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Evaluation Of The Current Knowledge, Attitude And Perception Of End-Of-Life Electronics Among Students Of Selected North Carolina Universities Located In Guilford County

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EVALUATION OF THE CURRENT KNOWLEDGE, ATTITUDE AND PERCEPTION OF END-OF-LIFE ELECTRONICS AMONG STUDENTS OF SELECTED NORTH CAROLINA UNIVERSITIES LOCATED IN GUILFORD COUNTY

by

Bethany L. Clark

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School of Graduate Studies
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This is to certify that the Master's Thesis of

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has met the thesis requirements of
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DEDICATION

I dedicate this thesis to my parents David W. Clark and Lori M. Clark for giving me so much love and for having unrelenting faith in me. I thank you both for giving me the fortitude to pursue my passions and for always standing beside me and cheering me on. I pray that if I one day become a parent, that I will be at least half as great as you both are. I love you.

BIOGRAPHICAL SKETCH

Bethany Clark was born on March 29, 1986, in Greensboro, North Carolina. She received the Bachelor of Science degree in Fisheries and Wildlife Sciences with a concentration in Wildlife and minors in both Plant Biology and Environmental Science from North Carolina State University in 2008. She is a candidate for the Master of Science degree in Plant, Soil and Environmental Science. Bethany completed two summer internships with the US Environmental Protection Agency at the Office of Air Quality Planning and Standards in Research Triangle Park, Durham, NC while completing the Master's program. She has earned a 40-Hour Hazmat Training Certificate and upon graduation, will receive a Waste Management Certificate from the NC A&T Waste Management Institute.

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ABSTRACT

Clark, Bethany L. EVALUATION OF THE CURRENT KNOWLEDGE, ATTITUDE AND PERCEPTION OF END-OF-LIFE ELECTRONICS AMONG STUDENTS OF SELECTED NORTH CAROLINA UNIVERSITIES LOCATED IN GUILFORD COUNTY. **(Major Advisor: Arona Diouf)**, North Carolina Agricultural and Technical State University.

The purpose of the present study was to determine how much the general student population understands about the dangers and lost value that result from not properly recycling end-of-life (EOL) electronic devices. It was believed that changing the language associated with EOL electronics would, in turn, change the disposal practices of the general student population. College students at North Carolina Agricultural and Technical State University (NC A&T SU) and the University of North Carolina at Greensboro (UNCG) were chosen for this study because college students are a large group of electronic device consumers and because they are the next generation of homeowners. By assessing their understanding and disposal practices, we can get a glimpse of the future of waste disposal and gain some perspective on how to ensure that future generations will be concerned with minimizing the amount of waste they produce.

A survey was developed and distributed electronically and in person to 274 students. It was found that students actually have a better understanding than expected of the contents of electronic items and of the problems associated with electronic items in landfills. Most students thought that recycling electronic items was at least “somewhat important.” Students indicated that they were not aware of the term “e-scrap” and their recycling practices were not influenced by the term “e-waste.” Finally, students indicated

that they would recycle EOL electronic items more if they knew more about the problems of not recycling.

This research suggests that the key to reducing the amount of electronic devices being landfilled is to increase the amount of outreach and education for the public. Citizens should be made aware of what electronic items are made of so that they understand more appropriately the dangers associated with landfilling EOL electronics. If more citizens knew about the dangers to human health from landfilling, and the amount of recyclable materials and precious metals inside electronic items, then citizens would be more likely to take the necessary steps to dispose of their electronic items responsibly.

CHAPTER 1

Introduction

"Waste" is a word people use to classify things they no longer want or use and is generally synonymous with "garbage." "E-waste" is the current term used to describe electronic items that are no longer useful to the consumer and are ready to be discarded. "Scrap" is a word that describes the breaking down of a product into pieces and processing it into usable material. "E-scrap" is a more appropriate term that should be used to describe end-of-life (EOL) electronics because the components of the equipment can be used for making something new. Any item containing electronic components is made of many valuable and reusable materials, which can be reprocessed into "virgin" metals like gold and platinum in the manufacture of new electronics (NCER, 2007). There is also a substantial environmental impact resulting from not scrapping EOL electronics including wasted landfill space and contamination of soil and groundwater caused by leaching (Earth911, 2009).

Associating EOL electronics with waste gives consumers the wrong idea about EOL electronics and results in improper disposal. The "throwaway society" of today is the culprit marking all EOL things as waste, destined to be thrown in the garbage can and landfilled along with other household solid waste (Cooper, 2005). This practice is filling landfills with toxic chemicals that could have much less of an environmental impact and avoid leaching of these chemicals into the ground, potentially poisoning groundwater supplies. This is a driving force behind the 2011 ban on electronics in North Carolina landfills (General Assembly of North Carolina House Bill 819, 2007).

It is believed that changing the language associated with EOL electronics is imperative to changing people's behavior. This research explored the current knowledge, attitude and perception of EOL electronics among college students at select universities in Greensboro, North Carolina. It is believed that people are apathetic about recycling when they do not know the importance of recycling an item. This thesis revealed the dangers to human health and the lost value when EOL electronics are landfilled and not recycled. The hypotheses tested are as follows:

Hypothesis 1:

H_o: Students are largely aware of the contents of electronic items

H_1: Students are not largely aware of the contents of electronic items

Hypothesis 2:

H_o: Students are largely aware of the problems of landfilling electronic items

H_2: Students are not largely aware of the problems of landfilling electronic items

Hypothesis 3:

H_o: Few students think recycling electronic items is at least "somewhat important"

H_3: Many students ($\geq$50%) think recycling electronic items is at least "somewhat important"

Hypothesis 4:

H_o: Students are aware of the term "e-scrap"

H_4: Students are not aware ($\leq$30%) of the term "e-scrap"

Hypothesis 5:

H_o: Student's EOL electronics recycling practices are not influenced by the term "e-waste"

H_5: Student's EOL electronics recycling practices are influenced by the term "e-waste"

Chapter 1 of this thesis provides a brief introduction to the need for this research and introduces the hypotheses. Chapter 2 presents a review of the relevant literature. In an effort to enhance the understanding of this topic, the literature review is split into three main sections. The first section helps readers gain a better understanding of how the contents of electronic items pose dangers to human health. The second section presents some of the valuable and recyclable materials that make up electronic components. The third and final section discusses general information about landfills and explains how the contents of electronic components can contaminate groundwater sources. This section also examines some of the successes of EOL electronics recycling and the future of disposal practices.

Chapter 3 presents how this study was carried out. This section includes how the research and survey was developed, how the survey was distributed, and how the data was managed. Chapter 4 is a presentation of the results based upon the analysis of the survey and a discussion of the results. Chapter 5 presents the conclusions and recommendations as a result of this research and discusses the conclusions based on the hypotheses tested.

CHAPTER 2

Literature Review

2.1 Dangers to Human Health

2.1.1 Lead. Electronic items are composed of potentially toxic materials comingled with valuable precious metals (Gregory & Kirchain, 2008), making separation of electronics both necessary and challenging. One study states that EOL electronics are likely considered hazardous waste because of the presence of lead that leaches out of the device and into the landfill leachate (Spalvins, Dubey & Townsend, 2008). The human health effects of lead have been studied in depth throughout the years and include such problems as blood, endocrine, and kidney toxicity, reproductive problems, reduced brain development in children, and an increased risk of attention-deficit hyperactivity disorder (ADHD). Although most human exposure to lead has been eradicated by banning lead based paint, leaded gasoline and reductions in other commercial uses, there is still reasonable concern about exposure from drinking water because of contaminated water sources or from lead plumbing or lead solder (Sanborn, Abelsohn, Campbell &Weir, 2002; Payne, 2008; Needleman & Bellinger, 1991). Drinking water sources can become contaminated by lead when lead leaches out of landfills and into groundwater supplies, making the disposal of electronics in landfills a serious issue for municipalities across the United States and worldwide.

Lead is found in large quantities in electronic components, particularly in computers and computer equipment. The Microelectronics and Computer Technology

Corporation (MCC, 1996) reported that lead makes up 6.2% of the total weight of a typical desktop personal computer (PC) weighing 60lbs, or 3.8lbs of the total weight (see Table 1). The Organisation for Economic Co-Operation and Development (OECD) reported that electrical solder is made of metallic lead; cathode ray tubes (CRTs), the common older model of computer screens, and the frit, glass solder holding the faceplate and funnel sections of the CRT together, are made of lead oxide. In addition, older model CRTs can contain 2-3kg of lead, with newer models having as much as 1kg (as cited in Greenpeace, 2006).

The US EPA reported in "Desktop Computer Displays: A Life Cycle Assessment" that modern LCD (Liquid Crystal Display) monitors do not contain much lead, and only about 8.5g, mostly as lead solder, in printed wire boards (Socolof, Overly, Kincaid & Geibig, 2001a). The Greenpeace Briefing (2006) points out that glass crushing and high temperature processes associated with recycling or disposal can result in the release of lead oxide dust or lead fume, and states that landfill conditions allow lead to leach from CRTs and printed circuit boards. Table 2 shows that 1,229 tons of lead was contained in the flat panel televisions, laptop computers and flat panel monitors that were sold in the US in 2004 (King County Solid Waste Division, 2008).

