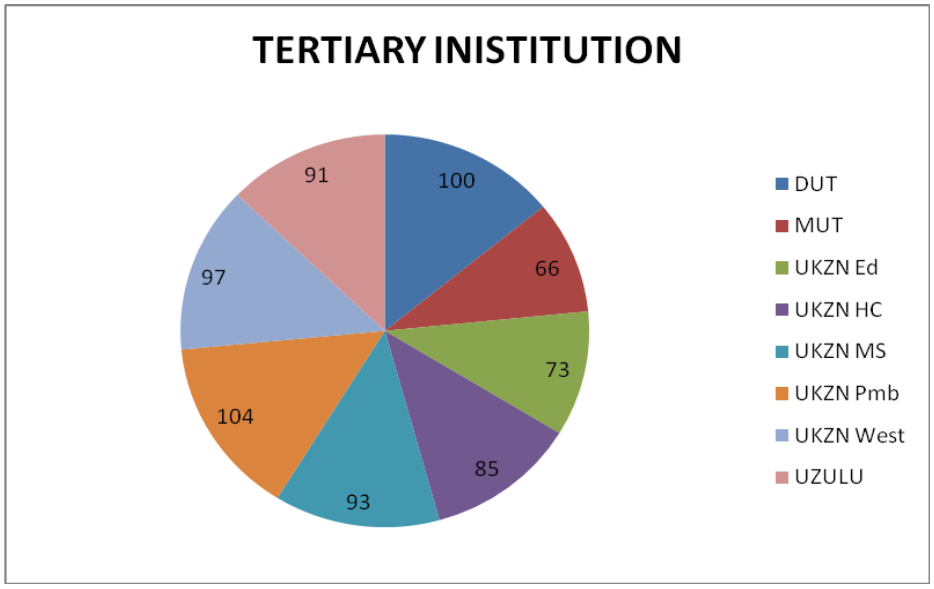

Figure 4.1: Number of Respondents per Institution

Figure 4.2 shows the age distribution of the respondents. Only 1 respondent is under the age of 17, 45 are in the 23-24 age category and 42 are in the over 24 age category. This was expected because the respondents are full time students at tertiary institutions. On closer examination the researcher decided to combine the categories as shown in Figure 4.3 so that the numbers of respondents in the different categories are more equitable. Due to this combination the age distribution collapses into four categories.

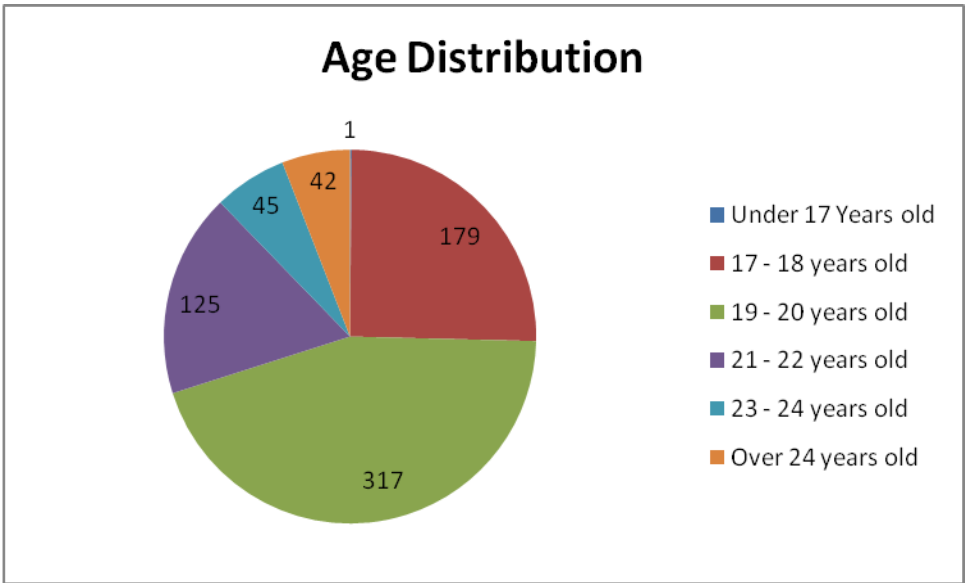

Figure 4.2: Age Distribution

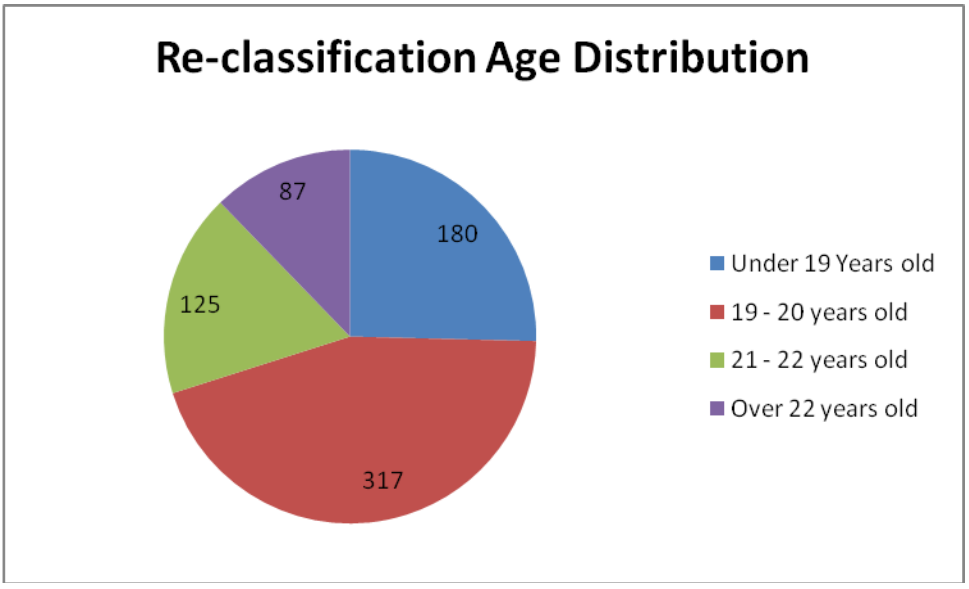

Figure 4.3: Re-Classification of Age Distribution

Figure 4.4 shows the distribution of the respondents' homes. Coincidently, the number of respondents from semi-rural and rural area was about the same. Semi-rural was defined as having both rural and urban characteristics of outlying areas adjacent to urban areas and rural areas was defined as large and isolated areas of open country with low population density that are not adjacent to urban areas (Yourdictionary.com, 2010).

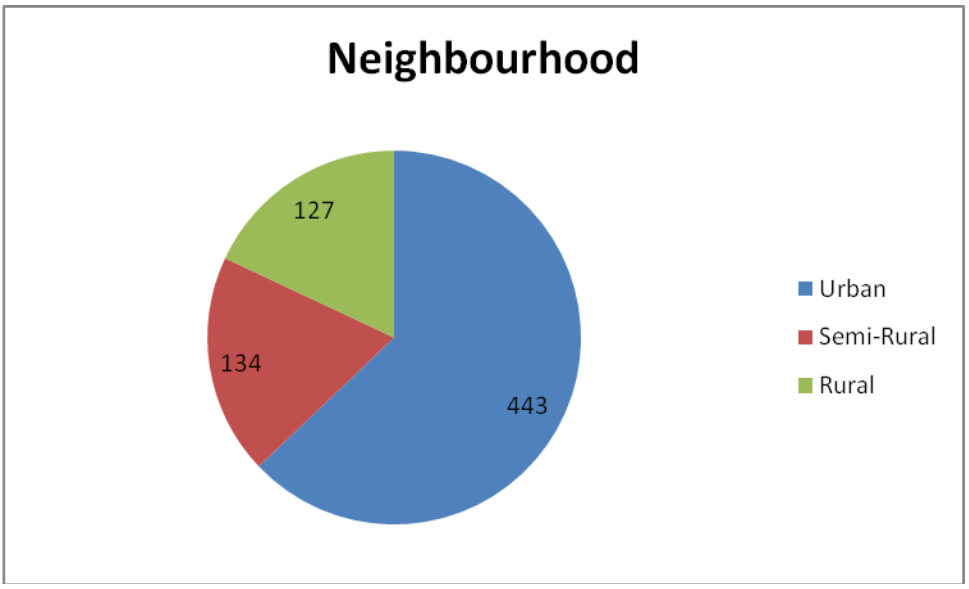

Figure 4.4: Neighbourhood

Figure 4.5 indicates that only 46 respondents did not have electricity at home.

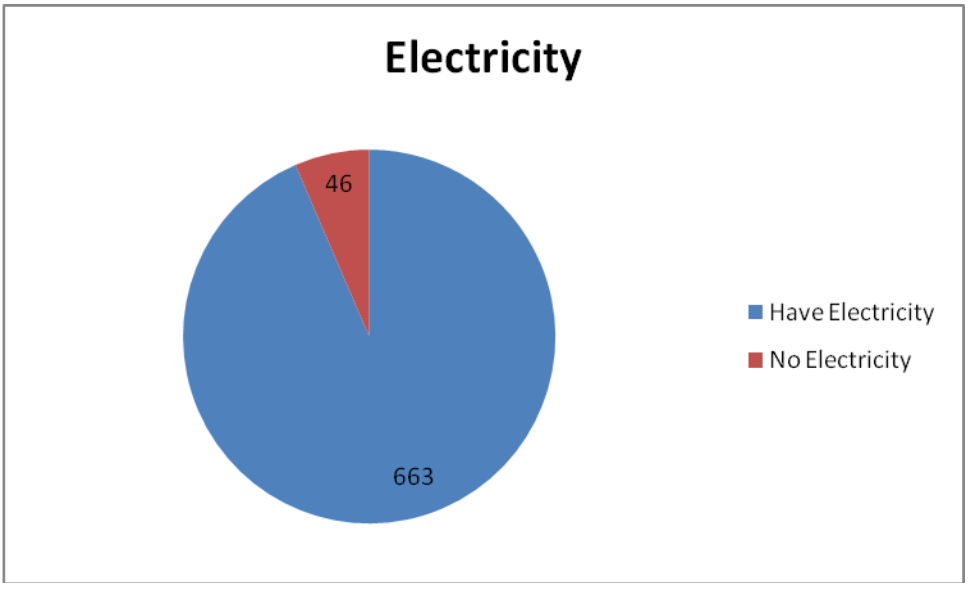

Figure 4.5: Electricity Availability

A cross-tab of neighbourhood and electricity yielded Figure 4.6 and Figure 4.7. Figure 4.6 shows the number of respondents from the different areas that have electricity and Figure 4.7 shows the number of respondents from the different areas that do not have electricity.

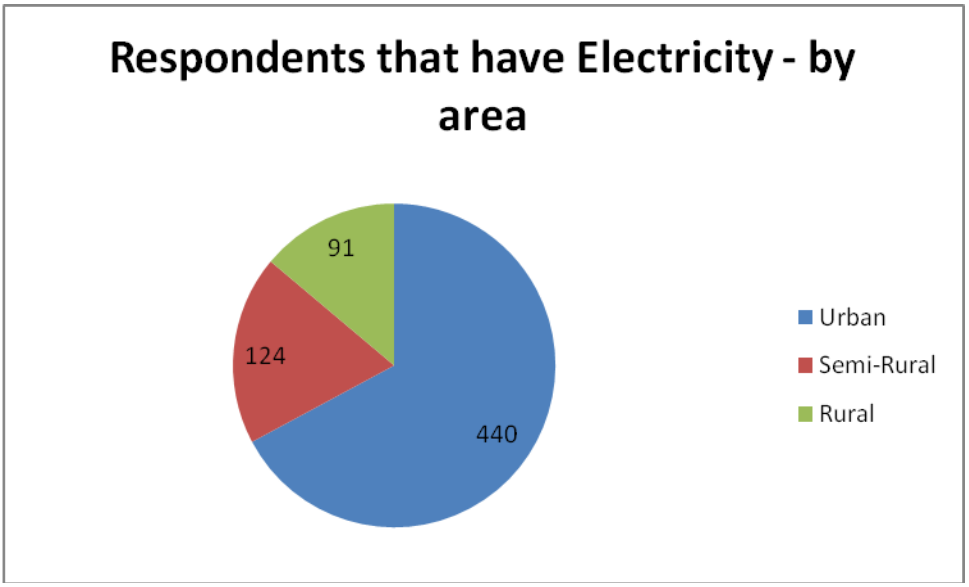

Figure 4.6: Respondents who have electricity – by area

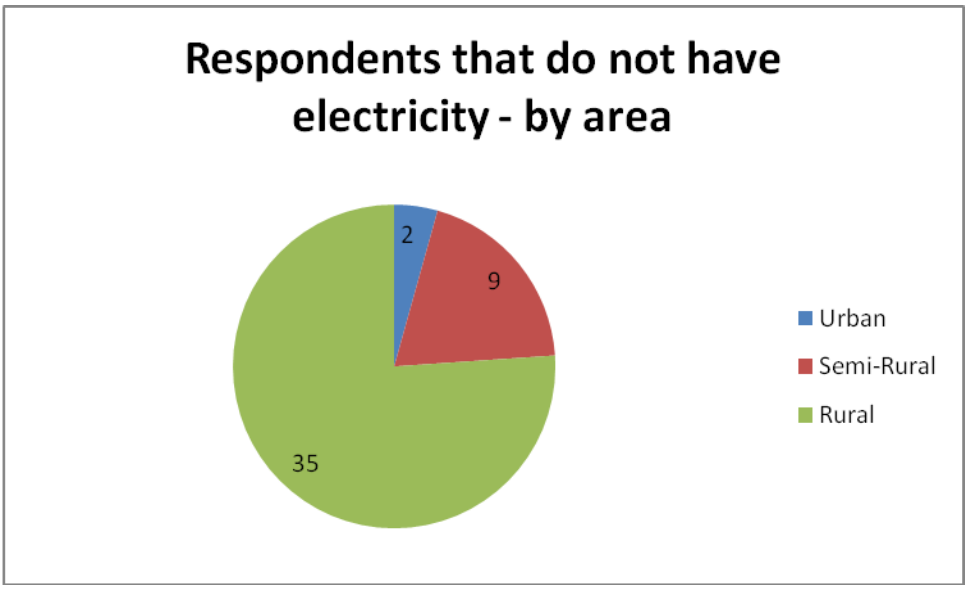

Figure 4.7: Respondents who do not have electricity – by area

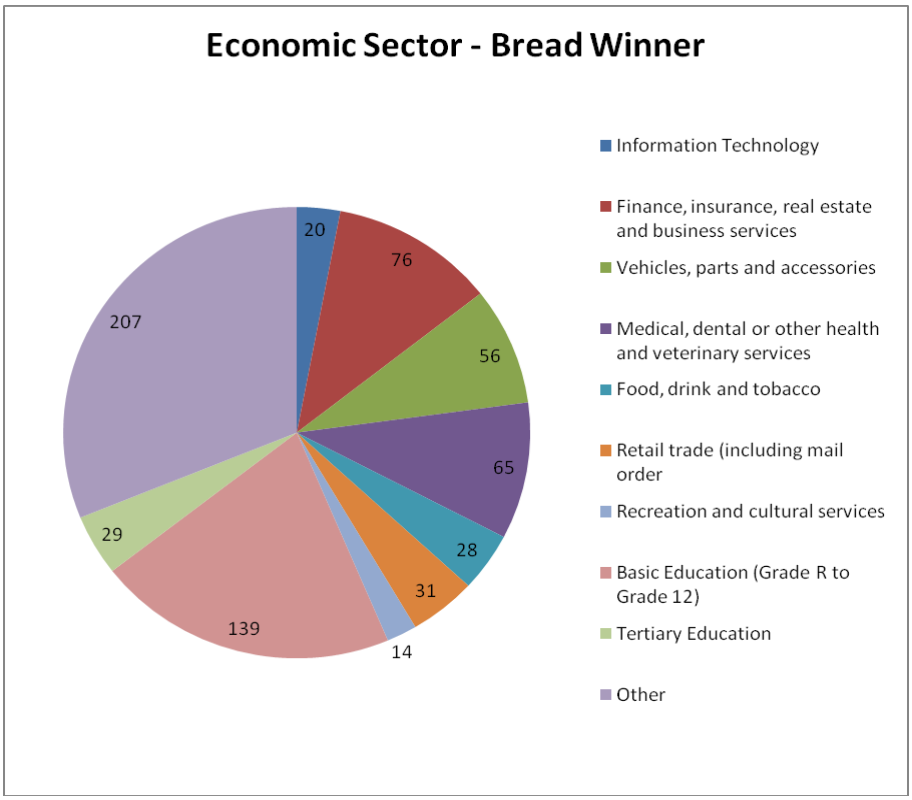

Figure 4.8: Economic sector of bread winner

The demographics give one an idea of the respondents that took part in this survey. A point to consider is that 2 respondents from the urban area do not have electricity, but this can be understood when one considers the informal settlements in urban and around urban areas.