2.1.2 Cadmium. Potential human and environmental health effects from improper disposal of EOL electronics are not limited to lead, they also include heavy metals like cadmium and mercury (deVries, Römkens & Schütze, 2007). Concentrations of cadmium in the human body tend to increase with age as a result of bioaccumulation in the liver and the lack of an elimination process. Evidence of kidney dysfunction and reductions in bone mineral density have surfaced as a result of exposure to cadmium in people with no signs or symptoms of nutritional insufficiency (Satarug &Moore, 2004).

Cadmium makes up an average of 0.0094% of total PC weight (see Table 1) and is found largely in rechargeable laptop batteries as nickel-cadmium (NiCd) (Greenpeace, 2006). Old CRTs contain cadmium in the form of cadmium sulphide as a phosphor coating inside the screen for blue-green light emission, and other cadmium compounds have been used for stabilizers in some types of PVC like wire insulation. Allsopp, Costner, and Johnston and the OECD reported that cadmium exposure occurs when incineration releases cadmium fly ash into the air, and when breaking CRT glass, which could be a risk to electronics recycling workers and persons who break or handle broken CRTs (as cited in Greenpeace, 2006).

2.1.3 Mercury. Mercury is a toxin that is known to bioaccumulate in fish and aquatic food species in the form of methylmercury, posing increased harm to humans who consume those species (Mergler et al., 2007). Methylmercury is also the reason pregnant and nursing women are encouraged to limit their intake of certain fish species. Children exposed to mercury levels that are considered to be safe have shown decreased memory and motor function. Similarly, adults exposed to mercury levels that are considered to be low have shown decreased memory, decreased fine motor function and disrupted attention. Neurological, immunological, motor, cardiac, and reproductive disorders have been linked to mercury exposure. Heavy metal toxicity in humans has been linked to such diseases as Lupus, Parkinson’s, Autism, and Alzheimer’s (Zahir, Rizwi, Haq & Khan, 2005).

Table 1. Materials used in desktop computers and the efficiency of current recycling processes.

Name	Content (% of total weight)	Weight of material (lbs.)	Recycling Efficiency (current recyclability)	Use/Location
Plastics†	22.9907	13.8	20%	Includes organics, oxides other than silica
Lead	6.2988	3.8	5%	Metal joining, radiation shield/CRT, PWB
Aluminum	14.1723	8.5	80%	Structural, conductivity/housing, CRT, PWB, connectors
Germanium	0.0016	< 0.1	0%	Semiconductor/PWB
Gallium	0.0013	< 0.1	0%	Semiconductor/PWB
Iron	20.4712	12.3	80%	Structural, magnetivity/(steel) housing, CRT, PWB
Tin	1.0078	0.6	70%	Metal joining/PWB, CRT
Copper	6.9287	4.2	90%	Conductivity/CRT, PWB,connectors
Barium	0.0315	<0.1	0%	Vacuum tube/CRT
Nickel	0.8503	0.51	80%	Structural, magnetivity/(steel) housing, CRT, PWB
Zinc	2.2046	1.32	60%	Battery, phosphor emitter/PWB, CRT
Tantalum	0.0157	<0.1	0%	Capacitors/PWB, power supply
Indium	0.0016	<0.1	60%	Transistor, rectifiers/PWB
Vanadium	0.0002	<0.1	0%	Red phosphor emitter/CRT
Terbium	0	0	0%	Green phosphor activator, dopant/CRT, PWB
Beryllium	0.0157	<0.1	0%	Thermal conductivity/PWB, connectors
Gold	0.0016	<0.1	99%	Connectivity, conductivity/PWB, connectors
Europium	0.0002	<0.1	0%	Phosphor activator/PWB
Titanium	0.0157	<0.1	0%	Pigment, alloying agent/(aluminum) housing
Ruthenium	0.0016	<0.1	80%	Resistive circuit/PWB
Cobalt	0.0157	<0.1	85%	Structural, magnetivity/(steel) housing, CRT, PWB
Palladium	0.0003	<0.1	95%	Connectivity, conductivity/PWB, connectors

Table 1 (cont.)

Name	Content (% of total weight)	Weight of material (lbs.)	Recycling Efficiency (current recyclability)	Use/Location
Manganese	0.0315	<0.1	0%	Structural, magnetivity/(steel) housing, CRT, PWB
Silver	0.0189	<0.1	98%	Conductivity/PWB, connectors
Antinomy	0.0094	<0.1	0%	Diodes/housing, PWB, CRT
Bismuth	0.0063	<0.1	0%	Wetting agent in thick film/PWB
Chromium	0.0063	<0.1	0%	Decorative, hardener/(steel) housing
Cadmium	0.0094	<0.1	0%	Battery, phosphor emitter/housing, PWB, CRT
Selenium	0.0016	0.00096	70%	Rectifiers/PWB
Niobium	0.0002	<0.1	0%	Welding allow/housing
Yttrium	0.0002	<0.1	0%	Red phosphor emitter/CRT
Rhodium	0	0	50%	Thick film conductor/PWB
Platinum	0	0	95%	Thick film conductor/PWB
Mercury	0.0022	< 0.1	0%	Batteries, switches/housing, PWB
Arsenic	0.0013	< 0.1	0%	Doping agents in transistors/PWB
Silica	24.8803	15	0%	Glass, solid state devices/CRT,PWB

Note. Plastics contain polybrominated flame retardants, and hundreds of additives and stabilizers not listed separately.

Based on a typical desktop computer weighing 60 lbs.

Table 2. Substances of concern in three high-volume flat panel products.

	U.S. Consumption in Units			Total Tons of Substances of Concern[d]	
Year	Flat Panel TVs[a]	Laptop Computers[b]	Flat Panel Monitors[c]	Lead[e]	Mercury[f]
1989	2,243,214	0	1,083,598	115	0.030
1990	1,479,513	0	882,707	79	0.021
1991	1,258,313	0	1,499,605	84	0.021
1992	2,388,180	1,850,000	1,726,516	158	0.043
1993	2,403,629	2,527,979	1,839,521	168	0.047
1994	1,648,638	3,200,464	2,795,290	166	0.045
1995	943,646	3,563,808	2,967,154	144	0.039
1996	1,217,575	4,949,204	2,266,424	154	0.046
1997	1,375,254	6,000,142	1,222,048	147	0.047
1998	2,228,984	6,407,928	1,849,201	197	0.062
1999	3,045,631	7,870,995	11,195,520	447	0.119

Table 2. (cont.)

	U.S. Consumption in Units			Total Tons of Substances of Concern[d]	
Year	**Flat Panel TVs[a]**	**Laptop Computers[b]**	**Flat Panel Monitors[c]**	**Lead[e]**	**Mercury[f]**
2000	2,554,290	9,622,814	12,817,066	480	0.128
2001	2,385,427	9,575,220	13,966,136	496	0.131
2002	3,124,772	10,883,296	23,463,917	744	0.187
2003	2,768,129	13,807,702	34,257,913	990	0.243
2004	2,748,560	16,623,580	44,155,156	1,229	0.299

a - Data for flat panel TVs based on TV sales data obtained from Consumer Electronics Association (CEA) Market Research, 2005 and ERG analyses of "Other TV" category in US Census data on shipments, imports, and exports, combined with CEA data on monochrome TVs. Data are for standard size units and do not include large screen TVs.

b - Data for laptop computers obtained from IDC WW Quarterly PC Tracker in October 2005.

c - Data for flat panel monitors based on ERG analysis of US Census data on shipments, imports, and exports.

d - Based on composition by weight for LCD flat panel monitors reported in "Desktop Computer Displays: A Life Cycle Assessment" (EPA/744-R-01-004a, December 2001). The weight of mercury in LCD backlight lamps and the weight of liquid crystals in LCD panels are assumed to be proportional to a unit's screen area. Average screen area for flat panel monitors and laptops is assumed to be 108 square inches, and average screen area for a 29-lb flat panel TV is estimated as 280 square inches.

e - Lead = (0.0028 lb lead per lb of product) x tons of flat panel products

f - Mercury = (8.1×10-8 lb mercury per sq inch of screen area) × viewing area per unit x number of units

Although mercury is found in small quantities in computers, the human health effects from acute exposures have proven significant. Mercury accounts for 0.0022% of the total PC weight as noted in Table 1. Table 2 shows that 0.299 tons of mercury was contained in the flat panel televisions, laptop computers and flat panel monitors that were sold in the US in 2004. OECD explained that mercury can be found in televisions, older model computer batteries and mainframe computer switches and relays (as cited in Greenpeace, 2006). LCD screens are backlit with 2 to 8 CCFLs (cold cathode fluorescent lamps) which is collectively as much as 3.99mg of mercury in the LCD (Socolof et al., 2001a). Allsopp et al. and the OECD also explained that the dismantling, incineration, or landfilling (all popular methods of disposal around the world) of these parts can result in mercury releases into the environment (as cited in Greenpeace, 2006).

2.2 Recyclable Materials and Precious Metals

2.2.1 Copper. Computers and other electronic devices are not only made up of potentially harmful substances, they also contain large amounts of recyclable materials. Some are mined, limited minerals, some precious metals, and some have great economic value to be had from proper recycling and separation of the comingled materials. For example, copper is a highly recyclable metal with a 90% recycling efficiency rate, and it makes up 6.92%, or approximately 4.2lbs of the total weight of a typical desktop PC (see Table 1). Copper is largely found in the printed circuit boards and CRTs and it is used so much because of its conductivity (see Table 1). Everyday, people take scraps of copper from their own job sites, scraps of piping in their homes and a number of other sources to local scrap metal recycling facilities and get cash in return; over $3 per pound (Metal Prices & News, 2010). One study reported that almost 53% of discarded copper worldwide was recovered and reused, but 30% of copper mining was used to simply replace the amount of copper that was discarded into landfills (Graedel, Bertram, Kapur, Reck & Spatari, 2004). It is important to consider the environmental impact associated with the mining of virgin materials. Significant environmental damage could be avoided if more efficient recycling and increased recovery of the valuable, limited resources could be obtained.