Interpretation

Demographics have taken into account the living area, age, income per household, electricity and economic sector of the respondents. The responses from these questions have reinforced the idea that the respondents are a representation of KwaZulu-Natal, South Africa. It was good to see that the majority of the respondents have electricity at home, as this could be considered an indirect prerequisite for having a computer at home. The reason for considering electricity an indirect prerequisite is that with a little more effort and imagination a computer could be used without electricity at home. A subsequent independent study could possibly look at whether the electricity is legal, or whether connecting from a battery is considered having electricity. It seems appropriate to check whether any of the options were favoured more than others. This will be done by "Chi-square goodness-of-fit tests".

4.3. Chi-square goodness-of-fit tests

The "Chi-Square" Test is a test procedure that computes a chi-square statistic by initially tabulating a variable into particular categories. The goodness-of-fit test does a comparison of the "observed and expected frequencies in each category and checks whether the categories contain the same proportion of values" (Levin, 1999).

This "Chi-square goodness of fit test was applied to all the questions" to ascertain "whether any one option was selected significantly more or less often than expected". The reason for this is that under the null hypothesis the assumption is that every option has an equal chance of being chosen. All significant results are summarised in Table 4.1 below. An explanation of each result will be given below table 4.1.

Key used in Table 4.1:

A - Significantly more respondents than expected selected.

B - Significantly fewer respondents than expected selected.

Table 4.1: Results Chi-square goodness-of-fit tests

Question No. and Description of question		**p-value**	**Interpretation**	
			A	**B**
4	Do you have electricity at home?	<.0005	Yes	
5	Do you use renewable energy resources (like solar panels) at home?	<.0005	No	
8	How many other people live in your household with you (including children and adults)?	<.0005	4 or more	

Question No. and Description of question		p-value	Interpretation	
			A	B
9	How many people in your household know how to use a computer (including children and adults)?	<.0005	All	None
10	How many people in your family regularly (at least one a day) use a computer (including children and adults)?	<.0005	1 or 2	
11	How many people in your household use a computer occasionally (once a week) (including children and adults)?	<.0005	No one	
12	How many working computers do you have at home?	<.0005	One	
13	What type of Internet access do you have from home?	<.0005	None	
14.1	What do you use your home computer for? Entertainment/hobby/social	<.0005	Regularly	
14.2	What do you use your home computer for? Studies	<.0005	Regularly	
14.3	What do you use your home computer for? Work	<.0005	Never	

Question No. and Description of question		p-value	Interpretation	
			A	B
15	How many broken computers do you have at home?	<.0005	None	
17	How would the following electronic goods be obtained? The results for all 19 devices are the same…	<.0005	A new one is purchased	
18	How would redundant goods be disposed of?			
18.1	Your old computer tower at home	<.0005	I do not use/ own	
18.2	Your old computer screen at home	<.0005	I do not use/ own	
18.3	Your old printer at home	<.0005	I do not use/ own	
18.4	Your old peripherals at home	<.0005	I do not use/ own	
18.5	Your old USB external hard drives at home	<.0005	I do not use/ own	
18.6	Your old games machine (e.g. Play station) at home	<.0005	I do not use/ own	
18.7	Your old MP3 Players and iPods at home	<.0005	Stored it somewhere	

Question No. and Description of question		p-value	Interpretation	
			A	B
18.8	Your old TV, VCR and DVD Player at home	<.0005	Stored it somewhere	
18.9	Your old Hi Fi and radio at home	<.0005	Stored it somewhere	
18.10	Your USB flash memory sticks from home	<.0005	Stored it somewhere	
18.11	Your old Secure Digital(SD) memory cards at home	<.0005	I do not use/ own	
18.12	Your old Decoders & PVR's at home	<.0005	I do not use/ own or Stored it somewhere	
18.13	Your old Cellular phone from home	<.0005	Stored it somewhere	
18.14	Your digital cameras from home	<.0005	Stored it somewhere	
18.15	Your old computer tower at work/ varsity	<.0005	I do not use/ own	
18.16	Your old computer screen at work/ varsity	<.0005	I do not use/ own	
18.17	Your old printer at work/ varsity	<.0005	I do not use/ own	

Question No. and Description of question		p-value	Interpretation	
			A	B
18.18	Your old peripherals at work/ varsity	<.0005	I do not use/ own	
18.19	Your old USB external hard drives at work/ varsity	<.0005	I do not use/ own	
19	Sorting of material into separate bags 19.1 - 19.4 all had same result	<.0005	Never	
Demographics				
Age		<.0005	19 - 20	
Income		<.0005	Less than R3000	
Neighbourhood		<.0005	Urban	
Economic sector - work of bread winner		<.0005	Other	

Explanation and Interpretation of Table 4.1

Question 4 (Electricity at home) indicates that significantly more respondents than expected indicated that they had electricity at home. Since electricity is a key component for electronic devices it implies that most of the respondents would not have electricity as an obstacle. Figure 4.7 indicates that 46 respondents do not have electricity at home. This would not exclude them totally from the study because electricity at home is not a primary prerequisite for owning or using electronic devices. An example of this would be memory sticks do not need to be

charged by electricity and notebook computers can be charged elsewhere and used at home by the respondents.

Question 5 (Renewable energy) indicates that significantly more respondents indicated that they did not use renewable energy sources at home. This is good because currently in South Africa renewable energy sources are more affordable to the middle and upper class. This would then imply that the respondents are across the lower, middle and upper class groups with probably more of the respondents being from the "lower income groups". This is further supported by the question on income that indicated that more of the respondents fell into the less than R3000 income group.

Question 8 (people in household) indicates that significantly more respondents chose the option with 4 or more indicating that they did not live alone but rather with families. This would make the availability of a computer easier as the cost of ownership is spread over the household.

Question 9 (know how to use a computer) the answers provided were not expected in that a significantly large number indicated that all members knew how to use a computer and significantly fewer chose the option none. Investigation is required to determine whether the use of cellular phones is considered as using a computer.

In question 10 (use a computer at least once a day) a significantly large number indicated 1 or 2, the question that arises is why, especially if everyone in the household know how to use a computer. A possible reason is that many people are using one computer and the time for using the computer is shared amongst the entire household.

Question 11 attempted to determine the number of people in the household who used a computer occasionally, this question together with questions 9 and 10 require further investigation because a significant number of respondents indicated that no one uses the computer occasionally. One computer is possibly shared by too many people in the household.

In question 12 a significant number indicated that they only have one working computer. Reasons for this may be the high costs associated with computers, or it may also be that computers become outdated in a few years.

Question 13 deals with Internet connectivity, the researcher believes the reason for a significant number of respondents not having Internet connection is that although the Internet connections are available; the cost of the Internet connection in South Africa is very high. This could probably be researched further.

In question 14 a significant number of respondents use the computer for entertainment, as a hobby, for social interaction and for studies. Since all the respondents were students it makes sense that most of them do not use the computer for work.

The answer to questions 15 and 16 was not really expected in that most of the respondents do not have broken or outdated computers at home. This is possibly due to space for storing the broken or outdated computer. These broken or outdated computers could possibly end up in a landfill.

In question 17, of all 19 sub questions, the most significant response from the respondents was that a new device is purchased. Initially this would seem strange as in some cases the respondents do not possess some of these devices, but when considering the question the respondents would possibly have considered the device or devices that they would like to acquire.

Question 18 was to establish what happens to the goods when they became redundant. A significant number of respondents chose the option "I do not use/own" for 13 of the 19 sub questions, however for 6 of the sub-questions the respondents chose the option "stored it somewhere". The significance of one of the option was split between the options "I do not use/own" and "stored it somewhere". Since the common option chosen was "I do not use/own", the analysis was repeated for the responses excluding the response "I do not use/own". With this exclusion the results showed significantly ($p < 0.0005$) more respondents than expected selected the "stored it somewhere" for the home items and "I do not know what is done with it" for the work items. This clearly indicated that the option of choice is "stored it somewhere" the main reason for this is that people consider the broken or outdated computer an asset. In the case of work computers, research done by EWASA of governmental departments' shows that the computers are stored for a period of time because they need to be accounted for on the

asset register. The mindset of the broken or outdated computer being an asset is possibly obtained from the work environment.

In question 19, significant numbers of the respondents chose the option that they never recycle normal waste. This shows that the general culture is not one of recycling. People need to be educated on the benefits of recycling.

4.4. Chi-square test of independence

The Chi-square test of independence is a test that is carried out on cross-tabulations of 2 variables to ascertain whether any significant relationship exists between the variables. Under the null hypothesis, no relationship exists between the variables; this implies that they are independent.

In order to satisfy conditions of the test and therefore ensure validity of results, categories in some of the questions were combined, when necessary, in such a way that sensible meaning was still retained. One of the main reasons for the recoding was done to ensure that outliers in the results were not ignored.

Recoding was done to questions resulting in the new categories as indicated in Table 4.2.

Table 4.2: Change of Categories

Question Number and Description	**Old Categories**	**New Categories**
Q2 Age	Under 17; 17-18; 19 - 20; 21 - 22; 23-24; Over 22.	Under 19; 19 - 20; 21 - 22; Over 22.
Q6 Income	<R3000; R3001 - R10000; R10001 - R20000; R20001 – R50000; >R50000	<R3000; R3001 - R10000; R10001 - R20000; >R20000
Q8 Number in house-	None; 1; 2; 3; 4 or more	None/1/2; 3; 4 or more

Question Number and Description	Old Categories	New Categories
hold		
Q12 working computers	None; 1; 2; 3;4; More than 4	None; 1; 2; More than 2
Q13 Internet access	None; Dial-up; ADSL; Wireless; Dial-up & ADSL; Dial-up & Wireless; ADSL & Wireless; Dial-up, ADSL & Wireless; Other	None; Dial-up; ADSL; Wireless; Multiple types/Other
Q14 Usage	Never (0); Occasionally (1); Occasionally (2); Sometimes (3); Sometimes (4); Regularly (5).	Never (0); Occasionally (1,2); Sometimes (3,4); Regularly (5).
Q16 Outdated computers	None; 1; 2 or more	None; 1 or more
Q17 Acquiring…	Not sure; Purchase new; Purchase refurbished; Purchase used; Purchase refurbished imported; Donation; Gift; competition; Other	Not sure; Purchase new; Purchase refurbished/used/refurbished imported; Donation/Gift/competition; Other
Q19 Separate refuse	Never (0); Occasionally (1); Occasionally (2); Sometimes (3); Sometimes (4); Regularly (5).	Never (0); Occasionally (1,2); Sometimes (3,4); Regularly (5)

Explanation for Regrouping

For question 2, the pie graph in Figure 4.2 shows the distribution before the recoding (old categories) and the pie graph in Figure 4.3 shows the distribution after recoding (new categories). Table 4.3 shows the distribution of the observed data before and after the regrouping of question 2 of the questionnaire. To ensure

that the raw data in the existing SPSS file was preserved, new columns were created for the recoding.

Table 4.3: Data for Question 2

Category	Observed
Under 17 Years old	1
17 - 18 years old	179
19 - 20 years	317
21 - 22 years old	125
23 - 24 years old	45
Over 24 years old	42
Number of respondents	709

Under 19
Observed = 180

Over 22
Observed = 87

Table 4.4 shows the distribution of the observed data before and after the regrouping for question 6. Due to some respondents not answering this question, the total number of respondents for this question is 656.

Table 4.4: Data for Question 6

Category	Observed
Less than R3000	229
R3001 - R10000	185
R10001 - R20000	124
R20001 - R50000	76
More than R50000	42
Number of respondents	656

> 20000
Observed = 118

Table 4.5 shows the distribution of the observed data before and after the regrouping for question 8. Due to one respondent not answering this question, the total number of respondents for this question is 708.

Table 4.5: Data for Question 8

Category	Observed
None	7
1	11
2	35
3	125
4 or more	530
Number of respondents	708

None/1/2
Observed = 53

Table 4.6 shows the distribution of the observed data before and after the regrouping for question 12. Due to some respondents not answering this question, the total number of respondents for this question is 706.

Table 4.6: Data for Question 12

Category	Observed
None	245
1	293
2	105
3	39
4	16
More than 4	8
Number of respondents	706

More than 2
Observed = 63

Table 4.7 shows the distribution of the observed data before and after the regrouping for question 13. Due to some respondents not answering this question, the total number of respondents for this question is 693.

Table 4.7: Data for Question 13

Category	Observed
None	452
Dial-up	74
ADSL	53
Wireless	56
Dial-up & ADSL	11
Dial-up & Wireless	11
ADSL & Wireless	3
Dial-up, ADSL & Wireless	18
Other	15
Number of respondents	693

Multiple Types/Other
Observed = 47

Table 4.8 shows the distribution of the observed data before and after the regrouping for question 14. Due to some respondents not answering different parts of this question, the total number of respondents is less than 709.

Table 4.8: Data for Question 14

Category	Observed		
	14.1	**14.2**	**14.3**
Never (0)	135	120	213
Occasionally (1)	46	21	31
Occasionally (2)	63	27	60
Sometimes (3)	97	82	57
Sometimes (4)	85	120	63
Regularly (5)	178	253	118
Number of respondents	604	623	542

Occasionally (1, 2)
Observed = 91

Sometimes (3, 4)
Observed = 120

Table 4.9 shows the distribution of the observed data before and after the regrouping for question 16. Due to a few respondents not answering this question, the total number of respondents for this question is 702.

Table 4.9: Data for Question 16

Category	Observed
None	537
1	157
2 or more	8
Number of respondents	702

1 or more
Observed = 163

The Chi-square test for question 17 produced 19 different tables. The tables can be found in Addendum 5. After analysing all the tables for this question it was decided to leave the three alternatives "Not sure"; Purchase new" and "Other" unchanged. Due to the smaller number of observations in some of the other alternatives it was decided to combine the observations from "purchase re-

furbished", "purchase used" and "purchase refurbished imported" into "purchase refurbished/used/refurbished imported" and also combine the observations of donation, gift and competition into donation/gift/ competition.

Table 4.10 shows the distribution of the observed data before and after the regrouping for question 19. Due to some respondents not answering different parts of this question, the total number of respondents is less than 709.

Table 4.10: Data for Question 19

Category	Observed			
	19.1	**19.2**	**19.3**	**19.4**
Never (0)	286	314	320	312
Occasionally (1)	66	82	75	66
Occasionally (2)	76	73	72	57
Sometimes (3)	71	77	73	59
Sometimes (4)	50	40	37	55
Regularly (5)	125	74	82	113
Number of respondents	674	660	659	662

Occasionally (1, 2)
Observed = 123

Sometimes (3, 4)
Observed = 114

After considering all the questions from the questionnaire and combing the alternatives as shown above, the questions were cross-tabulated with each other. Pearson's Chi square and p-value were obtained for each cross tabulation. Conclusions about the hypothesis may be drawn by comparing the obtained Pearson "chi-square value" to the "critical value of chi-square", or as an alternative "by comparing the" reported p-value of the chosen alpha level (Agresti, 1996). Since both Pearson's Chi-square and the p-value can be used to draw conclusions the researcher will explain the cross tabulations by considering the p-value. The Pearson chi-square value will be given for completeness.

The context in which the p-value is used in this research is that the "p-value is a measure of how much evidence" one has "against the null hypothesis". The

"null hypothesis" is considered as representing the "hypothesis of no change or no effect". The "smaller the p-value, the more evidence one has against the null hypothesis". It is also a "measure of how likely" one would get a "certain sample result" when assuming "that the null hypothesis is true".

In particular, the null hypothesis for this research is that no change or no effect occurs with the cross tabulations of the different questions. The null hypothesis would then be that the one question is not affected by the other question. The "p-value measures the consistency by calculating the probability of observing the results" whilst "assuming the null hypothesis is true". The "smaller the p-value would imply the greater the inconsistency". Generally a "hypothesis is rejected if the p-value is less than 0.05". The researchers' understanding is that the "general rule is that a small p-value is evidence against the null hypothesis whilst a large p-value means little or no evidence against the null hypothesis". The researcher also noted that little or no evidence against the null hypothesis does not imply that a "lot of evidence is in support of the null hypothesis".

The researcher is also aware that one needs to be cautious about a small p-value. The "sample size" may be so large that "even differences that are trivial" can still achieve statistical significance. The sample size being used in this research is 709, but the population for the province of KwaZulu-Natal is approximately 10 million. In relation to the population of KwaZulu-Natal the sample size is not very large. Table 4.13 shows the reclassification of question 17. Tables 4.11, 4.12 and 4.14 show cross tabulations for a number of questions from the questionnaire together with the Pearson Chi-square value and the p-value.

Table 4.11: Cross Tabulation Various Questions

Question	X	Question	Pearson's Chi-square	p-value
8		6	29.072	<.001
9		8	45.487	<.0005
		12	245.337	<.0005
		13	104.446	<.0005
		14.1	184.736	<.0005
		14.2	160.527	<.0006
		14.3	117.525	<.0005
		15	36.111	<.0005
		16	41.492	<.0005
12		1	91.453	<.0005
		6	194.63	<.0005
		7	63.703	<.0005
		9	245.337	<.0005
		13	227.046	<.0005
		14.1	330.979	<.0005
		14.2	277.916	<.0005
		14.3	141.786	<.0005
		15	60.037	<.0005
		16	79.076	<.0005
13		1	67.958	<.0005
		6	135.983	<.0005
		14.1	89.882	<.0005
		14.2	82.134	<.0005
		14.3	72.019	<.0005
		15	43.245	<.0005
		16	36.467	<.0005
14.1		1	66.544	<.0005
		6	95.336	<.0005
14.2		1	79.988	<.0005
		6	81.158	<.0005
14.3		1	63.066	<.0005
		6	71.243	<.0005
15		6	31.304	<.0005
		8	20.104	<.0005
		16	42.358	<.0005
16		1	17.479	<.015
		6	31.86	<.0005
		7	26.335	<.002

Explanation and Interpretation of Table 4.11

Question 8 (number of other people in household) cross tabbed (X) with question 6 (income) resulted in a p-value of 0.001, this implies the income of the household is influenced by the number of people in the household, on closer examination it was found that households that had 2 other people in it had incomes in the range of R3000 to R10000, and those with 3 other people in it had incomes in the range of R10000 to R20000.

Question 9 (number of people who know how to use a computer) X question 8 (number of other people in household) resulted in p-value of 0.0005. This was interpreted as the more people in the household the more likely that the people in the household will be influenced in the use of a computer.

Question 9 (number of people who know how to use a computer) X question 12 (number of working computers in household) resulted in p-value of 0.0005. This was interpreted as the more people in the household the greater the number of computers.

Question 9 (number of people who know how to use a computer) X question 13 (type of Internet access) resulted in p-value of 0.0005, this was interpreted as the more people in the household the greater the likelihood of the household having Internet access.

Question 9 (number of people who know how to use a computer) X question 14 (type of use) with 14.1 being entertainment, 14.2 being studies and 14.3 being work, resulted in an average p-value of 0.0005. This was interpreted as the possibility of the computer being used for variety of purposes increases with the increase in the number of people in the household.

Question 9 (number of people who know how to use a computer) X question 15 (number of broken computers), resulted in p-value of 0.0005. This was interpreted as the more people in the household the greater the possibility of the household having broken computers.

Question 9 (number of people who know how to use a computer) X question 16 (number of outdated but working computers), resulted in p-value of

0.0005 this was interpreted as the more people in the household the greater the possibility of the household outdated working computers.

Question 12 (number of working computers in the household) X question 1 (Organization), resulted in p-value of 0.0005 this was interpreted as the larger the number of working computers in the household the greater the possibility of the household being linked to a particular organisation.

Question 12 (number of working computers in the household) X question 6 (income), resulted in p-value of 0.0005 this was interpreted as the larger the number of working computers in the household the higher the income of the household.

Question 12 (number of working computers in the household) X question 7 (economic sector), resulted in p-value of 0.0005 this was interpreted the number of working computers in the household is influenced by the economic sector that the people in the household worked in.

Question 12 (number of working computers in the household) X question 9 (number of people that know how to use a computer), resulted in p-value of 0.0005 this was interpreted as the larger the number of working computers in the household the greater the number of people that know how to use a computer in the household. In this question the dependent and independent variables were swopped around showing that question 12 influences the responses in question 9 and that question influences the responses in question 12.

Question 12 (number of working computers in the household) X question 13 (type of Internet access); resulted in p-value of 0.0005 this was interpreted as the larger the number of working computers in the household the greater the possibility of the household having Internet access.

Question 12 (number of working computers in the household) X question 14 (type of use) with 14.1 being entertainment, 14.2 being studies and 14.3 being work, each having a p-value of 0.0005 this was interpreted as the more working computers in the household the greater the possibility of the computer being used for variety of purposes.

Question 12 (number of working computers in household) X question 15 (number of broken computers); resulted in p-value of 0.0005 this was interpreted as the larger the number of working computers in the household the greater the possibility of the household having broken computers.

Question 12 (number of working computers in household) X question 16 (number of outdated but working computers), resulted in p-value of 0.0005 this was interpreted as the larger the number of working computers in the household the greater the possibility of the household also having outdated but working computers.

Question 13 (type of Internet access) X question 1 (Organization), resulted in p-value of 0.0005. This was interpreted as the Internet access and the type thereof of a household was linked to an organisation.

Question 13 (type of Internet access) X question 6 (income), resulted in p-value of 0.0005. This was interpreted as the Internet access and the type thereof was influenced by the income of the household.

Question 13 (type of Internet access) X question 14 (type of use) with 14.1 being entertainment, 14.2 being studies and 14.3 being work with each having a p-value of 0.0005. This was interpreted as the type of Internet access that a household has, influences the variety of purposes for the computer is used.

Question 13 (type of Internet access) X question 15 (number of broken computers), resulted in p-value of 0.0005, this was interpreted as the type of Internet access in the household influences the possibility of the household having broken computers.

Question 13 (type of Internet access) X question 16 (number of outdated but working computers), resulted in p-value of 0.0005 this was interpreted as the type of Internet access in the household the greater the possibility of the household also having outdated but working computers.

Question 14.1 (type of use - entertainment) X question 1 (organization), resulted in p-value of 0.0005. This was interpreted as the type of use, in this case entertainment, in the household the greater the possibility of the household being linked to an organisation.

Question 14.1 (type of use - entertainment) X question 6 (income), resulted in p-value of 0.0005 this was interpreted the type of use in this case entertainment was influenced by the income of the household.

Question 14.2 (type of use - studies) X question 1 (organization), resulted in p-value of 0.0005 this was interpreted the type of use in this case studies, in the household the greater the possibility of the household being linked to an organisation.

Question 14.2 (type of use - studies) X question 6 (income), resulted in p-value of 0.0005 this was interpreted the type of use in this case studies was influenced by the income of the household.

Question 14.3 (type of use – work) X question 1 (organization), resulted in p-value of 0.0005 this was interpreted the type of use in this case work, in the household the greater the possibility of the household being linked to an organisation.

Question 14.3 (type of use - work) X question 6 (income), resulted in p-value of 0.0005 this was interpreted the type of use in this case work was influenced by the income of the household.

Question 15 (number of broken computers) X question 6 (income), resulted in p-value of 0.0005 this was interpreted as the greater number of broken computers in the household the larger the household income.

Question 15 (number of broken computers) X question 8 (number of other people in household), resulted in p-value of 0.0005 this was interpreted as the greater number of broken computers in the household the greater the number of people in the household.

Question 15 (number of broken computers) X question 16 (number of outdated but working computers), resulted in p-value of 0.0005 this was interpreted as the greater number of broken computers in the household the larger the number of outdated but working computers in the household.

Question 16 (number of outdated but working computers) X question 1 (organization), resulted in p-value of 0.015 this value is still less than 0.05 and this was therefore interpreted as the greater number of outdated but working com-

puters in the household the more likely that this would be linked to an organisation. This was actually linked to the University of KwaZulu-Natal Howard College Campus Engineering students.

Question 16 (number of outdated but working computers) X question 6 (income), resulted in p-value of 0.005 this was therefore interpreted as the greater number of outdated but working computers in the household the larger the household income.

Question 16 (number of outdated but working computers) X question 7 (economic sector), resulted in p-value of 0.002 this was therefore interpreted as the number of outdated but working computers in the household is influenced by the economic sector that the people in the household worked in.

Table 4.12: Cross Tabulation with Question 17

Question	X	Question	Pearson's Chi-square	p-value
6		17 (Home Computer)	637.279	<.0005
		17 (Home entertainment)	695.776	<.0005
		17 (Work computer)	249.274	<.0005
7		17 (Home computer)	146.634	<.0005
		17 (Home entertainment)	240.998	<.0005
		17 (Work computer)	134.708	<.0005
8		17 (Work computer)	134.708	<.0005
		17 (Home computer)	57.595	<.0005
		17 (Home entertainment)	62.846	<.0005
9		17 (Home computer)	553.185	<.0005
		17 (Home entertainment)	481.548	<.0005
		17 (Work computer)	274.322	<.0005
15		17 (Home computer)	92.628	<.0005
		17 (Home entertainment)	70.26	<.0005
16		17 (Home computer)	72.486	<.0005
		17 (Home entertainment)	50.69	<.0005

Explanation of Table 4.13

Nineteen different electronic goods have been identified in question 17; the purpose of this question was to establish the manner in which the electronic goods are obtained. In order to have meaningful cross tabulations the 19 different electronic goods have been reclassified into 3 groups. Although the reclassification

was done, the original objective, which is to determine how electronic goods are obtained, is still maintained. Table 4.13 shows how the reclassification was done.

Table 4.13: Reclassification of question 17

Computer tower for home	Home Computer
Computer screen for home	
Printer for home	
Other computer peripherals for home	
USB external hard drives for home	
Gaming machine (eg Play station) for home	Home Entertainment
MP3 Players and iPods for home	
TV, VCR and DVD Player for home	
HiFi and radio for home	
USB flash memory sticks for home	
Secure Digital (SD) memory cards for home	
Decoders & PVR's for home	
Cellular phone for home	
Digital cameras for home	
Computer tower for work/ varsity	Work Computer
Computer screen for work/ varsity	
Printer for work/ varsity	
Other computer peripherals for work/ varsity	
USB external hard drives for work/ varsity	

Question 6 (income) X question 17 (home computer), resulted in p-value of 0.0005 this was therefore interpreted as the income in the household is influenced by the manner in which the home computer is obtained. On further investigation it was found that respondents that have a household income less than R3000 indicated that they were not sure how the home computer was obtained. Income between R3001 and R10000 indicated that a second hand computer was purchased whilst household incomes greater than R10000 indicated that they purchased a new home computer.

Question 6 (income) X question 17 (home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the income in the household is influenced by the manner in which the home entertainment is obtained. On further investigation it was found that respondents that have a household income less than R3000 indicated that they were not sure how the home entertainment was obtained. New home entertainment was purchased by household incomes greater than R3000.

Question 6 (income) X question 17 (work computer), resulted in p-value of 0.0005 this was therefore interpreted as the income in the household is influenced by the manner in which the work computer is obtained. Most respondents indicated that a new computer was purchased.

Question 7 (economic sector) X question 17 (home computer), resulted in p-value of 0.0005 this was therefore interpreted as the economic sector that influenced the household also had a bearing in the manner in which the home computer is obtained.

Question 7 (economic sector) X question 17 (home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the economic sector that influenced the household also had a bearing in the manner in which the home entertainment is obtained.

Question 7 (economic sector) X question 17 (work computer), resulted in p-value of 0.0005 this was therefore interpreted as the economic sector that influenced the household also had a bearing in the manner in which the work computer is obtained.

Question 8 (number of other people in household) X question 17 (home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of other people in the household influenced the manner in which the home computer is obtained.

Question 8 (number of other people in household) X question 17 (home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of other people in the household influenced the manner in which the home entertainment is obtained.