2.2.2 Aluminum. Aluminum is another highly recyclable metal that is used in the manufacture of lots of electronic components. Aluminum has an 80% recycling efficiency rate and makes up 14.17%, or about 8.5lbs of a typical desktop PC (see Table 1). Table 3 shows that in modern LCD panels, aluminum accounts for 1% or 0.065kg

(0.143lbs) of the total weight (Socolof, Overly, Kincaid & Geibig, 2001b). Aluminum is used so much in electronics because it does not hold heat, offers structural integrity, it is lightweight, and it is an excellent conductor. It is used in the housing, CRTs, connectors, and printed circuit boards of computers, televisions, and other electronics like data storage disks (Roeser, 1987). Aluminum cans and other scrap aluminum are collected and taken to scrap metal facilities where cash is given for scrap aluminum; over $1 per pound depending on the type of aluminum (Metal Prices & News, 2010). Scrap aluminum recycling is highly efficient and only needs 5% of the energy required to turn bauxite ore into the same amount of metal (Process Engineering, 2003).

2.2.3 Iron. Approximately 20.47%, or 12.3lbs, of a typical desktop PC is made of iron (Table 1). Iron in the form of steel accounts for 47% or 3.055kg (6.735lbs) of the more modern LCD panels (Table 3).

Table 3. Percent contribution of major materials in the final product

Material	CRT	LCD
Glass	43% (9.48 kg)	9% (0.585 kg)
Steel	30% (6.61 kg)	47% (3.055 kg)
Plastic	17% (3.75 kg)	40% (2.60 kg)
Aluminum	2% (0.441 kg)	1% (0.065 kg)
Total	92% (22.043 kg)	97% (6.5 kg)

Iron is a highly recyclable (80% recycling efficiency) valuable metal with a scrap value over $300 per ton, and has great contamination potential when handled in an area that does not have specific measures to prevent leaching (Metal Prices & News, 2010; Jensen, Holm & Christensen, 2000). Obtaining virgin iron ore is very invasive with huge environmental impacts. In fact, a tool had to be developed to detect the risk of ground deformation or collapse in areas where iron mining was taking place or was proposed to ensure safety and environmental preservation. This particular study points out the significant risks to humans and nature due to ground instabilities associated with past exploitations of iron mining, specifically looking at Lorraine, France (Colesanti et al., 2005).

2.2.4 Gold. Scrapping EOL electronics can keep precious metals like those used in jewelry out of landfills. Although they are present in small amounts in most electronic items, gold and silver are still present in almost all electronic components, particularly because of their conductivity as indicated in Table 1. Gold is used in many electronics and a suitable alternative has not been found for all uses in electronics. In fact, cost-benefit analysis shows that if a product is manufactured in small quantities, then switching to an alternative is less likely to occur as opposed to when larger amounts of gold are needed to produce a larger quantity of goods (Goodman, 2002). According to MCC, gold has a 99% recycling efficiency rate and can mostly be found in printed electronic board. Scrap prices for gold have been increasing in today's economic slow-down. Gold sells for more than $1,100 per ounce and silver more than $17 per ounce on the scrap metal market (Metal Prices & News, 2010).

2.2.5 Platinum and Rhodium. Platinum is another very valuable and precious metal used in the manufacture of electronic components, and it has a 95% recycling efficiency rate (see Table 1). One source reports that platinum is considered a "scarce metal" and is at risk of becoming depleted in this century at the current rate of use (Anonymous, 2006). Scrap platinum sells for over $1,500 per ounce (Metal Prices &

News, 2010) and is commonly used in very expensive jewelry. Rhodium is also very valuable and used similarly in electronics manufacturing as a conductor (see Table 1). Rhodium scrap sells for over $6,800 per ounce (Metal Prices & News, 2010) and is also used in jewelry, most notably for its silver luster and its ability to cover yellow gold, making it what is commonly called “white gold.” Although present in very small quantities in a typical desktop PC, its value and limited availability for the future are reason for proper recycling of EOL electronics.

2.3 Landfills

2.3.1 Electronics in Landfills. Although EOL electronics make up only 2% of the garbage, it accounts for 70% of the toxic waste in US landfills (Earth911, 2009). The concern most talked about with EOL electronics ending up in landfills is lead. In fact, EOL electronics account for 40% of lead in landfills (SCLF®, 2010). Concerns were high enough in Europe that the European Union placed a ban that began in 2006 on lead solder being used in the manufacture of particular electronic devices (Brown, 2004). Some estimates show that 315 million computers went obsolete between 1997 and 2004 which contained about 1.2 billion pounds of lead, 2 million pounds of cadmium content, and over 400,000 pounds of mercury (SCLF®, 2010). Perhaps of greater concern is the diminishing landfill space and lack of land and residential willingness to opening a new landfill. According to the US EPA, there are approximately 7,000 landfills in the US (US EPA MSWLF, 2010) and 132 landfills were present in North Carolina in 2004 (NC State Energy Office, 2004). Figure 1 displays the locations of these landfills (Brown, 2010).

At one time, there were more than 10,000 municipal landfills, but they were condensed into about 3,500 safer and newer landfills in 1988 with the US Environmental Protection Agency's implementation of the first federal standards, which were directed towards making a safer design for municipal solid waste (MSW) landfills. The idea behind the new design was to prevent the spread of disease by scavengers like buzzards, and to protect the environment from water and air pollution (Taylor, 1999). Another older study conducted in North Carolina points out that a major concern with landfills is the leaching of toxic inorganic and organic pollutants into groundwater, and the potential of that leachate to render ground and surface water unusable without treatment. This study was conducted before the federal landfill standards were implemented, and it found that water quality standard violations for inorganic and organic pollutants were found at 53% of the existing unlined landfills in North Carolina (Borden & Yanoschak, 1989). Figure 2 shows how rainwater moves through a landfill and becomes leachate where it is either collected or escapes into groundwater (Environmental Engineering, 2010). The operation of municipal solid waste landfills (MSWLFs) are guided by the federal regulations in 40 CFR 258 (Subtitle D of the Resource Conservation and Recovery Act (RCRA)) which contains the criteria for all MSWLFs in the US. Some standards include:

- **Location restrictions** which assess the land of a proposed landfill to make certain that landfills are not built near wetlands, fault lines, flood plains or other sensitive or protected areas.
- **A composite liner system** which is composed of a flexible layer over top of compacted clay oil two feet deep and covers the bottom and sides of the landfill.

This is to collect leachate; protecting soil and groundwater from potential pollutants (see Figure 3: Republic Services Inc., 2010).

- **A leachate collection and removal system** which sits on top of the composite liner system and removes leachate. (Some landfills have a gas collection system for capturing methane and sometimes converting it into an energy supply.)

(see Figure 3).

- **Operating practices** such as disease vector population control, covering the municipal solid waste (MSW) at the end of each day with six inches of soil, and controlling explosive gases (see Figure 3).
- **Monitoring groundwater** wells for landfill contaminants and waste materials.
- **Proper closure and postclosure** guidelines for covering the landfill and providing long-term attention to landfills that have closed.
- **Corrective action provisions** set groundwater standards and allow control and clean-up of landfill releases.
- **Financial assistance** is provided during and after landfill closure to ensure environmental protection. (US EPA Wastes, 2010).

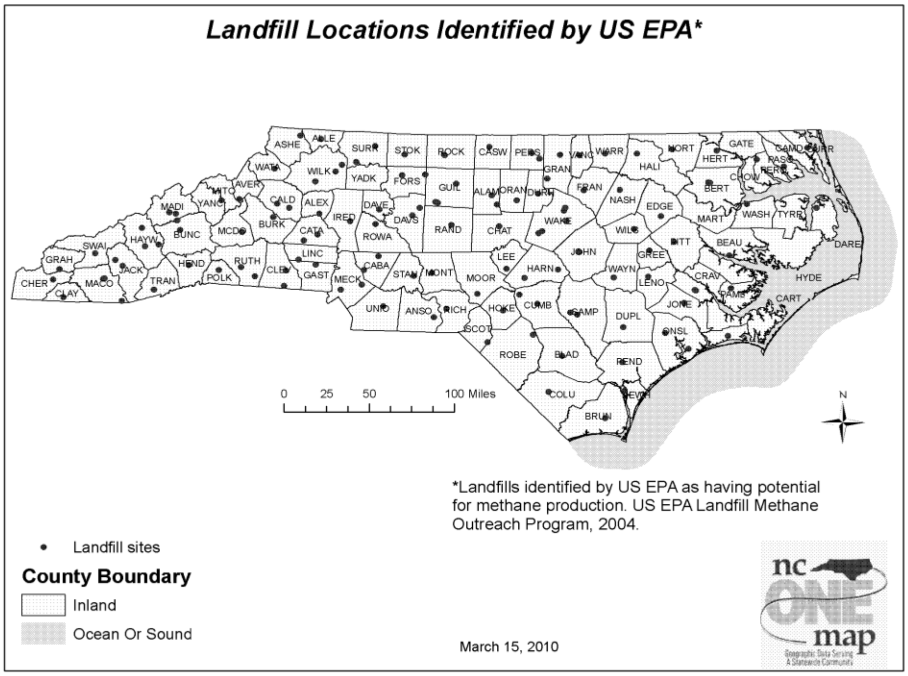

Figure 1. North Carolina landfill locations identified by US EPA.