Question 8 (number of other people in household) X question 17 (work computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of other people in the household influenced the manner in which the work computer is obtained. The reason for this is that the people from the household worked in different economic sectors.

Question 9 (number of people who know how to use a computer) X question 17 (home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of people that know how to use a computer in the household influenced the manner in which the home computer is obtained.

Question 9 (number of people who know how to use a computer) X question 17 (home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of people that know how to use a computer the household influenced the manner in which the home entertainment is obtained.

Question 9 (number of people who know how to use a computer) X question 17 (work computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of people that know how to use a computer in the household influenced the manner in which the work computer is obtained. The reason for this is that the people from the household probably use a computer at work.

Question 15 (number of broken computers) X question 17 (home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of broken computers in the household influenced the manner in which the home computer is obtained.

Question 15 (number of broken computers) X question 17 (home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of broken computers in the household influenced the manner in which the home entertainment is obtained.

Question 16 (number of outdated but working computers) X question 17 (home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of outdated but working computers in the household influenced the manner in which the home computer is obtained.

Question 16 (number of outdated but working computers) X question 17 (home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of outdated but working computers in the household influenced the manner in which the home entertainment is obtained.

Table 4.14: Cross Tabulation with questions 18 and 19

Question	X	Question	Pearson's Chi-square	p-value
19.1		5	19.435	<.002
		6	22.682	<.007
19.2		5	27.977	<.0005
		6	34.896	<.0005
19.3		5	15.677	<.008
		6	18.894	<.026
19.4		3	25.467	<.005
		5	26.939	<.0005
		6	22.426	<.008
6		18 (Home computer)	350.043	<.0005
		18 (Home entertainment)	488.534	<.0005
		18 (work computer)	186.97	<.0005
7		18 (Home computer)	332.197	<.0005
		18 (Home entertainment)	336.555	<.0005
		18 (Work computer)	307.56	<.0005
8		18 (Home computer)	120.112	<.0005
		18 (Home entertainment)	81.304	<.0005
15		18 (Home computer)	412.128	<.0005
		18 (Home entertainment)	229.04	<.0005
16		18 (Home computer)	211.198	<.0005
		18 (Home entertainment)	158.582	<.0005
17 (Home computer)		18 (Home computer)	2019.352	<.0005
		18 (Home entertainment)	1839.732	<.0005
		18 (Work computer)	1062.267	<.0005
17 (Home entertainment)		18 (Home computer)	1901.859	<.0005
		18 (Home entertainment)	3537.005	<.0005
		18 (Work computer)	1598.373	<.0005
17 (Work computer)		18 (Home computer)	922.858	<.0005
		18 (Home entertainment)	1448.324	<.0005
		18 (Work computer)	2344.447	<.0005
19.1		18 (Home computer)	73.678	<.0005
		18 (Home entertainment)	115.146	<.0005
		18 (Work computer)	103.125	<.0005
19.2		18 (Home computer)	66.72	<.0005
		18 (Home entertainment)	117.231	<.0005
		18 (Work computer)	102.473	<.0005

Question	X	Question	Pearson's Chi-square	p-value
19.3		18 (Home computer)	82.523	<.0005
		18 (Home entertainment)	156.096	<.0005
		18 (Work computer)	149.223	<.0005
19.4		18 (Home computer)	125.307	<.0005
		18 (Home entertainment)	184.568	<.0005
		18 (Work computer)	128.488	<.0005

Explanation of Table 4.14

Question 19.1(recycling of paper) X question 5 (use of renewable energy resources e.g. Solar panels); resulted in p-value of 0.002 this was therefore interpreted as people that recycled paper in the household influenced the use of renewable energy.

Question 19.1 (recycling of paper) X question 6 (income), resulted in p-value of 0.007 this was therefore interpreted as people that recycled paper in the household was influenced by the household income. On further analysis it was found that household income of less than R3000 recycled paper regularly whilst those with household income more than R3000 never recycled paper.

Question 19.2 (recycling of cardboard) X question 5 (use of renewable energy resources e.g. Solar panels); resulted in p-value of 0.0005 this was therefore interpreted as people that recycled cardboard in the household influenced the use of renewable energy.

Question 19.2 (recycling of cardboard) X question 6 (income), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled cardboard in the household was influenced by the household income. On further analysis it was found that household income of less than R3000 recycled cardboard occasionally, households with income between R3001 and R10000 never recycled cardboard, whilst those with household income of more than R20000 recycled cardboard sometimes.

Question 19.3 (recycling of glass) X question 5 (use of renewable energy resources e.g. Solar panels); resulted in p-value of 0.008 this was therefore interpreted as people that recycled glass in the household influenced the use of renewable energy.

Question 19.3 (recycling of glass) X question 6 (income), resulted in p-value of 0.026 this was therefore interpreted as people that recycled glass in the household was influenced by the household income. On further analysis it was found that household income of less than R3000 recycled glass regularly, households with income between R3001 and R10000 recycled glass sometimes, whilst those with household income of more than R20000 never recycled glass.

Question 19.4 (recycling of plastic) X question 3 (neighbourhood eg. urban), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled plastic in the household are influenced by where they live. It was further established that people from rural areas regularly recycle plastic.

Question 19.4 (recycling of plastic) X question 5 (use of renewable energy resources e.g. Solar panels); resulted in p-value of 0.005 this was therefore interpreted as people that recycled plastic in the household influenced the use of renewable energy.

Question 19.4 (recycling of plastic) X question 6 (income), resulted in p-value of 0.008 this was therefore interpreted as people that recycled plastic in the household was influenced by the household income. On further analysis it was found that household income of less than R3000 recycled plastic regularly.

19 different electronic goods have been identified in question 18; the purpose of this question was to establish the manner in which the electronic goods are disposed off. In order to have meaningful cross tabulations the 19 different electronic goods have been reclassified into 3 groups. Although the reclassification was done the original objective of this question was still maintained. Table 4.15 shows how the reclassification was done

Table 4.15: Reclassification of question 18

Your old computer tower at home	Home Computer
Your old computer screen at home	
Your old printer at home	
Your old peripherals at home	
Your old USB external hard drives at home	
Your old games machine (eg Play station) at home	Home Entertainment
Your old MP3 Players and iPods at home	
Your old TV, VCR and DVD Player at home	
Your old HiFi and radio at home	
Your old USB flash memory sticks from home	
Your old Secure Digital (SD) memory cards at home	
Your old decoders & PVR's at home	
Your old cellular phone at home	
Your digital cameras at home	
Your old computer tower at work/ varsity	Work Computer
Your old computer screen at work/ varsity	
Your old printer at work/ varsity	
Your old other peripherals at work/ varsity	
Your old USB external hard drives at work/ varsity	

Question 6 (income) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as the income in the household influences the manner in which the old home computer is discarded. On further investigation it was found that respondents that have a household income less than R3000 indicated that they do not use /own a home computer, income between R3001 and R20000 indicated that the old home computer is stored whilst households with income greater than R20000 indicated that they either stored the old home computer or gave it away.

Question 6 (income) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the income in the household is

influenced by the manner in which the old home entertainment is disposed off. On further investigation it was found that respondents that have a household income less than R3000 indicated that they do not use or do not know or the old home attainment is used for spares, whilst households income greater than R3000 indicated that they either stored or gave the old home entertainment away.

Question 6 (income) X question 18 (old work computer), resulted in p-value of 0.0005 this was therefore interpreted as the income in the household influences the manner in which the work computer is disposed off. On further investigation it was found that respondents that have a household income less than R3000 indicated that the old work computer are recycled. Income between R3001 and R10000 indicated that the old work computer is traded-in. Income between R10001 and R20000 indicated that the old work computer is stored, whilst income greater than R20000 indicated that they are either stored or given away.

Question 7 (economic sector) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as the economic sector that influenced the household also had a bearing in the manner in which the old home computer was disposed off.

Question 7 (economic sector) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the economic sector that influenced the household also had a bearing in the manner in which the old home entertainment was discarded.

Question 7 (economic sector) X question 18 (old work computer), resulted in p-value of 0.0005 this was therefore interpreted as the economic sector that influenced the household also had a bearing in the manner in which the old work computer was discarded.

Question 8 (number of other people in household) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of other people in the household influenced the manner in which the old home computer was discarded. The outcome was similar to the cross tabulation with questions 6, as the income was influenced by the number of people in the house hold.

Question 8 (number of other people in household) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of other people in the household influenced the manner in which the old home entertainment equipment was discarded. The outcome was similar to the cross tabulation with questions 6, as the income was influenced by the number of people in the house hold.

Question 15 (number of broken computers) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of broken computers in the household influenced the manner in which the old home computer is discarded. Depending on the income group of the household the old home computer was either stored or given away.

Question 15 (number of broken computers) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of broken computers in the household influenced the manner in which the old home entertainment was discarded. This was further investigated as cellular phones fell into this category. It was found that the old cellular phones were either stored or given away. In a few cases the old cellular phones were traded-in for a new one.

Question 16 (number of outdated but working computers) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as the number of outdated but working computers in the household influenced the manner in which the home computer is discarded. The popular choice was the storing of the old home computers.

Question 16 (number of outdated but working computers) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as the number of outdated but working computers in the household influenced the manner in which the old home entertainment was disposed off. The popular choice was storage.

Cross tabulation of all 3 categories of question 17 with all 3 categories of question 18 cross tabbed yielded a p-value of 0.0005 this was therefore interpreted as the manner in which a home computer, home entertainment equipment or work computer was obtained influences the manner in which it is disposed off.

Question 19.1 (recycling of paper) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled paper in the household influenced disposal of the old home computer.

Question 19.1 (recycling of paper) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled paper in the household influenced the disposal of old home entertainment.

Question 19.2 (recycling of cardboard) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled cardboard in the household influenced the disposal of the old home computer.

Question 19.2 (recycling of cardboard) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled cardboard in the household influenced the disposal of the old home entertainment.

Question 19.3 (recycling of glass) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled glass in the household influenced the disposal of the old home computer.

Question 19.3 (recycling of glass) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled glass in the household influenced the disposal of the old home entertainment.

Question 19.4 (recycling of plastic) X question 18 (old home computer), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled plastic in the household influenced the disposal of the old home computer.

Question 19.4 (recycling of plastic) X question 18 (old home entertainment), resulted in p-value of 0.0005 this was therefore interpreted as people that recycled plastic in the household influenced the disposal of the old home entertainment.

On further analysis of the cross tabulation of question 19 with question 18 it was found that awareness of recycling whether it is paper, cardboard, glass or plastic influenced the manner in which one discarded old electronic equipment.

4.5. Correlations

Spearman's correlation was applied to all pairs of questions for which the response options are ordinal. Two variables are positively correlated if high response values of "one variable are associated with high" response values of the other variable. A negative "correlation occurs" if high values of one variable are associated with low values from the other variable. All correlations are shown in Table 4.16. "In a negative correlation, as the data or values of one of the variables increase, the data or values of the second variable decrease whilst in positive correlations as the values of one of the variables increase, the values of the second variable also increase". Positive correlations are in red whilst negative correlation is in blue.

Table 4.16: Correlations

	6	8	9	12	14.1	14.2	14.3	15	16	19.1	19.2	19.3	19.4
6		-.078(*) 0.045	.482(**) 0	.501(**) 0	.303(**) 0	.153(**) 0	.258(**) 0	.190(**) 0	.220(**) 0	-.085(*) 0.035	-0.062 0.128	-.095(*) 0.019	-.135(**) 0.001
8			.117(**) 0.002	-0.052 0.168	-.087(*) 0.033	0.017 0.681	-0.029 0.504	-.129(**) 0.001	0.005 0.893	0.018 0.639	.084(*) 0.03	0.063 0.106	0.066 0.093
9				.547(**) 0 0	.374(**) 0 0	.239(**) 0 0	.372(**) 0 0	.217(**) 0 0.004	.223(**) 0 0	-0.026 0.506 0.347	0.009 0.816 0.726	0.03 0.437 0.725	-0.065 0.098 0.843
12					.481(**) 0	.400(**) 0	.439(**) 0	.258(**) 0	.338(**) 0	-0.021 0.592	-0.006 0.873	-0.026 0.514	-.112(**) 0.004
14.1						.419(**) 0	.420(**) 0	.161(**) 0	.187(**) 0	0.047 0.256	0.067 0.108	0.048 0.251	-0.03 0.47
14.2							.490(**) 0	0.046 0.257	.126(**) 0.002	0.077 0.06	.080(*) 0.05	.098(*) 0.017	0.052 0.207
14.3								0.07 0.105	.213(**) 0	0.065 0.138	.123(**) 0.005	.099(*) 0.023	0.027 0.541
15									.249(**) 0	0.021 0.588	0.03 0.435	0.026 0.507	0.021 0.585
16										-0.017 0.662	0.011 0.788	0.019 0.631	-0.044 0.258
19.1											.717(**) 0	.499(**) 0	.633(**) 0
19.2												.542(**) 0	.632(**) 0
19.3													.626(**) 0
19.4													

Explanation and Interpretation of Table 4.16

Question 6 which is monthly income is negatively correlated with questions 8 (number of people in the household), question 19.1 (recycling of paper), question 19.3 (recycling of glass) and question 19.4 (recycling of plastic). The interpretation of this would be as the household income increases a decrease in the number of people in the household occurs. This is reasonable because as peoples income increase, they tend to be more independent and live on their own. This correlation shows as the income increases the recycling decreases. This would seem as though people who recycle either save some money or they could earn some money from recycling.

Question 6 is positively correlated with question 9 (number of people in household that know how to use a computer), question 12 (number of working computers), question 14.1 (Usage-entertainment/hobby/social), question 14.2 (Usage – studies), question 14.3 (Usage – work), question 15 (number of broken computers), question 16 (number of outdated computers). As the income increases the computer literacy increases together with an increase in the variety of the uses of the computer. The increase in the income increases the number of working computers, the number of broken computers and the number of outdated computers. It can be seen from this that the larger the income the greater the possibility of computer literacy and the greater the possibility of the household having broken and redundant computers. Another important aspect from the correlations in question 6 is that as the income increases, the less likely the possibility of recycling. The broken and redundant computers are possibly put into storage because they are still considered an asset.

Question 8 which is the number of people in the household is negatively correlated to 14.1 (Usage-entertainment/hobby/social) and question 15 (number of broken computers). These correlations show that as the number of people in the household increases it is less likely that the computers will be used for entertainment/hobby/social aspects and that it is less likely to have broken computers in the household. Question 8 is positively correlated to question 9 (number of people in household that know how to use a computer) and question 19.2 (recycling of cardboard). The greater the number of people in the household; the larger the

number of people in the household, that can use a computer and it is more likely that they would be recycling cardboard.

Question 9 which is the number of people in household that know how to use a computer, have no negative correlations. Question 9 is positively correlated with question 12 (number of working computers), question 14.1 (Usage-entertainment/hobby/social), question 14.2 (Usage – studies), question 14.3 (Usage – work), question 15 (number of broken computers) and question 16 (number of outdated computers). As the computer literacy increases the variety in the use of the computer increases, it also increases the need for a larger number of working computers and results in an increase in the number of broken computers and an increase in the number of outdated computers. With an increase in computer literacy, the possibility of the household having broken and redundant computers also increases and it is less likely that the household participates in recycling. This also increases the broken and redundant computers that are possibly put into storage, as they are still considered an asset.

Question 12 which is the number of working computers, is negatively correlated with question 19.4 (recycling of plastic). This would mean that as the number of working computers increases the possibility of recycling plastic decreases. Question 12 is positively correlated question 14.1 (Usage-entertainment/hobby/social), question 14.2 (Usage – studies), question 14.3 (Usage – work), question 15 (number of broken computers) and question 16 (number of outdated computers). An increase in the number of computers increases the variety of use of the computer. This could result in an increase in the number of broken computers and an increase in the number of outdated computers. With an increase in the number of working computers, the possibility of the household having broken and redundant computers also increases and the less likely the possibility of recycling because as the number of computers increases the recycling of plastic decreases. This also increases the broken and redundant computers that are possibly put into storage, as they are still considered an asset.

Question 14.1 which is the usage - entertainment/hobby/social, have no negative correlations. Question 14.1 is positively correlated question 14.2 (Usage – studies), question 14.3 (Usage – work), question 15 (number of broken com-

puters) and question 16 (number of outdated computers). As the usage for entertainment, hobby and social aspects increases the use of the computer for studies and work increases. This could also result in an increase in the number of broken computers and an increase in the number of outdated computers. It is also interesting to see that using a computer for pleasure has the possibility of increasing the use of the computer for business. With an increase in the number of working computers, the possibility of the household having broken and redundant computers also increases and the possibility of recycling is less likely because as the number of computers increases the recycling of plastic decreases. This also increases the broken and redundant computers that are possibly put into storage, as they are still considered an asset.

Question 14.2 which is the usage - studies, have no negative correlations. Question 14.2 is positively correlated to question 14.3 (Usage – work), question 16 (number of outdated computers), question 19.2 (recycling of cardboard) and question 19.3 (recycling of glass). An increase in the usage for studies increases the use of the computer for work. This could also result in an increase in the number of outdated computers. It is also interesting to see that by using a computer for studies seems to increase ones awareness of recycling just as recycling of cardboard and glass increases. Another aspect to consider is that the numbers of broken computers are not negatively or positively affected. A possible reason for this is that the computers are used at the place of study.

Question 14.3 which is the usage - work, have no negative correlations. Question 14.3 is positively correlated to question 16 (number of outdated computers), question 19.2 (recycling of cardboard) and question 19.3 (recycling of glass). As the usage for work increases the number of outdated computers increases. It is also interesting to see that by using a computer for work to increase ones awareness of recycling as recycling of cardboard and glass increases.

Question 15 which is the number of broken computers, have no negative correlations. Question 15 is positively correlated to question 16 (number of outdated computers. As the number of broken computers increases the number of outdated computers increases. This seems as though the broken and outdated computers are stored because they are considered assets.

Question 16 which is the number of outdated computers, have no negative correlations or positive correlations. This seems as though the outdated computers are stored because they are considered assets.

Question 19 which deals with different types of recycling is positively correlated with other types of recycling. It is interesting in that if one starts to become aware of recycling then one would apply recycling to other materials as well.

4.6. Structural, Recycling and Impact Framework

Table 4.17 was adapted as an indicator system "to structure, analyse and compare WEEE management systems from different countries". This system has been used to compare the "e-waste management" systems in India and China. It is also an indicator to determine or evaluate an existing e-waste management system. The system "considers the prevailing structural framework" in relation to "politics and legislation, economy, society and culture, science and technology together with the quality of the existing recycling system" and the impact it has on the environment, human health and labour (Widmer *et al*., 2005).

Table 4.17: Assessment indicator system to measure and compare WEEE management systems Widmer *et al*., 2005.

Aspect	Criterion	Indicator
Structural framework	Politics and Legislation	• Ratifying of the Basel Convention and Ban Amendment • The position or status of a national waste legislation • The position or status of a national e-waste legislation • Perception index of corruption
	Economy	• The cost of Capital (industrial investments) • Resultant or secondary markets for raw material
	Society and Culture	• Civil and political liberties • Activities of NGOs' • Culture of recycling • Societies awareness of the environmental

	Science an d Technology	• Knowledge of recycling technologies associated with WEEE • Research in WEEE management / recycling technologies • Application in WEEE management / recycling technologies
Recycling system	Material flow	• WEEE generation per capita • Management of closed loop recycling
	Technologies	• Efficiency of material recovery • Quality of the recovered materials
	Financial Flow	• Coverage of financial aspects • Coverage of externalities • Financial incentives for eco-design
Impacts	Environment	• Final disposal of WEEE in normal landfills • Emissions of hazardous substances
	Human Health	• Health and safety implementation at workplaces • Hazardous substance exposure to neighbouring populations
	Labour	• In relation to the number of jobs generated • Distribution of income

A discussion on the Structural, Recycling & Impact framework as applicable to South Africa follows next.

- **Structural framework**
  - **Politics and legislation**

The Consultative National Environmental Policy Process was the first step in a series of environmental policy initiatives by the Department of Environmental Affairs and Tourism (DEAT). This process culminated in the promulgation of the existing environmental legislation, which either directly or indirectly has implications to waste management (Widmer and Lombard, 2005). Key legislations and processes relevant to waste management activities in South Africa have been identified and are briefly outlined in Chapter

2. In addition eWASA, a section 21 company, is the official body for e-waste in South Africa.

- **Economy**

According to Widmer and Lombard, (2005) “South Africa is a middle-income, developing country with an abundant supply of resources, well developed financial, legal, communications, energy, and transport sectors, a stock exchange that ranks among the 10 largest in the world, and a modern infrastructure supporting an efficient distribution of goods to major urban centres throughout the region”.

“South Africa is rich in mineral and energy resources”(Widmer and Lombard, 2005). “The resources of South Africa contribute to the country's strategic importance on regional and global markets”. The supporting economic infrastructure of South Africa “consists of the major economic centres, well-organised metropolitan cities, modern motor ways (freeways & highways) that connect the main centres, international and domestic airports and harbours”. The World Bank classification of South Africa „is an upper middle income country”, but “quite a large proportion of South Africa's population display human development qualities mostly associated with low income countries and are living below the poverty line”. This is probably due to the vast difference in wealth and infrastructure when one compares urban and rural areas (Widmer and Lombard, 2005).

eWASA, (2010) has found that South Africans tend to participate in a system that gives them direct rewards. This was also found in the responses to the questionnaires because cardboard was recycled more often because the financial reward was greater. eWASA, (2011) is trying to engage with current e-waste recyclers in the city to ensure they reach critical capacity to function and grow in an economically viable manner. The Take Back System is also being investigated by eWASA (eWasa, 2011).

○ **Society and culture**

South Africa is a "multicultural country that has eleven official languages". Although literacy levels differ, "English is generally understood by most to a greater or lesser degree". Due to the "fusion of African, European and Asian cultural influences", South Africans often refer to themselves as a "Rainbow Nation". The democratic government of South Africa was instituted "in 1994, along with a new, progressive constitution, with forward thinking that takes environmental legislation into consideration". "Despite all these positive advances, many South Africans still live below the bread line or in poverty, with inadequate access to sanitation, water and healthcare, which is particularly critical given the scale of the HIV/AIDS epidemic". "As a result of this, environmental awareness, is generally low among people who are struggling to subsist" (Widmer and Lombard, 2005).

According to eWASA a culture of recycling is being promoted by the municipalities in that the municipalities provide households with different colour bags for different types of disposal (eWasa, 2010).

○ **Science and technology**

"Policies and established research bodies and councils" have been promulgated in the South African Department of Science and Technology in "order to align research with the nation's needs and as a support system" towards "technology development and innovation". In addition the "National Biotechnology Strategy (NBS) was approved by cabinet in 2001", the purpose of NBS is "to address new developments in biotechnology and the country's vulnerability based on its biodiversity, indigenous knowledge and the advent of new technologies". To ensure the enhancement of the National Systems of Innovation, the "National Research and Development (R&D) Strategy was approved by cabinet in 2002" (Widmer and Lombard, 2005).

Different technologies which support recycling are promoted by the private sector by encouraging relationships between companies that require materials from recycling and companies that do not have use for recycled materials (eWasa, 2010). An example of this is that Company A, that makes roof tiles from plastic is encouraged to form a relationship with a Company

B that deals with recycled plastic to supplement Company A's demand for plastic. In addition the public sector together with the private sector is being encouraged to use the plastic roof tiles.

- **Recycling system**

  - **Material flow**

South Africa "currently does not have any legislation" that deals directly with the "handling or recycling of e-waste". Most of the material generated from "e-waste is generally stored and eventually disposed of in municipal landfill sites". According to Widmer and Lombard, (2005) a very small percentage, probably "less than one percent of waste deposited on landfill sites in South Africa is recovered by the informal sector that operates on sites where salvage activity is tolerated. Government's policy is to discourage salvaging off landfill sites but is instead to promote the provision of clean work for the salvagers". Due to "concerns regarding data integrity and safety" some contactors issue a certificate of safe disposal to commercial manufacturers and "distributors that pay for the disposal of e-waste in permitted hazardous waste disposal sites" (Widmer and Lombard, 2005).

  - **Technologies**

A few formal recyclers operate from a small number of locations. Approximately, "1800 tonnes of electronic scrap is processed per annum". This is done with the use of sophisticated technology that includes amongst others mechanical shredders, pulverisers, rotary magnets, granulators, shears and balers on the "disassembly" lines. In the initial stages ferrous materials are separated from non-ferrous materials. An "eddy" current separator is used to then extract aluminium from these materials. Generally the heavy and precious "metals are shipped to a European refinery, whilst steel is processed locally and aluminium is exported to the Far East". "Non-metallic" fractions which are disposable are sent to landfill sites. Although the recycling of plastics is improving a "market for plastics has not yet been located"(Widmer and Lombard, 2005). Subsequently, plastics are being sent to a plant that uses the plastics to manufacture roof tiles (eWASA, 2008).

The possibility of glass, especially CRT glass, being crushed and used in the place of Tar is being investigated (eWasa, 2010).

- **Financial flow**

Formal recycling is not seen as being financially feasible and sustainable. A major problem is that the cost of recycling CRT monitors is greater than the money accrued from the recycled products (eWasa, 2010). eWASA is therefore looking at a take back system together with other EPR systems so that the recycling cost can be cross-subsidized.

- **Impacts**

  - **Environment**

The "leaching of toxins into groundwater, and the emission of toxic air pollutants, including dioxins" are some of the environmental impacts associated "with the disposal of e-waste into landfills". Due to the minimum requirements "for waste disposal at landfill" sites and for the "monitoring at waste management facilities", one cannot ensure that any negative environmental impacts are being minimised (Widmer and Lombard, 2005). Although legislation is in place these legislations are not strictly enforced (eWasa, 2010).

The e-waste recycling process would seem to have some benefits in the health, labour and environmental areas. Due to the adoption of appropriate "operating procedures and policies as prescribed in the relevant legislation and guideline documents" these benefits are minimised or mitigated (eWasa, 2010).

  - **Human health**

Widmer and Lombard (2005) have listed direct and indirect impacts on South African formal e-waste recyclers' human health.

Direct impacts on human health:

- Dust is "generated in manual and mechanical dismantling processes" especially when done indoors. (e.g. when processing plastics or CRT);

- The mechanical dismantling process generates filter dust;
- Conveyor belts, hammering, shredders etc produce "noise emissions during the manual and mechanical dismantling process";
- Occupational safety standards may be deviated.

Indirect impacts on human health

- "Air pollution due to high-temperature (HT) used in incineration (however, the situation has been very much improved since waste gas purification systems became a common standard)";
- "Transportation of e-waste materials" (emission from the transport);
- Water systems and soil near landfills – may become contaminated;
- "Synergistic effects and the time-lag between exposure and reaction" are some of the reasons why the "indirect impacts on human health are difficult to quantify".

○ **Labour**

Currently, e-waste recycling is highly specialised, hence there are no major labour accounts, with the exception of the dismantling process. However, any labour related impacts associated with the recycling process would be mitigated by the Occupational Health and Safety Act which protects workers and ensures a safe and healthy working environment (Widmer and Lombard, 2005).

A site that employed locals was set up by Switzerland in Cedara for the recycling of computers. This was not feasible because the employees left as soon as they found employment that paid more (eWasa, 2010).

4.7. Conclusion

The literature review from Chapter 2 together with the methodologies from Chapter 3 was used to analyse and interpret the results obtained from the respondents. The analysis and interpretation was done with a constant check with the

problem statement, research questions and research objectives from Chapter 1. The analysis and interpretation in this Chapter proved to be extremely valuable with an enormous amount of valid data. The difficulty in this Chapter was to decide which data to report on and which data to attach to the addendum for further reading and analysis.

A complete description and analysis of the data relating to the demographics of the respondents have been provided. Pi-charts were used to so that the demographics are clearly illustrated. After each of the pi-charts interpretations of the pi-charts were discussed.

Chi-square goodness-to-to fit was used on all 19 questions in the questionnaire to compare the "observed and expected frequencies in each category and test that all categories contain the same proportion of values". The explanation and interpretation of the results were followed by a discussion of the chi-square of independence. This resulted in the regrouping of some of options of a few of the questions. It was ensured at all times that the regrouping was done in a manner that preserved the integrity of the data. Pearson's Chi-square and p-value were obtained for cross-tabulations of questions from the questionnaire. The p-value was used to draw conclusions and interpretations.

Spearman's correlation was applied to all pairs of questions for which the response options are ordinal. Explanations and interpretations were given for all negative and positive correlations.

Different data analysis was done on the data so that the data could be analysed and interpreted correctly.

The management of e-waste was investigated in a number of first world and developing countries. The countries that have been investigated are Switzerland, India, Europe, Japan, South Korea, United States of America, South Africa and Developing countries such as Nigeria. Switzerland was looked at in detail because South Africa has agreements with Switzerland concerning e-waste (Widmer, and Lombard, 2005). A recycling centre was set up by Switzerland in Cedara, KwaZulu-Natal which was closed after just a few months (eWASA, 2010).

It was found that a common trait "in the management of e-waste in all the countries" has been "Extended Producer Responsibility (EPR)". Of the fourteen

(14) examples of EPR listed in Chapter 2, Table 2.5, it was found that South Africa only used the Public/private partnership on a totally informal basis. Currently a number of methods are being investigated to implement EPR in South Africa.

Chapter 5 uses the analysis and interpretations from this Chapter, together with the methodology from Chapter 3 and the literature review from Chapter 2 to draw conclusions in relation to the research problem stated in Chapter 1.

Chapter 5

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1. Introduction

The problem statement, together with the literature review, the research methodology and the analysis and interpretation has contributed to drawing conclusions and limitations about this study. This has resulted in a number of recommendations.