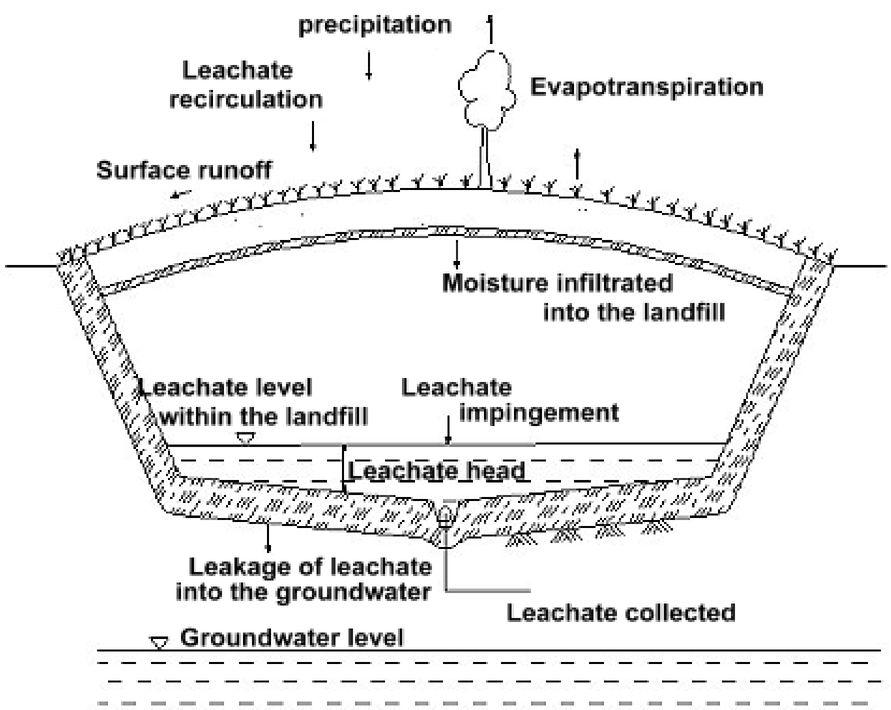

Figure 2. Cross-section of a landfill showing how leachate is formed and the movement into groundwater.

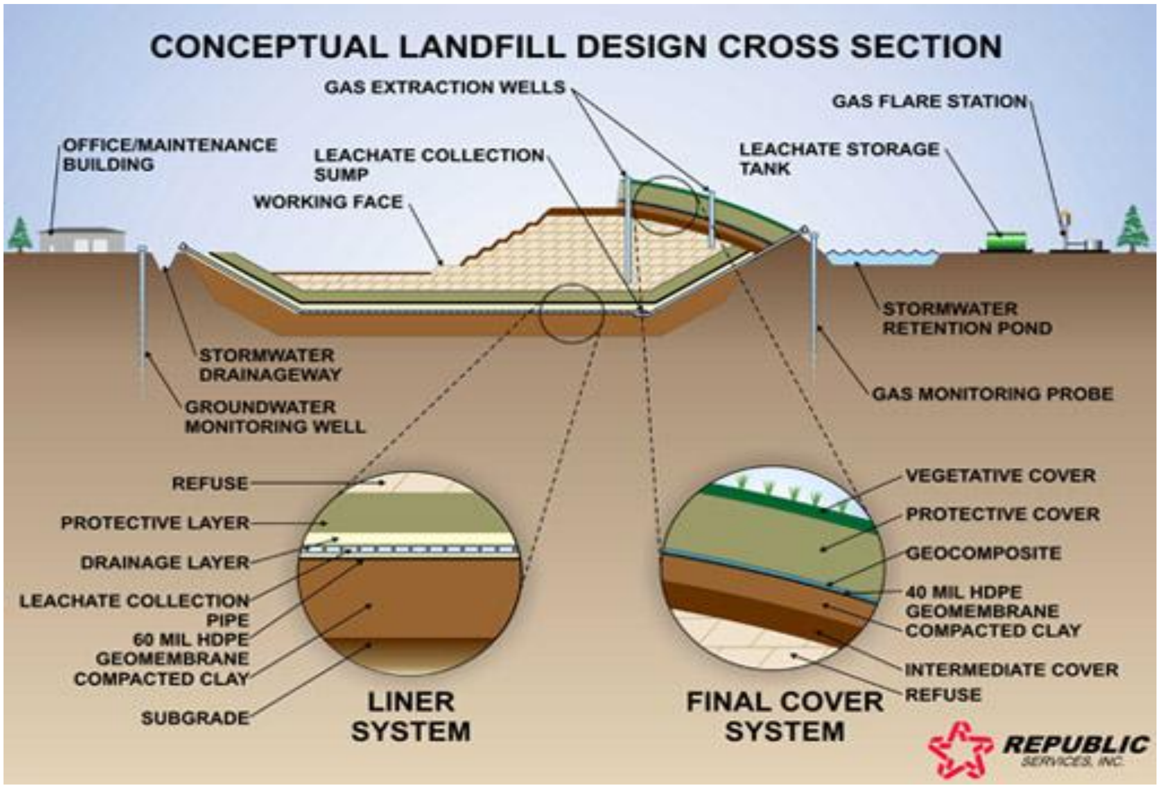

Figure 3. Cross-section of MSW landfill meeting RCRA standards.

2.3.2 Wasted Landfill Space. Electronic components tend to be very bulky items that take up a lot of space, especially when thrown away as a whole item. A typical desktop PC is 22.99% plastic, or about 13.8 pounds (see Table 1). It is well known that plastics are only photodegradable and, although the numbers vary widely, plastic can take 700 years to even begin decomposing when not in sunlight. When just one ton of plastic is recycled, 7.4 cubic yards of landfill space are saved (SKS Bottle & Packaging, 2010).

Electronic components are not just an important part of our everyday life, they are also responsible for a large portion of our economy – generating almost $2 billion a year (US EPA Fact Sheet, 2008). In 2007, electronics recycling rates had increased but the amount of disposed electronics was still very high. Table 4 shows the number of televisions, computer products, and cellular phones that were made, disposed, and recycled in the US (US EPA eCycling, 2008). The fourth column of the table shows the percent that was recycled, which is below 20% across the board.

Table 4. EPA's US electronics recycling vs. disposal chart for 2006 – 2007

	Generated (million of units)	Disposed (million of units)	Recycled (million of units)	Recycling Rate (by weight)
Televisions	26.9	20.6	6.3	18%
Computer Products†	205.5	157.3	48.2	18%
Cell Phones	140.3	126.3	14.0	10%

Note: Computer products include CPUs, monitors, notebooks, keyboards, mice, and hard copy peripherals.

2.3.3 Recycling Electronics. More than 100 million pounds of materials are recovered from electronics recycling (eCycling) annually. The federal government is taking part in making eCycling easier and more popular with the help of the EPA. The EPA encourages responsible manufacturing and disposal of electronics including the "Plug-In To eCycling Campaign," which seeks to increase the recycling rate and has an ongoing list of partners who support electronics collection programs. The US EPA also has the "Design for the Environment Program" which works with original equipment manufacturers (OEMs) of electronic devices to include environmental responsibility in product designing and recognizes those products that exemplify those qualities (US EPA eCycling, 2010). The US EPA and the US DOE also help protect the environment with the very popular Energy Star Program which encourages the design, manufacture and purchase of energy efficient products and homes (EnergySTAR, 2010).

2.4 The Global Perspective

2.4.1 Hazardous Waste and Commodities. There are two main perspectives associated with EOL electronic items: e-waste being considered a hazardous waste, and e-scrap being a commodity. Each of these perspectives has environmental implications and both address responsible recycling of EOL electronics. However, they each have their own philosophies for the proper management of EOL electronic devices.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (The Basel Convention) considers EOL electronics to be a hazardous waste which causes much debate about the appropriate disposal and transboundary movement of EOL electronics. The Basel Convention is an environmental agreement with 175 global signatories, which came about as a result of industrialized countries coming under tighter environmental regulations and the resulting uncontrolled "trading" of toxic materials to developing countries. The Basel Convention is founded on the principle that "hazardous wastes should be dealt with as close to where they are produced as possible" in an effort to reduce the human and environmental health threat (The Basel Convention, 2010). The Basel Convention requires the exporting country to notify and receive consent from the importing and transit countries prior to shipping. The Basel Convention has restrictions on the export of waste including that a country can only export if the country does not have the ability to dispose of the waste, can not dispose of the waste in an environmentally responsible manner, and if the importing country requires the raw material for their own material recovery industries (US EPA Hazardous Waste, 2008). This is an effort to keep OECD countries (developed countries) from taking advantage of non-OECD countries (developing countries) (OECD Guidance Manual, 2009).

The United States has signed but not ratified the Basel Convention and therefore cannot trade waste with Basel parties unless a separate equal agreement exists. The US, Canada and Mexico have an agreement allowing the import and export of hazardous waste. The US has a separate agreement with Costa Rica, Malaysia and the Philippines (Basel Convention parties) which allows the US to import but not export hazardous waste with those countries (US EPA Hazardous Waste, 2008).

The Institute of Scrap Recycling Industries, Inc. (ISRI) is "the voice of the scrap recycling industry" and looks at EOL electronics as a commodity with the potential to benefit environmental sustainability, job creation and economic development (ISRI, 2010). ISRI also created Design for Recycling, a concept that addresses the designs of products that are not easily recycled while still being mindful of environmental protection and sustainable conservation of natural resources. The main goals of Design for Recycling are to address, in the design stage, the reduction or elimination of toxic or hazardous materials, and to discourage the use of materials and manufacturing techniques that result in a non-recyclable product (ISRI Design for Recycling, 2010). This program is a working example of the concept of the Extended Producer Responsibility detailed in section 2.4.2.

The designation of EOL electronics as e-waste or e-scrap is critical to the disposal options. When goods are labeled as hazardous waste, they can incur an increased price for disposal. Conversely, when a good is labeled as a scrap material, it opens the option for that material to move internationally. The problem then is that a country might accept EOL electronics as scrap because of the revenue they can generate, but that country may not have viable means to properly disassemble and scrap the goods. This concerns the Basel Convention because human and environmental health can be drastically impacted by that country's disposal methods which could include burning and landfilling. ISRI is concerned because some countries do have the technology to safely disassemble and scrap the goods. However, if the goods are labeled as a hazardous waste, the country may lose revenue when they can no longer accept EOL electronics from other countries, and the exporting country loses an option to safely dispose of its EOL electronics.

2.4.2 Extended Producer Responsibility. Lindhqvist (2000) created a definition of Extended Producer Responsibility (EPR) that reads:

> Extended Producer Responsibility is an environmental protection strategy to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product. (p. ii)

By making the collection and recycling of electronic items easier for the consumer, the apathy factor can be reduced and eventually eliminated. An OEM and a retailer could work synergistically to encourage consumers to bring in the old electronic items they are replacing with the purchase of a new product. For example, a computer OEM and a distribution company could work in concert so that when a consumer buys a new laptop, the distributor could remind shoppers that they can bring in their old computer which will be sent to the OEM. This makes the OEM responsible for the product throughout its life cycle and makes responsible recycling easy for the consumer. Lindhqvist (2000) goes on to explain that EPR is more than a product take-back policy with the following revised definition:

> Extended Producer Responsibility (EPR) is a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product. (p. v)

This definition goes along with ISRI's Design for Recycling in that it promotes environmental consideration and manufacturer responsibility at all stages of the life cycle of a product.

EPR legislation has been enacted by many state governments across the US including North Carolina. The first step will be the ban on televisions and computer equipment in landfills beginning July 1, 2011. This legislation provides specific directions for computer equipment and television manufacturers operating in the State of North Carolina, including that manufacturers and collectors are responsible for providing education to citizens on the laws and recycling options available to them. Computer Equipment manufacturers in North Carolina will be required to have a computer equipment recycling plan that is convenient and free to the consumer and will also be subject to annual fees (General Assembly of North Carolina Senate Bill 887, 2009).

CHAPTER 3

Materials and Methods

3.1 Research Design and Survey Development

This research used a survey questionnaire given to voluntary participants to assess their attitudes towards and understanding of their current disposal practices of EOL electronics. The survey was distributed to local academic institutions in the Greensboro, NC area, specifically North Carolina A&T State University and the University of North Carolina at Greensboro. The link to the survey was sent via email, to the Department Chairpersons of each college at NC A&T SU, asking them to distribute the link to their students in an effort to help with this thesis research. Emails with the link to the survey were also sent to students at UNCG seeking their voluntary participation. The survey questions were designed to assess participants' knowledge of the contents of electronic items, their opinion of the importance of recycling EOL electronics, and determine if calling EOL electronics "scrap" would change the way they dispose of EOL electronics. The questionnaire also asked the student if they thought "e-scrap" or "e-waste" was a more appropriate term, and how labeling EOL electronics as "scrap" might affect their disposal habits. No identifiers were collected in the survey in an effort to preserve anonymity of students. The survey questionnaire can be found in Appendix A.

The NC A&T SU Department of Research and Economic Development (DORED) requires that students conducting research using surveys, as well as their advisors, take and successfully complete the Collaborative Institutional Training Initiative (CITI)

Training prior to applying for Institutional Review Board (IRB) approval. DORED provides a template cover letter of "Informed Consent to Participate in a Research Study" to be edited to fit each survey to ensure students' understanding of the survey, what the survey will be used for, and to ensure that no private or personal information will be collected (see Appendix B). DORED also maintains an account with Survey Monkey for students to use for electronic survey distribution. The "Informed Consent to Participate in a Research Study" was used as the opening page of the survey. Survey students were instructed to read and click "Next" in order to participate in the survey.

The majority of the research, writing, and analysis was completed in the Natural Resources and Environmental Design Graduate Student Office in 215 Carver Hall on the NC A&T SU campus. The research and writing primarily required a computer, internet access, and Microsoft Office software including the use of Word and Excel. Students' responses to the survey were all voluntary. The goal was to gather responses from at least 200 individuals.

3.2 Survey Distribution

Upon IRB approval (see Appendix C), an email containing the IRB approval forms and survey link was sent to every Department Chairperson in each college at NC A&T SU, asking them to distribute the link to the online survey to their students. Unfortunately, there was very little correspondence from the Chairpersons and there is no way to know how many of them distributed the link to their students. UNCG also required proof of NC A&T SU IRB approval before giving UNCG IRB approval to seek student participation in the survey. UNCG then provided a list of undergraduate students who did not have a privacy setting for their email addresses. Students were selected alphabetically from that list and 3,611 students were sent an email with the link to the survey asking for their voluntary participation. Survey Monkey provided an analysis of the responses as percentages of the total replies. These results were entered into a histogram for each question. NC A&T SU IRB approval can be found in Appendix B. The UNCG IRB Approval can be found in Appendix C.

CHAPTER 4

Results and Discussion

4.1 Results

The survey was open online from August 4, 2010 until October 5, 2010 at 11:00am. A total of 274 responses were received from students at NC A&T SU and UNCG. Students had the option to answer all or some of the questions, and some students chose not to answer all questions. Therefore, the n-value (number of responses received) for some questions vary. The data collected is presented in the order the questions were presented in the survey (see Appendix A).

A question was developed to see what the students thought an electronic device is composed of. A total of 266 students responded to the question. The results are revealed in Figure 4. The question in Figure 5 was developed to determine how much students know about landfills and the issues of electronics in landfills. This figure represents the responses from a total of 270 students. Figure 6 describes a question that was developed to determine if students had previously encountered the terms “e-waste” or “e-scrap.” Responses from a total of 270 students are outlined in this figure. In addition, Figure 7 represents a question that was developed to gauge the importance of recycling electronic devices to the students. A total of 274 students responded to this question. The results reveal that 15.3% of students think recycling electronic devices is “not important,” 63.9% think recycling electronic devices is “somewhat important,” and 20.8% think recycling electronic devices is “critical.”

Figure 8 represents the question that sought to determine why those who chose not to recycle electronic devices, made that choice. A total of 242 students responded to this question. Figure 9 represents the results from a question that was used to determine, if students do not already recycle electronic devices, would they begin recycling these devices if they knew more about the problems associated with electronics in landfills. A total of 254 students responded to this question. Those who responded indicating that they would change their recycling practices made up 94.1% of the respondents, and 5.9% of the respondents indicated that they would not. The question in Figure 10 was used to determine if the term "e-waste" has any affect on how students dispose of electronic devices. A total of 273 students responded to this question. The results reveal that 27.8% of students are influenced by the term, and 72.2% are not influenced by the term "e-waste" in their disposal practices of electronic devices.

Figure 11 represents the question that was developed as a follow up to the previous question, and determined if students would dispose of their electronic devices differently if EOL electronics were publicly referred to as "e-scrap" instead of "e-waste." A total of 270 students responded to this question. The results reveal that 27.4% would change their disposal practices and 72.6% would not. The question in Figure 12 was developed to determine how students currently dispose of batteries in an effort to understand the contents going into the landfills now and in the future. A total of 273 students responded to this question. Figure 13 describes a question that was developed to determine how students dispose of EOL television sets. A total of 274 students responded to this question. Figures 4 through 13 represent these findings.