5.2. Conclusions

In Chapter 1 the problem statement was refined into sub-problems, research objectives and finally into research questions. It was ensured at all times that the problem statement, sub-problems, research objectives and research questions are aligned to one another. Each research question will now be individually considered.

The research question "What is the true cost of computers and electronic equipment by taking decommissioning of the computers and equipment into account?" is answered by using the literature examined in Chapter 2. It was shown that the true cost cannot be determined because the cost of decommissioning cannot be determined. This is due to the fact that one does not know the volume of "e-waste" that is being generated in South Africa. When the Extended Producer Responsibility (EPR) is enforced in South Africa the cost of decommissioning could be determined. Monitoring methods or devices many have to be installed at landfill sites and at depots to determine the volume of e-waste that ends up at these sites. Informal recyclers may be trained to perform these tasks.

Another benefit in involving the informal recyclers is that a database of the informal recyclers may be created, this in turn may help to formalise the informal recycler's methods of extraction, and distribution or use of the "recycled prod-

ucts". This will also help in the proper disposal of harmful substances that may be obtained from the recycling process.

It was also established that the cost of decommissioning electronic devices differs from one type of device to another type of device. Differences may be attributed to the place and date of manufacture. Specifications for the use of the device, compatibility to other devices and the estimated longevity are also influencing factors to be considered when estimating costs for the decommissioning of such devices.

It was further established that the cost of decommissioning a computer in India is $2 whist the cost of decommissioning the computer in America is $20. The exact cost of decommissioning electronic devices in South Africa cannot be calculated, until factors influencing the decommissioning are considered. The cost of decommissioning may be affected by labour, time, effort, space, tools, travel expenses, transportation of devices as well as administration. These costs exclude the administration that will need to consider further costs such as registration, licensing and taxes. This complication increases even further when one considers both the formal and informal sectors.

It was found that the "Take Back System" by manufacturers is difficult to monitor because one cannot separate the quantity of new and used electronic devices being imported. A collaborative relationship with Customs and Excise department will enhance the collection and analysis of data relating to the import and export of both new and used electronic devices. Legislation would probably facilitate this process.

The answer to the research question "What happens to computers that have been "donated" after they are no longer useful?" is that these computers are either stored or end up in a landfill. Recycling, no matter what the form is, is not a method that is well supported, although both formal and informal recyclers are in existence. One of the main reasons for this is that the "recycling of e-waste" is not profitable; for recycling to become profitable the key is Extended Producer Responsibility (EPR).

Question 19 from the questionnaire gives an indication that people would like to be paid for material that they send for recycling. The fact that people return

old car batteries because they are paid for it reinforces the idea that the electronic devices will be sent for recycling if they are paid for the obsolete or redundant device at recycling centres. Other forms of rewards such as certificates for community organisations involved in recycling should also be investigated.

The answer to the research question "What does one do with the obsolete computer when one purchases a new computer?" is that this depends on the income group that one is considering. In the income group <R3000, the computers are generally disposed of by being sent for recycling, or to a landfill. In the income group >R3000, the method varies in that some computers are sent for recycling, whilst others are stored. The reason for this is that this income group still considers the computer an asset although it is obsolete. Others donate the computer to friends, relatives or needy organisations.

The answer to the research question "What are the reasons for storing the obsolete computers?" is that the computers are stored because they are still considered an asset. The storing of obsolete or redundant or broken computers may imply that people do not know what to do or where to have such items recycled. In some cases it is considered that parts from the computer can be used for repairs to another computer. A possible method that may increase the number of devices sent for recycling would be to have recycling depots easily accessible.

The research question "To what extent are obsolete computers:

- Stored?
- Resold?
- Sent for waste management (recycled)?
- Sent to a landfill?"

The majority of obsolete computers are stored. The problem with this is that after storage, when the space is required, the obsolete computer is sent to local dump sites. At these dump sites the computers are informally sorted and the more valuable item are sent to informal recyclers. The problem with this is that the items that are not considered valuable are sent to a landfill. Even at the landfill informal recyclers remove parts that they could use and then dump the rest.

The research question “Is South Africa importing refurbished obsolete computers from 1st world countries?” This could not be determined from the formal sector because used and new computers share the same tax number. A possibility is to engage with Customs and Excise to implement different Tax numbers for used and new electronics.

From the above it can be seen that the majority of electronic devices that are replaced by new ones are stored. South Africa does have formal recyclers of all electronic devices, because at this point it is still not profitable. Cathode Ray Tubes are a big concern because they are not profitable to recyclers and they contain a large amount of harmful substances. Currently the Take Back method or other EPR methods ought to be seriously considered.

It may be ascertained from the small number of media reports that the reporters or journalists need to be educated about e-waste so that more reports may be carried in the media. In this way the general public may be educated about recycling being an option for e-waste. Education, at schools and tertiary institutions, needs to improve awareness of the benefits of recycling because ignorance may be the greatest possible hindrance to recycling. Staff at local waste sites should be educated about e-waste, and given incentives to prevent the e-waste ending up at the landfill.

5.3. Limitation

The study was limited to Government tertiary institutions in the province of KwaZulu-Natal and although this gave a wide variety of respondents, some categories of respondents may have not been considered, e.g. distance education students.

The study did not look at obsolete/broken white goods, the likes of electric stoves or fridges. White goods would have added other dimensions to the survey, because the general public would have come across these goods. Such devices were not considered in this survey as they were not part of the research objective.

The study did not investigate the quantity of devices or components that end up at a landfill, as a lack of monitoring and evaluation systems are a further drawback that prevented such an investigation.

Collection points had been identified but the study did not investigate the path of the devices or goods after the collection point. The scope of this survey would have had to be widened to include this path. The collaboration of the companies concerned would be essential as vital private company information may have to become public information. Financial statements, work contracts and other confidential information may need to be revealed through such a study. Businesses may not be willing to participate in a study of this nature.

5.4. Recommendation

A "Take Back System" similar to the one that takes back motor vehicle batteries could be investigated further. Such a system would have to have the cooperation of commercial companies that deal with new items. The impact of such a system on staffing, finance, storage and evaluation for the participating company has to be considered. However, incentives such as tax rebates, certificates from local government units, and publicity may encourage companies to participate in such a venture.

Further research into the replacement of certain types of sand by crushed CRT glass in the building industry could also be undertaken. This would reduce the quantity of sand required for the building of offices and homes and at the same time it would be using the unwanted CRT glass from obsolete or redundant computers. This will save the environment as less sand would be mined from areas such as river beds. The additional financial cost may be offset by tax reductions to the companies using this material, or by levies charged to companies manufacturing these materials.

5.5. Further Research

The monitoring of dump sites for the dumping and recycling of e-waste over a short term, possibly 6 months would be beneficial to environmental and manufacturing processes of electronic devices. This would determine the volume of e-waste ending up at the land fill sites. A list of formal and informal recyclers that obtain e-waste from the landfill may be generated. Such research will also help to determine the substances that the recyclers require and the substances that the recyclers do not use. Quantities of such substances can also be monitored.

A further study that looks at obsolete/broken white goods that is linked to outlets that sell white goods may be undertaken. Quantities, life span, repairs, re-usable parts and the cost of decommissioning need to be considered. Greater participation from the general public may be expected as these goods are considered to be essential items in any household. From personal experience it has to be noted that old white goods are traded-in when purchasing the new replacement item, sold to a second-hand dealer or simply sent to the land fill site.

5.6. Conclusion

This study has really been a journey from looking at the benefits of Information Technology and then considering the "Darker side" of information Technology being the disposal of obsolete/broken electronic devices. Although the study was carried out in at tertiary institutions in KwaZulu-Natal, the study can be applied to the province of KwaZulu-Natal because the respondents reside in most parts of KwaZulu-Natal. When considering Green IT and the benefits to the environment, one realises that the proper disposal methods, whether it is paper or electronic devices save the environment in a number of ways.

The researcher began his study by discussing the research problem and the sub-problems related to the research problem. Research objectives and questions were explained in Chapter One where the research also provided an outline to this study.

Chapter Two revolved around the Literature Review that was undertaken. All the sources consulted for this study were listed. Legislation relating to Local, Provincial, National and International Governments were discussed. E-Waste management in European, Asian, American and Developing countries was investigated. The lack of e-waste law enforcement in South Africa, in particular was discussed. The financial implications of e-waste management were explained.

The Research Methodology, with particular emphasis on the Research Onion was discussed in Chapter Four. The research philosophy, research approaches and the researcher's choice of the deductive approach was explained. This was followed by an exploration of the different strategies, choice of Methodology, and theoretical frameworks.

Data analysis and Interpretation of the survey were the focus of Chapter Four. The statistics was done explicitly so that the reported research results could be generalised. An example of this is that the Chi square test was used instead of the Pearson test. Spearman's correlations were used to analyze data. The structural, recycling and impact framework in relation to the South African context was explored.

In the theoretical framework of this study, International, National, Provincial as well as municipal legislations that relate to e-waste was listed. The level and depth of the application of the legislation have also been discussed. A theoretical framework showing the preferred Life-cycle of e-waste was explained in the context of this study. The cost or lack of profit is the main driving force for incorrect disposal methods. It would seem as though the correct manner in calculating the cost of an item would not only be the cost of manufacturing but would also include the cost of proper disposal. This will not only save the raw materials, but will also save the environment. The implication from this is that the best method of disposal is the take back system.

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ADDENDA

5.8. Addendum 1: Research instruments

UNIVERSITY OF KWAZULU-NATAL
School of Information System & Technology

Dear Respondent,

M Com Research Project

Researcher: Karunagaran Naidoo (0312603526)

Supervisor: Prof. Rembrandt Klopper (0218551435)

Research Office: Ms P Ximba 031-2603587

I, Karunagaran Naidoo am a Masters in Commerce student in the School of Information Systems & Technology, at the University of KwaZulu-Natal. You are invited to participate in a research project entitled *The Management of e-Waste in South Africa.*

The aim of this study is to: determine the manner in which electronic equipment is obtained and how redundant or obsolete electronic equipment is disposed off.

Through your participation I hope to understand what happens to obsolete/redundant electronic equipment. The results of this survey is intended to contribute to determine whether any patterns occur in the manner in which electronic equipment is obtained and the safe disposal of redundant or obsolete electronic equipment.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this research project. Confidentiality and anonymity of records identifying you as a participant will be maintained by the School of Information Systems & Technology, UKZN.

If you have any questions or concerns about participating in this study, please contact me or my supervisor at the numbers listed above.

It should take you about 20 minutes/s to complete the questionnaire. I hope you will take the time to complete the questionnaire.

Sincerely

Investigator's signature_____ Date_____

This page is to be retained by participant

UNIVERSITY OF KWAZULU-NATAL
School of Information System & Technology

M Com Research Project

Researcher: Karunagaran Naidoo(0312603526)

Supervisor: Prof. Rembrandt Klopper (0218551435)

Research Office: Ms P Ximba 031-2603587

CONSENT

I_____(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

_____ _____

Signature of Participant Date

This page is to be retained by researcher

Respondent number: _____

VOLUNTARY QUESTIONNAIRE FOR RESPONDENTS IN KWAZULU-NATAL

Managing of Electronic Waste Products

RESEARCHER: KARNA NAIDOO (031 2603526/ NAIDOOK82@UKZN.AC.ZA)

SUPERVISOR: PROF. REMBRANDT KLOPPER (0844466662/

RKLOPPER@GMAIL.COM)

DISCIPLINE: INFORMATION SYSTEMS & TECHNOLOGY

INSTITUTION: UNIVERSITY OF KWAZULU-NATAL

- Please complete this voluntary questionnaire on e-Waste Management.
- Please be forthright in your answers.
- Complete the questionnaire by pen and please do not revise your initial answers.
- Please sign the letter of informed consent, giving me permission to use your responses for this research project.

1. School/Organisation (will only be referred to by a unique organization number)

☐ DUT
☐ MUT
☐ UKZN Edgewood
☐ UKZN Howard College
☐ UKZN Medical School
☐ UKZN Pietermaritzburg
☐ UKZN Westville
☐ UZULU

2. What is your age? (Please select one.)

☐ Under 17 years old
☐ 17 – 18 years old
☐ 19 – 20 years old
☐ 21 – 22 years old
☐ 23 – 24 years old
☐ Over 24 years old

3. In what type of neighbourhood do you live? (Please select one.)

- ☐ Urban
- ☐ Semi-Rural
- ☐ Rural

4. Do you have electricity at home? (Please select one.)

- ☐ Yes
- ☐ No

5. Do you use renewable energy resources (like solar panels) at home? (Please select one.)

- ☐ Yes
- ☐ No

6. What is the approximate total monthly income of the people in your household, including money provided by family that do not live with you at the moment? (Please select one.)

- ☐ Less than R3000
- ☐ R3001 - R10000
- ☐ R10001 – R20000
- ☐ R20001 – R50000
- ☐ More than R50000

7. In which economic sector does the main breadwinner in your family work? (Please select one.)

- ☐ Information Technology
- ☐ Finance, insurance, real estate and business services
- ☐ Vehicles, parts and accessories
- ☐ Medical, dental or other health and veterinary services
- ☐ Food, drink and tobacco
- ☐ Retail trade (including mail order)
- ☐ Recreation and cultural services
- ☐ Basic Education (Grade R to Grade 12)
- ☐ Tertiary Education
- ☐ Other (please specify) _____

8. How many other people live in your household with you (including children and adults)? (Please select one.)

- ☐ None
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 or more

9. How many people in your household know how to use a computer (including children and adults)? (Please select one.)

- ☐ None
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ All

10. How many people in your family **regularly** (at least one a day) use a computer (including children and adults)? (Please select one.)

No-one	1	2	3	4	Everyone

11. How many people in your household use a computer **occasionally** (once a week) (including children and adults)? (Please select one.)