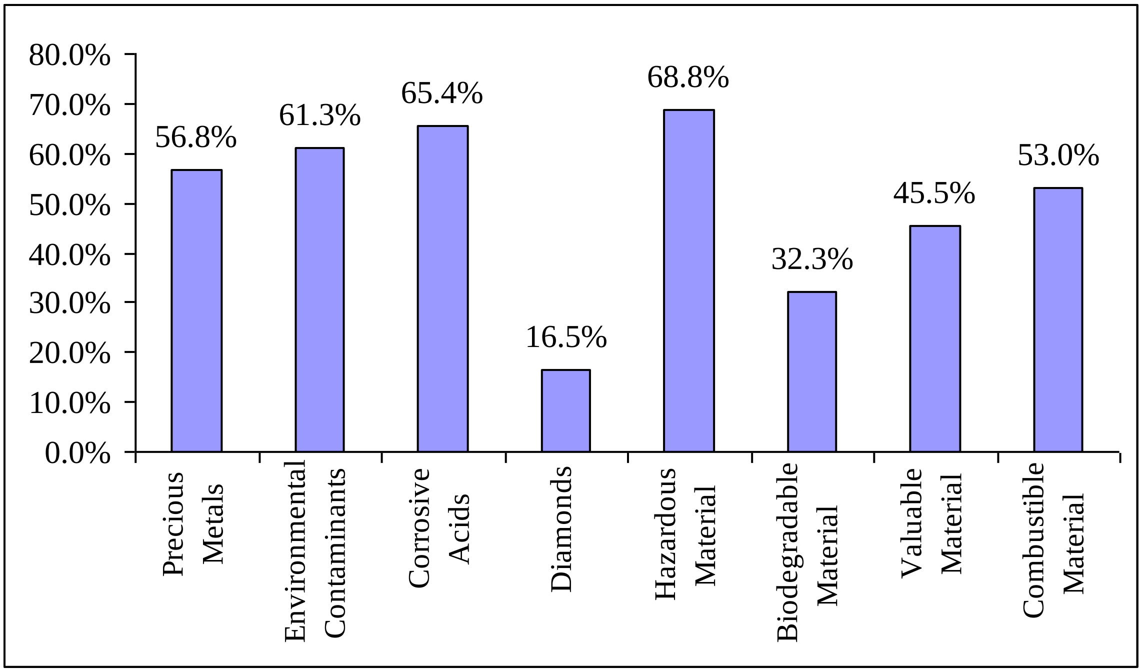

Figure 4. Please check all of the following materials that you KNOW are used in electronics

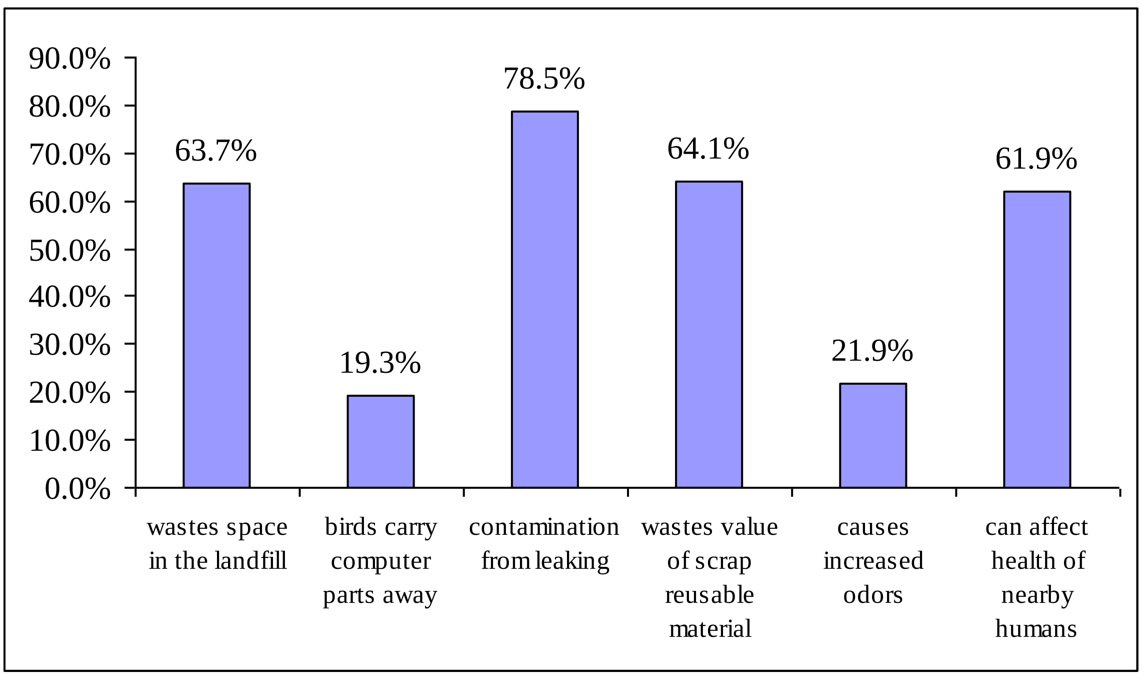

Figure 5. What is true about electronics in the landfills? (Check all that apply)

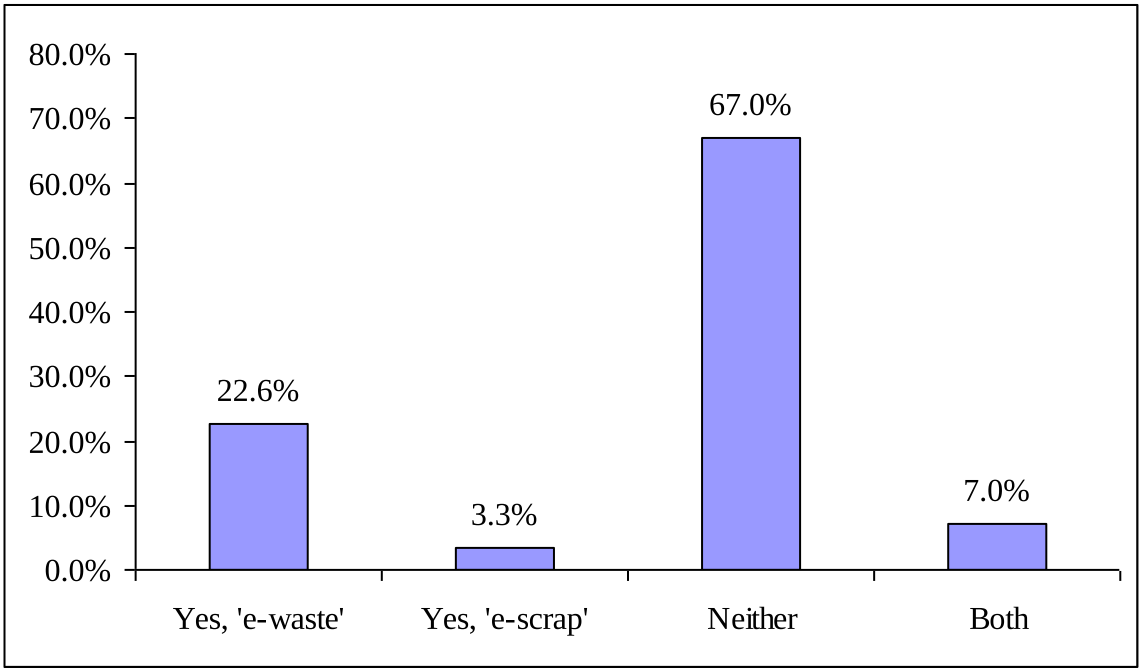

Figure 6. Have you ever heard the terms "e-waste" or "e-scrap?"

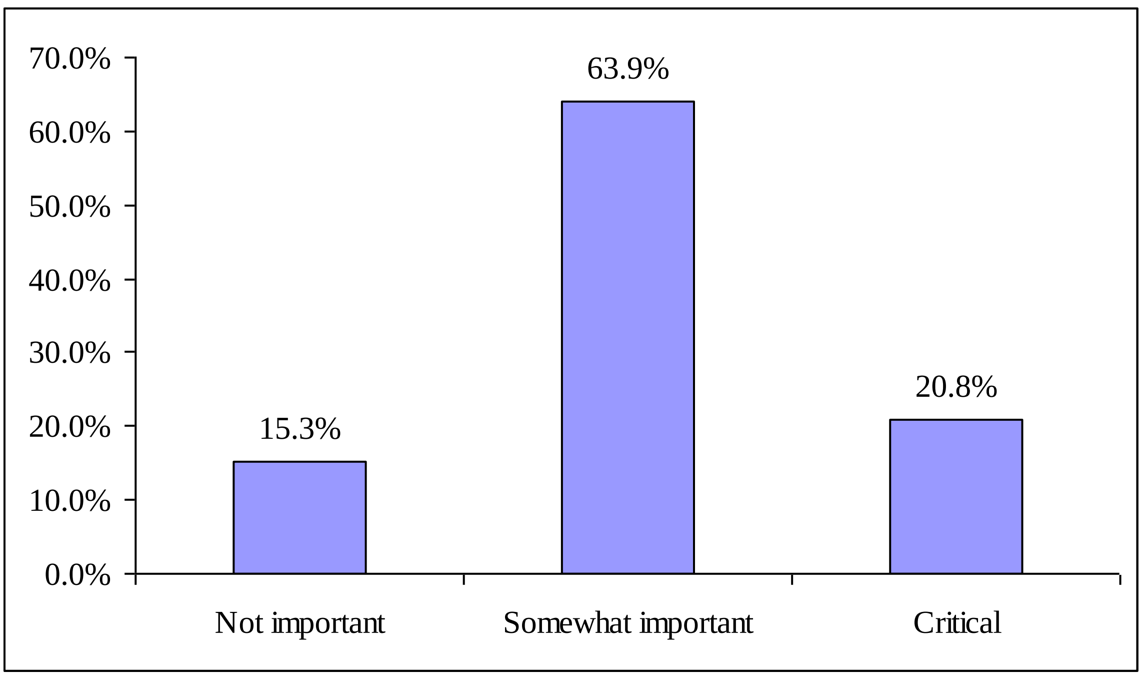

Figure 7. How important is recycling electronics to you?

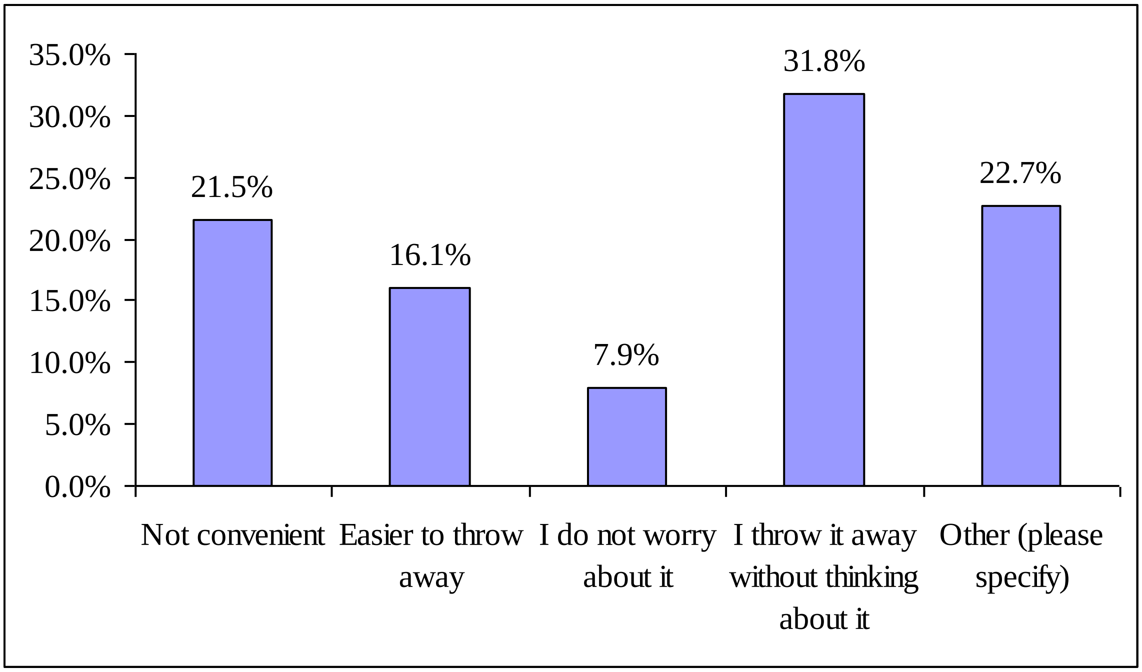

Figure 8. If you do not currently recycle electronics, why not?

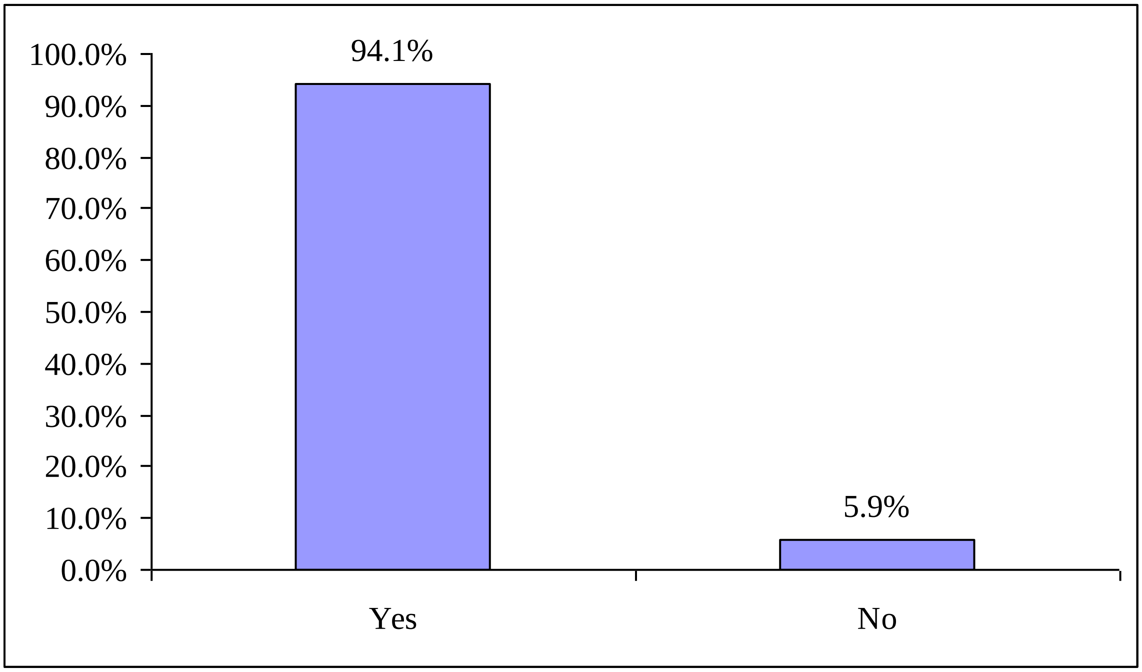

Figure 9. If you do not currently recycle electronics, would you recycle more if you knew more about the problems of not recycling electronics?

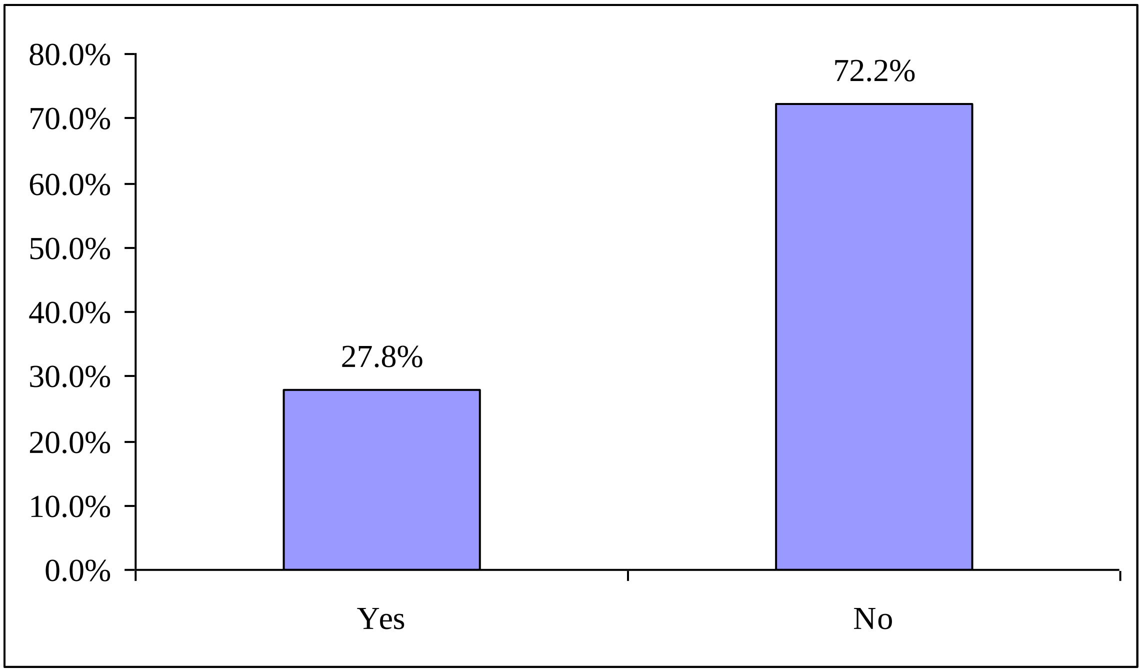

Figure 10. Does the term "e-waste" have any affect on how you dispose of electronics?

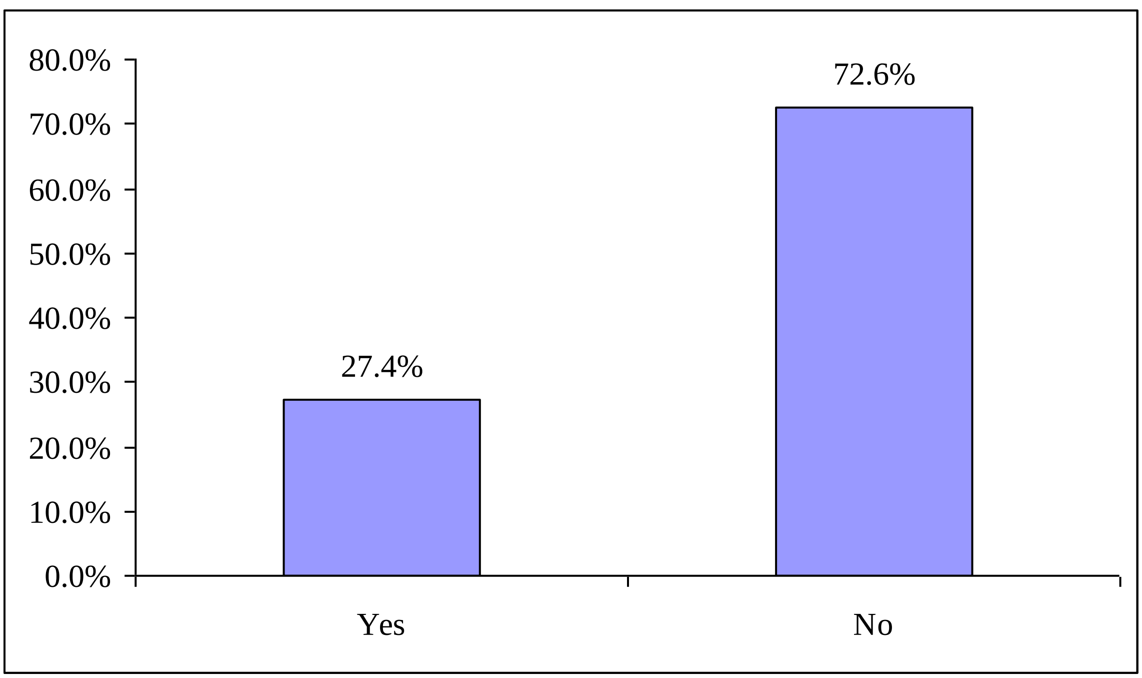

Figure 11. If electronics were referred to publicly as "e-scrap" instead of "e-waste," would you dispose of them any differently?