No-one	1	2	3	4	Everyone

12. How many working computers do you have at home? (Please select one.)

None	1	2	3	4	More than 4

13. What type of Internet access do you have from home? (Please select one.)

- ☐ None
- ☐ Dial-up access
- ☐ ADSL access
- ☐ Wireless access
- ☐ Dial-up access & ADSL access
- ☐ Dial-up access & Wireless access
- ☐ Dial-up access, ADSL access & Wireless access
- ☐ ADSL access & Wireless access
- ☐ Other (please specify) _____

14. What do you use your home computer for? (Please select one in each line)

	Never					**Regularly**
	0	1	2	3	4	5
14.1. Entertainment/hobby/social						
14.2. Studies						
14.3. Work						

15. How many broken computers do you have at home? (Please select one.)

- ☐ None
- ☐ 1
- ☐ 2 or more

16. How many outdated but still working computers do you have at home? (Please select one.)

- ☐ None
- ☐ 1
- ☐ 2 or more

17. How would the following electronic goods (components or devices) be obtained for home, work/ varsity use?

	I'm not sure how it is obtained	A new one is purchased	A refurbished one is purchased	A second hand (used) one is purchased	An imported refurbished one is purchased	A relative or friend donates it to us	It is given to us as a gift	We win it in competitions	Other
17.1. Computer tower for home									
17.2. Computer screen for home									
17.3. Printer for home									
17.4. Other computer peripherals for home									
17.5. USB external hard drives for home									
17.6. Gaming machine (eg Play station) for home									
17.7. MP3 Players and iPods for home									
17.8. TV, VCR and DVD Player for home									
17.9. HiFi and radio for home									
17.10. USB flash memory sticks for home									
17.11. Secure Digital (SD) memory cards for home									
17.12. Decoders & PVR's for home									
17.13. Cellular phone for home									
17.14. Digital cameras for home									
17.15. Computer tower for work/ varsity									
17.16. Computer screen for work/ varsity									
17.17. Printer for work/ varsity									
17.18. Other computer peripherals for work/ varsity									
17.19. USB external hard drives for work/ varsity									

18. How would the following redundant electronic goods be disposed of at home, or at work/ varsity?

	I do not use/ own such an item	I don't know what was done with it	Stored it somewhere	Give it to someone else to use	Donated it to charity	Traded it in	Put it out with trash	Sent it for recycling	Broke it up for spare parts
18.1. Your old computer tower at home									
18.2. Your old computer screen at home									
18.3. Your old printer at home									
18.4. Your old peripherals at home									
18.5. Your old USB external hard drives at home									
18.6. Your old games machine (e.g. Play station) at home									
18.7. Your old MP3 Players and iPods at home									
18.8. Your old TV, VCR and DVD Player at home									
18.9. Your old HiFi and radio at home									
18.10. Your USB flash memory sticks from home									
18.11. Your old Secure Digital(SD) memory cards at home									
18.12. Your old Decoders & PVR's at home									
18.13. Your old Cellular phone from home									
18.14. Your digital cameras from home									
18.15. Your old computer tower at work/ varsity									
18.16. Your old computer screen at work/ varsity									
18.17. Your old printer at work/ varsity									
18.18. Your old peripherals at work/ varsity									
18.19. Your old USB external hard drives at work/ varsity									

19. How regularly do you sort the following material into separate bags for refuse collection?

	Never					**Regularly**
	0	1	2	3	4	5
19.1. Paper						
19.2. Cardboard						
19.3. Glass						
19.4. Plastic						

Thank you very much. Your time and effort is highly appreciated.

5.9. Addendum 2: Gatekeepers Letters

Tuesday 24 June 2009

Attention: Prof. T.Nepal
Durban University of Technology

Dear Prof Nepal

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I, Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year students (preferably Computer Studies) on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or institution will be identified by name and only aggregated results will appear in print.

2. The research is of a constructive, cooperative nature, and respondents would be able to withdraw at any time.

3. Research will not be conducted in the fourth term of 2009.

4. Research will only commence after ethical clearance for the project has been obtained from the university's ethical clearance committee.

If you have any queries you may contact me or my supervisor.

My supervisor Prof. Rembrandt Klopper's contact details are:
Cell phone: 0844466662
Email: rklopper@gmail.com.

Regards

_____
K. Naidoo
0837991746/0312603526
Email: naidook82@ukzn.ac.za

Tuesday 21 July 2009

Attention: Ms Fiona
Mangosuthu University of Technology

Dear Ms Fiona

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I, Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year students (preferably Computer Studies) on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or institution will be identified by name and only aggregated results will appear in print.

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If you have any queries you may contact me or my supervisor.

My supervisor Prof. Rembrandt Klopper's contact details are:
Cell phone: 0844466662
Email: rklopper@gmail.com.

Regards

_____

K. Naidoo
0837991746/0312603526
Email: naidook82@ukzn.ac.za

Tuesday 21 July 2009

Attention: Mr Govender
Dean's Assistant
Edgewood Campus
University of KwaZulu-Natal

Dear Mr Govender

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I, Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year students (preferably Computer Studies) on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or institution will be identified by name and only aggregated results will appear in print.

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If you have any queries you may contact me or my supervisor.

My supervisor Prof. Rembrandt Klopper's contact details are:
Cell phone: 0844466662
Email: rklopper@gmail.com.

Regards

_____

K. Naidoo
0837991746/0312603526
Email: naidook82@ukzn.ac.za

Tuesday 21 July 2009

Attention: Prof. S.Ngubane
Howard College Campus
University of KwaZulu-Natal

Dear Prof Nugubane

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I,Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year Computer Literate students on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or school will be identified by name and only aggregated results will appear in print.

2. The research is of a constructive, cooperative nature, and respondents would be able to withdraw at any time.

3. Research will not be conducted in the fourth term of 2009.

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If you have any queries you may contact me or my supervisor.

My supervisor Prof. Rembrandt Klopper's contact details are:
Cell phone: 0844466662
Email: rklopper@gmail.com.

Regards

_____
K.Naidoo
0837991746/0312603526

Tuesday 21 July 2009

Attention: Dr. N.Sunderlall
Medical School
University of KwaZulu-Natal

Dear Dr Sunderlall

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I,Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year Computer Literate students on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or school will be identified by name and only aggregated results will appear in print.

2. The research is of a constructive, cooperative nature, and respondents would be able to withdraw at any time.

3. Research will not be conducted in the fourth term of 2009.

4. Research will only commence after ethical clearance for the project has been obtained from the university's ethical clearance committee.

If you have any queries you may contact me or my supervisor.

My supervisor Prof. Rembrandt Klopper's contact details are:
Cell phone: 0844466662
Email: rklopper@gmail.com.

Regards

_____
K.Naidoo
0837991746/0312603526

Tuesday 23 June 2009

Attention: Prof. B.McArthur
School of Information Systems & Technology (Pietermaritzburg)
University of KwaZulu-Natal

Dear Prof McArthur

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I,Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year Information Systems & Technology students on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or school will be identified by name and only aggregated results will appear in print.

2. The research is of a constructive, cooperative nature, and respondents would be able to withdraw at any time.

3. Research will not be conducted in the fourth term of 2009.

4. Research will only commence after ethical clearance for the project has been obtained from the university's ethical clearance committee.

Regards

_____

K.Naidoo

Tuesday 23 June 2009

Attention: Prof. M.Maharaj
School of Information Systems & Technology
University of KwaZulu-Natal

Dear Prof Maharaj

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I,Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year Information Systems & Technology students on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or school will be identified by name and only aggregated results will appear in print.

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3. Research will not be conducted in the fourth term of 2009.

4. Research will only commence after ethical clearance for the project has been obtained from the university's ethical clearance committee.

Regards

_____

K.Naidoo

Tuesday 23 June 2009

Attention: Prof. V.Rugbeer
University of Zululand

Dear Prof Rugbeer

APPLICATION FOR ACCESS TO SELECTED STUDENTS FOR RESEARCH ON THE MANAGEMENT OF ELECTRONIC WASTE MATERIAL

I,Mr. K. Naidoo (student number 7710043) am applying for access in principle to conduct research among first year Information Systems & Technology students on the management of electronic waste material (e-Waste) in the greater Durban region, subject to the following requirements:

1. Research will be on a voluntary, anonymous basis. No learner or school will be identified by name and only aggregated results will appear in print.

2. The research is of a constructive, cooperative nature, and respondents would be able to withdraw at any time.

3. Research will not be conducted in the fourth term of 2009.

4. Research will only commence after ethical clearance for the project has been obtained from the university's ethical clearance committee.

Regards

_____
K.Naidoo

5.10. Addendum 3: Concept matrix

Concepts / References	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
Agresti, (1996)																								✓
Ahluwalia, (2007)									✓															
Aljazeera. (2010).							✓	✓		✓	✓													
Blanche *et al.*, (2007)																			✓	✓	✓		✓	
Bridgen *et al.*,(2007)				✓													✓							
Chen *et al.*, (2006)						✓								✓		✓								
Chen *et al.*, (2009)				✓	✓	✓										✓	✓							

Concepts / References	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
Clark *et al.*, (1984)																		✓						
Deng *et al.*, (2008)						✓								✓		✓								
Dictionary.com		✓																✓						
Dittke,M (2009)															✓									
Dwivedy and Mittal, (2010)																								
Ecroignard. (2006)		✓			✓	✓										✓								
Ecroignard, (2008)		✓			✓	✓										✓								
eWASA. (2008).														✓										
Enviroadmin,															✓									

Concepts / References	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
2010																								
Esty *et al*.,(2005)					✓	✓			✓															
eWASA. (2010).				✓						✓				✓										
eWASA. (2011).				✓										✓		✓								
Fact_Sheet_ Mercury, (2008)				✓	✓																			
Glatthorn, (1998)																								
Kahhat *et al*., (2008)																								
Kaur, (Undated).	✓	✓																			✓			
Kerlinger &												✓												

References \ Concepts	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
Lee. (2000)																								
Klopper. (2008).												✓												
KZN Education (2010)													✓											
Leedy & Omrod (2005)												✓												
Levin, (1999).																								✓
Lieberman, (1971).																								✓
May, (1997).																			✓					
McKendric,(1999).																						✓		
Miller,(1983).																		✓						
Morales, (2008).	✓																							
Mouton,																						✓		

Concepts / **References**	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
(2003).																					✓			
New air quality															✓									
Nnorom & Osibanjo (2008)a							✓				✓			✓										
Nnorom & Osibanjo (2008)b				✓	✓		✓																	
OECD (2001)									✓	✓				✓										
Osibanjo & Nnorom		✓			✓						✓													
Population Estimates (2010)													✓											
Puckett *et*							✓	✓																

Concepts / References	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
al.,(2005)																								
Purnell, (2009)				✓	✓											✓								
Robinson (2009)							✓		✓		✓													
Saunders, *et.al* (2009)																		✓						
Schluep *et.al* (2009)				✓												✓								
Sekaran and Bougie. 2010													✓					✓		✓	✓	✓		
Sinha-Khetriwala *et al.*, (2005)																								
South Africa.info (2010)																								

Concepts / References	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
SPSS (2010)																								
StEP (2005)																								
Streicher *et.al.* 2005				✓	✓											✓								
Thanawut, 2009																			✓					
The BAN & STVC (2002)					✓										✓		✓							
Tsoulfas *et al.*, (2002)																	✓							
Van Schaik & Reuter (2010)							✓			✓	✓													
WasteWise. (2007).				✓	✓	✓			✓															
Whyte, 2010				✓	✓											✓								
Widmer & Lombard															✓	✓								

Concepts / References	Obsolete computers	Definition obsolete	Extrapolates	Materials identification	Proper disposal	Benefits Reuse	Importing/ Exporting old computers	Hand me down	Steps in recycling electronic devices	Cost of recycling	Informal Sector	Problem based research	Sample size	Categories of e-Waste	Laws	Solving the e-waste problem	Lead in m CRTs	Define Research	Research Philosophy	Research approaches	Research Strategies	Research Choices	Time Horizons	Statistics
(2005)																								
Widmer *et al.*, (2005)						✓	✓								✓									
Worldbank, (2010)											✓													✓
Yang & Williams. (2009).			✓																					
Yourdictionary.com		✓																✓						
Yu *et al.*, (2010)				✓										✓		✓								

5.11. Addendum 4: Frequency tables

Question 1 to Question 6

Question 1
School/Organisation (will only be referred to by a unique organization number)

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DUT	100	14.0	14.1	14.1
	MUT	66	9.3	9.3	23.4
	UKZN - Edgewood	73	10.3	10.3	33.7
	UKZN - Howard College	85	11.9	12.0	45.7
	UKZN - Medical School	93	13.1	13.1	58.8
	UKZN - Pmb	104	14.6	14.7	73.5
	UKZN - Westville	97	13.6	13.7	87.2
	UZULU	91	12.8	12.8	100.0
	Total	709	99.6	100.0	
Missing	System	3	.4		
Total		712	100.0		

Question 2
What is your age?

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 17 years old	1	.1	.1	.1
	17 - 18 years old	180	25.3	25.4	25.5
	19 - 20 years old	317	44.5	44.6	70.1
	21 - 22 years old	125	17.6	17.6	87.7
	23 - 24 years old	45	6.3	6.3	94.1
	Over 24 years old	42	5.9	5.9	100.0
	Total	710	99.7	100.0	
Missing	System	2	.3		
Total		712	100.0		

Question 3
In what type of neighbourhood do you live?

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Urban	443	62.2	62.9	62.9
	Semi-Rural	134	18.8	19.0	82.0
	Rural	127	17.8	18.0	100.0
	Total	704	98.9	100.0	
Missing	System	8	1.1		
Total		712	100.0		

Question 4
Do you have electricity at home?

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	663	93.1	93.5	93.5
	No	46	6.5	6.5	100.0
	Total	709	99.6	100.0	
Missing	System	3	.4		
Total		712	100.0		

Question 5
Do you use renewable energy resources (like solar panels) at home?

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	84	11.8	11.8	11.8
	No	625	87.8	88.2	100.0
	Total	709	99.6	100.0	
Missing	System	3	.4		
Total		712	100.0		

Question 6
What is the approximate total monthly income of the people in your household, including money provided by family that do not live with you at the moment?

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than R3000	229	32.2	34.9	34.9
	R3001 - R10000	185	26.0	28.2	63.1
	R10001 - R20000	124	17.4	18.9	82.0
	R20001 - R50000	76	10.7	11.6	93.6
	More than R50000	42	5.9	6.4	100.0
	Total	656	92.1	100.0	
Missing	System	56	7.9		
Total		712	100.0		

Question 7
In which economic sector does the main breadwinner in your family work?

Description		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Information Technology	20	2.8	3.0	3.0
	Finance, insurance, real estate and business services	76	10.7	11.4	14.4
	Vehicles, parts and accessories	56	7.9	8.4	22.9
	Medical, dental or other health and veterinary services	65	9.1	9.8	32.6
	Food, drink and tobacco	28	3.9	4.2	36.8
	Retail trade (including mail order	31	4.4	4.7	41.5
	Recreation and cultural services	14	2.0	2.1	43.6
	Basic Education (Grade R to Grade 12)	139	19.5	20.9	64.5
	Tertiary Education	29	4.1	4.4	68.9
	Other	207	29.1	31.1	100.0
	Total	665	93.4	100.0	
Missing	System	47	6.6		
Total		712	100.0		

5.12. Addendum 5: Chi-Square Test - Question 17

Frequencies

17.1 Acquiring:Computer tower for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	146	72.6	73.4
A new one is purchased	368	72.6	295.4
A refurbished one is purchased	9	72.6	-63.6
A second hand (used) one is purchased	33	72.6	-39.6
An imported refurbished one is purchased	2	72.6	-70.6
A relative or friend donates it to us	11	72.6	-61.6
It is given to us as a gift	11	72.6	-61.6
We win it in competitions	1	72.6	-71.6
Other	72	72.6	-.6
Total	653		

17.2 Acquiring:Computer screen for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	86	71.8	14.2
A new one is purchased	401	71.8	329.2
A refurbished one is purchased	10	71.8	-61.8
A second hand (used) one is purchased	45	71.8	-26.8
An imported refurbished one is purchased	1	71.8	-70.8
A relative or friend donates it to us	16	71.8	-55.8
It is given to us as a gift	9	71.8	-62.8
We win it in competitions	3	71.8	-68.8
Other	75	71.8	3.2
Total	646		

17.3 Acquiring:Printer for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	85	70.8	14.2
A new one is purchased	394	70.8	323.2
A refurbished one is purchased	21	70.8	-49.8
A second hand (used) one is purchased	23	70.8	-47.8
An imported refurbished one is purchased	3	70.8	-67.8
A relative or friend donates it to us	8	70.8	-62.8
It is given to us as a gift	11	70.8	-59.8
We win it in competitions	1	70.8	-69.8
Other	91	70.8	20.2
Total	637		

17.4 Acquiring:Other computer peripherals for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	115	69.7	45.3
A new one is purchased	352	69.7	282.3
A refurbished one is purchased	19	69.7	-50.7
A second hand (used) one is purchased	35	69.7	-34.7
An imported refurbished one is purchased	9	69.7	-60.7
A relative or friend donates it to us	9	69.7	-60.7
It is given to us as a gift	5	69.7	-64.7
We win it in competitions	3	69.7	-66.7
Other	80	69.7	10.3
Total	627		

17.5 Acquiring:USB external hard drives for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	82	70.3	11.7
A new one is purchased	421	70.3	350.7
A refurbished one is purchased	13	70.3	-57.3
A second hand (used) one is purchased	27	70.3	-43.3
An imported refurbished one is purchased	3	70.3	-67.3
A relative or friend donates it to us	14	70.3	-56.3
It is given to us as a gift	12	70.3	-58.3
We win it in competitions	1	70.3	-69.3
Other	60	70.3	-10.3
Total	633		

17.6Acquiring:Gaming machine (eg Play station) for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	78	67.6	10.4
A new one is purchased	326	67.6	258.4
A refurbished one is purchased	17	67.6	-50.6
A second hand (used) one is purchased	40	67.6	-27.6
An imported refurbished one is purchased	9	67.6	-58.6
A relative or friend donates it to us	14	67.6	-53.6
It is given to us as a gift	25	67.6	-42.6
We win it in competitions	8	67.6	-59.6
Other	91	67.6	23.4
Total	608		

17.7 Acquiring:MP3 Players and iPods for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	58	68.7	-10.7
A new one is purchased	420	68.7	351.3
A refurbished one is purchased	9	68.7	-59.7
A second hand (used) one is purchased	25	68.7	-43.7
An imported refurbished one is purchased	8	68.7	-60.7
A relative or friend donates it to us	12	68.7	-56.7
It is given to us as a gift	28	68.7	-40.7
We win it in competitions	6	68.7	-62.7
Other	52	68.7	-16.7
Total	618		

17.8 Acquiring:TV, VCR and DVD Player for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	36	73.0	-37.0
A new one is purchased	535	73.0	462.0
A refurbished one is purchased	12	73.0	-61.0
A second hand (used) one is purchased	22	73.0	-51.0
An imported refurbished one is purchased	8	73.0	-65.0
A relative or friend donates it to us	9	73.0	-64.0
It is given to us as a gift	7	73.0	-66.0
We win it in competitions	2	73.0	-71.0
Other	26	73.0	-47.0
Total	657		

17.9 Acquiring:HiFi and radio for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	41	72.2	-31.2
A new one is purchased	529	72.2	456.8
A refurbished one is purchased	23	72.2	-49.2
A second hand (used) one is purchased	18	72.2	-54.2
An imported refurbished one is purchased	4	72.2	-68.2
A relative or friend donates it to us	5	72.2	-67.2
It is given to us as a gift	5	72.2	-67.2
We win it in competitions	3	72.2	-69.2
Other	22	72.2	-50.2
Total	650		

17.10 Acquiring:USB flash memory sticks for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	50	71.0	-21.0
A new one is purchased	483	71.0	412.0
A refurbished one is purchased	20	71.0	-51.0
A second hand (used) one is purchased	19	71.0	-52.0
An imported refurbished one is purchased	3	71.0	-68.0
A relative or friend donates it to us	5	71.0	-66.0
It is given to us as a gift	14	71.0	-57.0
We win it in competitions	3	71.0	-68.0
Other	42	71.0	-29.0
Total	639		

17.11 Acquiring:Secure Digital (SD) memory cards for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	98	69.1	28.9
A new one is purchased	399	69.1	329.9
A refurbished one is purchased	17	69.1	-52.1
A second hand (used) one is purchased	15	69.1	-54.1
An imported refurbished one is purchased	6	69.1	-63.1
A relative or friend donates it to us	7	69.1	-62.1
It is given to us as a gift	12	69.1	-57.1
We win it in competitions	2	69.1	-67.1
Other	66	69.1	-3.1
Total	622		

17.12 Acquiring:Decoders & PVR's for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	88	68.4	19.6
A new one is purchased	389	68.4	320.6
A refurbished one is purchased	14	68.4	-54.4
A second hand (used) one is purchased	13	68.4	-55.4
An imported refurbished one is purchased	7	68.4	-61.4
A relative or friend donates it to us	7	68.4	-61.4
It is given to us as a gift	8	68.4	-60.4
We win it in competitions	3	68.4	-65.4
Other	87	68.4	18.6
Total	616		

17.13 Acquiring:Cellular phone for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	32	72.6	-40.6
A new one is purchased	544	72.6	471.4
A refurbished one is purchased	14	72.6	-58.6
A second hand (used) one is purchased	20	72.6	-52.6
An imported refurbished one is purchased	6	72.6	-66.6
A relative or friend donates it to us	10	72.6	-62.6
It is given to us as a gift	8	72.6	-64.6
We win it in competitions	1	72.6	-71.6
Other	18	72.6	-54.6
Total	653		

17.14 Acquiring:Digital cameras for home

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	72	70.4	1.6
A new one is purchased	406	70.4	335.6
A refurbished one is purchased	17	70.4	-53.4
A second hand (used) one is purchased	26	70.4	-44.4
An imported refurbished one is purchased	7	70.4	-63.4
A relative or friend donates it to us	7	70.4	-63.4
It is given to us as a gift	13	70.4	-57.4
We win it in competitions	6	70.4	-64.4
Other	80	70.4	9.6
Total	634		

17.15 Acquiring:Computer tower for work/ varsity

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	192	70.7	121.3
A new one is purchased	308	70.7	237.3
A refurbished one is purchased	19	70.7	-51.7
A second hand (used) one is purchased	36	70.7	-34.7
An imported refurbished one is purchased	9	70.7	-61.7
A relative or friend donates it to us	6	70.7	-64.7
It is given to us as a gift	7	70.7	-63.7
We win it in competitions	1	70.7	-69.7
Other	58	70.7	-12.7
Total	636		

17.16 Acquiring:Computer screen for work/ varsity

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	191	70.6	120.4
A new one is purchased	308	70.6	237.4
A refurbished one is purchased	19	70.6	-51.6
A second hand (used) one is purchased	38	70.6	-32.6
An imported refurbished one is purchased	10	70.6	-60.6
A relative or friend donates it to us	6	70.6	-64.6
It is given to us as a gift	5	70.6	-65.6
We win it in competitions	1	70.6	-69.6
Other	57	70.6	-13.6
Total	635		

17.17 Acquiring:Printer for work/ varsity

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	193	70.6	122.4
A new one is purchased	306	70.6	235.4
A refurbished one is purchased	16	70.6	-54.6
A second hand (used) one is purchased	26	70.6	-44.6
An imported refurbished one is purchased	10	70.6	-60.6
A relative or friend donates it to us	13	70.6	-57.6
It is given to us as a gift	8	70.6	-62.6
We win it in competitions	4	70.6	-66.6
Other	59	70.6	-11.6
Total	635		

17.18 Acquiring:Other computer peripherals for work/ varsity

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	218	70.7	147.3
A new one is purchased	286	70.7	215.3
A refurbished one is purchased	17	70.7	-53.7
A second hand (used) one is purchased	20	70.7	-50.7
An imported refurbished one is purchased	10	70.7	-60.7
A relative or friend donates it to us	15	70.7	-55.7
It is given to us as a gift	5	70.7	-65.7
We win it in competitions	4	70.7	-66.7
Other	61	70.7	-9.7
Total	636		

17.19 Acquiring:USB external hard drives for work/ varsity

Description	Observed N	Expected N	Residual
I'm not sure how it is obtained	195	71.3	123.7
A new one is purchased	325	71.3	253.7
A refurbished one is purchased	18	71.3	-53.3
A second hand (used) one is purchased	15	71.3	-56.3
An imported refurbished one is purchased	8	71.3	-63.3
A relative or friend donates it to us	12	71.3	-59.3
It is given to us as a gift	11	71.3	-60.3
We win it in competitions	1	71.3	-70.3
Other	57	71.3	-14.3
Total	642		

5.13. Addendum 6: Significance tables

Question	X	Question	Pearson's Chi-square	p-value
8		6	29.072	0.001
9		6	169.727	<.0005
		8	45.487	<.0005
		10	602.575	<.0005
		11	300.074	<.0005
		12	245.337	<.0005
		13	104.446	<.0005
		14.1	184.736	<.0005
		14.2	160.527	<.0006
		14.3	117.525	<.0005
		15	36.111	<.0005
		16	41.492	<.0005
12		1	91.453	<.0005
		6	194.63	<.0005
		7	63.703	<.0005
		9	245.337	<.0005
		13	227.046	<.0005
		14.1	330.979	<.0005
		14.2	277.916	<.0005
		14.3	141.786	<.0005
		15	60.037	<.0005
		16	79.076	<.0005
13		1	67.958	0.0005
		6	135.983	<.0005
		14.1	89.882	<.0005
		14.2	82.134	<.0005
		14.3	72.019	<.0005
		15	43.245	<.0005
		16	36.467	<.0005
14.1		1	66.544	<.0005
		6	95.336	<.0005
14.2		1	79.988	<.0005
		6	81.158	<.0005
14.3		1	63.066	<.0005
		6	71.243	<.0005
15		6	31.304	<.0005
		8	20.104	<.0005
		16	42.358	<.0005

Question	X	Question	Pearson's Chi-square	p-value
16		1	17.479	0.015
		6	31.86	<.0005
		7	26.335	0.002
6		17 (Home computer)	637.279	<.0005
		17 (Home entertainment)	695.776	<.0005
		17 (Work computer)	249.274	<.0005
7		17 (Home computer)	146.634	<.0005
		17 (Home entertainment)	240.998	<.0005
		17 (Work computer)	134.708	<.0005
8		17 (Work computer)	134.708	<.0005
		17 (Home computer)	57.595	<.0005
		17 (Home entertainment)	62.846	<.0005
9		17 (Home computer)	553.185	<.0005
		17 (Home entertainment)	481.548	<.0005
		17 (Work computer)	274.322	<.0005
15		17 (Home computer)	92.628	<.0005
		17 (Home entertainment)	70.26	<.0005
		17 (Work computer)	44.259	<.0005
16		17 (Home computer)	72.486	<.0005
		17 (Home entertainment)	50.69	<.0005
		17 (Work computer)	23.794	<.0005

Question	X	Question	Pearson's Chi-square	p-value
19.1		17 (Home computer)	84.014	<.0005
		17 (Home entertainment)	106.35	<.0005
		17 (Work computer)	106.077	<.0005
19.2		17 (Home computer)	119.13	<.0005
		17 (Home entertainment)	138.604	<.0005
		17 (Work computer)	83.193	<.0005
19.3		17 (Home computer)	133.812	<.0005
		17 (Home entertainment)	184.909	<.0005
		17 (Work computer)	74.147	<.0005
19.4		17 (Home computer)	201.28	<.0005
		17 (Home entertainment)	215.958	<.0005
		17 (Work computer)	74.086	<.0005
19.1		5	19.435	0.002
		6	22.682	0.007
		13	21.637	0.042
		14.2	18.568	0.029
19.2		5	27.977	<.0005
		6	34.896	<.0005
		13	22.488	0.032
		14.1	24.466	0.004
		14.2	18.81	0.027
19.3		5	15.677	0.008
		6	18.894	0.026
		14.1	19.624	0.02
		14.3	18.946	0.026
19.4		3	25.467	0.005
		5	26.939	<.0005
		6	22.426	0.008
		14.1	18.562	0.029

Question	X	Question	Pearson's Chi-square	p-value
6		18 (Home computer)	350.043	<.0005
		18 (Home entertainment)	488.534	<.0005
		18 (work computer)	186.97	<.0005
7		18 (Home computer)	332.197	<.0005
		18 (Home entertainment)	336.555	<.0005
		18 (Work computer)	307.56	<.0005
8		18 (Home computer)	120.112	<.0005
		18 (Home entertainment)	81.304	<.0005
		18 (Work computer)	81.168	<.0005
15		18 (Home computer)	412.128	<.0005
		18 (Home entertainment)	229.04	<.0005
		18 (Work computer)	139.068	<.0005
16		18 (Home computer)	211.198	<.0005
		18 (Home entertainment)	158.582	<.0005
		18 (Work computer)	99.473	<.0005
17 (Home computer)		18 (Home computer)	2019.352	<.0005
		18 (Home entertainment)	1839.732	<.0005
		18 (Work computer)	1062.267	<.0005
17 (Home entertainment)		18 (Home computer)	1901.859	<.0005
		18 (Home entertainment)	3537.005	<.0005
		18 (Work	1598.373	<.0005

Question	X	Question	Pearson's Chi-square	p-value
		computer)		
17 (Work computer)		18 (Home computer)	922.858	<.0005
		18 (Home entertainment)	1448.324	<.0005
		18 (Work computer)	2344.447	<.0005
19.1		18 (Home computer)	73.678	<.0005
		18 (Home entertainment)	115.146	<.0005
		18 (Work computer)	103.125	<.0005
19.2		18 (Home computer)	66.72	<.0005
		18 (Home entertainment)	117.231	<.0005
		18 (Work computer)	102.473	<.0005
19.3		18 (Home computer)	82.523	<.0005
		18 (Home entertainment)	156.096	<.0005
		18 (Work computer)	149.223	<.0005
19.4		18 (Home computer)	125.307	<.0005
		18 (Home entertainment)	184.568	<.0005
		18 (Work computer)	128.488	<.0005

INDEX

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8 November 2011

Mr K Naidoo (7710043)
Information Systems and Technology

Dear Mr Naidoo

PROTOCOL REFERENCE NUMBER: HSS/0407/09M
NEW PROJECT TITLE: The Management of e-Waste in KwaZulu-Natal

APPROVAL AND CHANGE OF DISSERTATION TITLE

I wish to confirm that ethical clearance has been granted full approval for the above mentioned project:

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach/Methods must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years

Best wishes for the successful completion of your research protocol.

Yours faithfully

.....

Professor Steven Collings (Chair)
Humanities & Social Sciences Research Ethics Committee

cc Supervisor Professor R Klopper
cc Mrs C Haddon