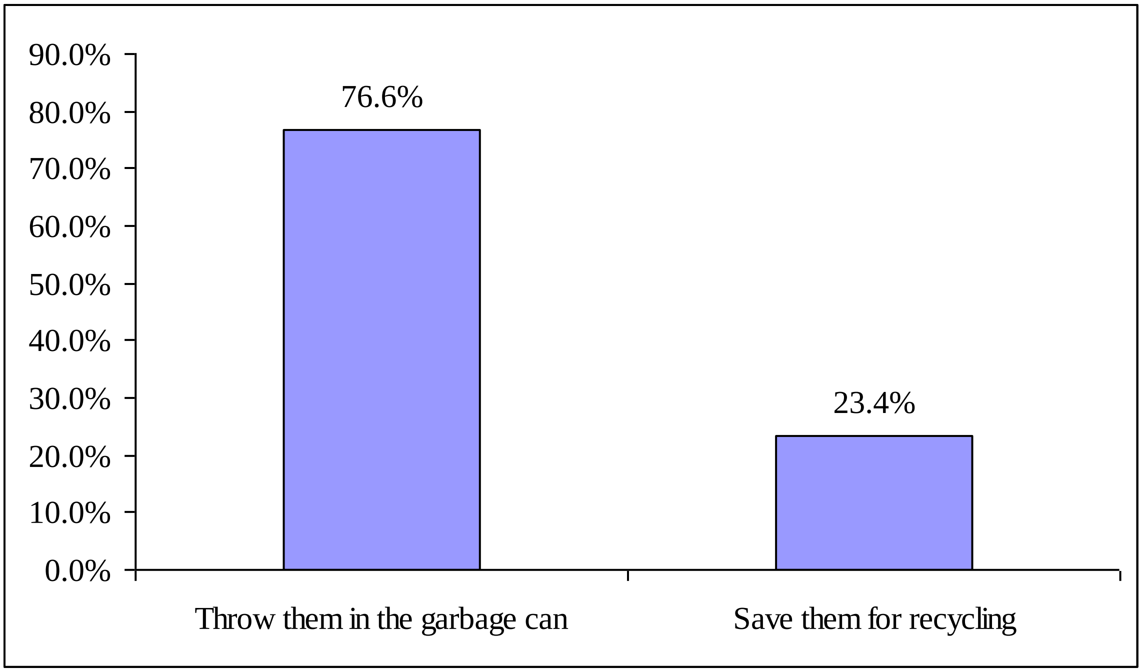

Figure 12. Which best describes what you do with old batteries when you replace them?

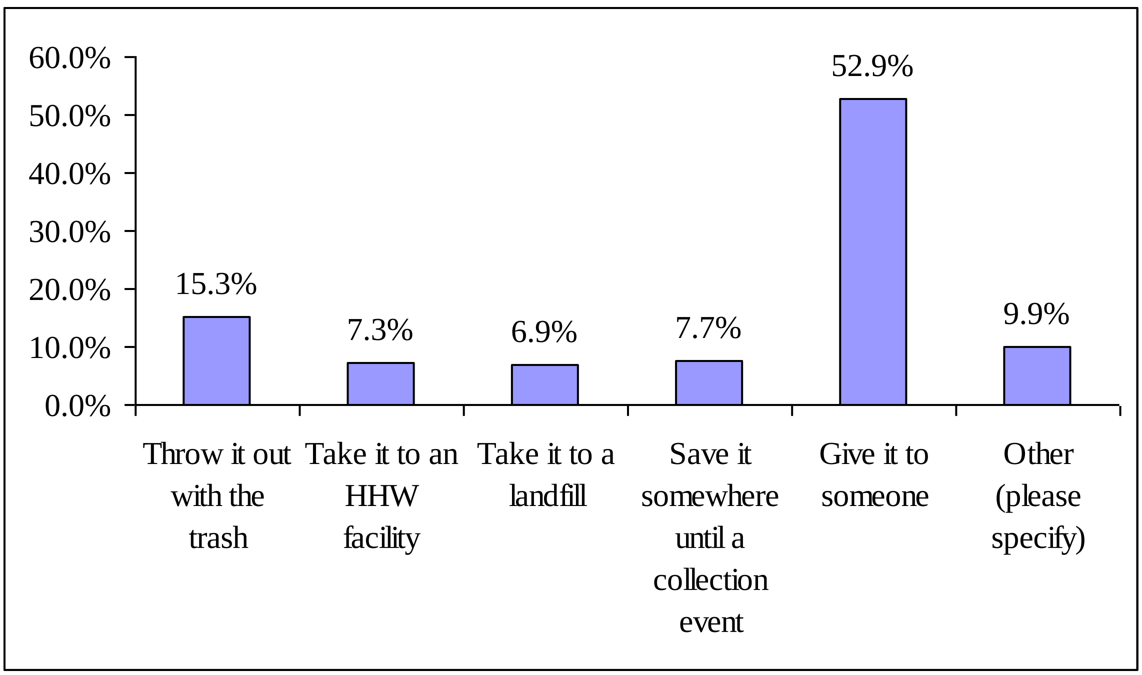

Figure 13. Which best describes what you do with an old TV?

4.2 Discussion

Survey responses show that students actually have a higher level of knowledge of the contents of electronic items than expected (see Figure 4). An overwhelming number of students knew that electronic items contain hazardous material (68.8%), environmental contaminants (61.3%) and precious metals (56.8%) (see Figure 4). Students also have a greater understanding than anticipated of the issues associated with landfilling electronic items as noted in Figure 5. More specifically, 78.5% of students knew that electronics could cause contamination from leaking, 64.1% knew that landfilling electronics resulted in wasted value of scrap reusable material, and 61.9% knew that electronics in landfills can affect the health of nearby humans (see Figure 5). As expected, more students (63.9%) responded that recycling electronics is “somewhat important” than those who believed that it was “critical” or “not important” (see Figure 7).

While it was anticipated that few students have heard the term “e-scrap”, it was not expected to be as low as it was (3.3%) (see Figure 6). A surprising majority of the students had never heard either of the terms, e-scrap or e-waste (67.0%) (see Figure 6). It was expected that the term e-waste would have an affect on how students disposed of their electronics, but that was not the case. A surprising 72.2% reported that the term e-waste has no affect on how they dispose of electronics (see Figure 10).

Figure 9 indicates that an overwhelming 94.1% of students stated that they would recycle electronics more if they knew more about the problems associated with not recycling EOL electronics. Responses indicate that 72.6% of students would not change their disposal practices if EOL electronic devices were publicly referred to as “e-scrap” (see Figure 11). A disturbing 76.6% of students stated that when replacing batteries, they dispose of the old batteries in the garbage can, as indicated in Figure 12. This is disturbing because various batteries contain a plethora of hazardous materials and should not be landfilled.

CHAPTER 5

Conclusions and Recommendations

5.1 Conclusions

The following conclusions were made from the previous results:

Hypothesis 1:

Figure 4 indicates that many of the students acknowledged hazardous material, environmental contaminants and precious metals as being contents of electronic items. Therefore, we fail to reject H_o: students are largely aware of the contents of electronic items.

Hypothesis 2:

Figure 5 shows that students are aware of many of the issues associated with landfilling electronic items. Therefore, we fail to reject H_o: students are largely aware of the problems of landfilling electronic items.

Hypothesis 3:

Figure 7 shows that the majority of students (63.9%) indicated that recycling electronic items is somewhat important. Therefore, we reject H_o: few students think recycling electronic items is at least somewhat important, and conclude that many students ($\geq$50%) think recycling electronic items is at least somewhat important.

Hypothesis 4:

Figure 6 indicates that very few students (3.3%) have heard the term e-scrap. Therefore, we reject H_o: students are aware of the term "e-scrap", and conclude that students are not aware (≤30%) of the term e-scrap.

Hypothesis 5:

Figure 10 indicates that the term “e-waste” has no affect on how students dispose of electronic items. Figure 11 supports this response and indicates that students would not dispose of electronic items any differently if they were publicly referred to as e-scrap instead of e-waste. Therefore, we fail to reject H_o: students EOL electronics recycling practices are not influenced by the term e-waste.

Relating figures 10, 11 and 12 shows that the term e-waste does not affect how students dispose of electronic items, and that publicly referring to EOL electronics as e-scrap would not change their disposal practices. An overwhelming 94.1% of students stated that they would recycle electronics more if they knew more about the problems associated with not recycling. This led to the conclusion that perhaps changing the language associated with EOL electronics is not as important as providing the outreach and education to the public, making them aware of the dangers associated with not recycling EOL electronics.

Students were asked why they do not recycle electronics, if they currently do not, and 31.8% stated that they “throw it away without thinking about it” and 21.5% stated that it’s “not convenient” (see Figure 8). The “other” option was chosen by 22% of the students and their typed responses can be found in Table 5. The responses suggest that students should have been given the option to select more than one answer and should have been given an option to indicate that they do currently recycle electronics. This question also had the least number of responses at 242.

Table 5. Open-ended responses to the survey question "if you do not currently recycle electronics, why not?"

#	Other (please specify)
1	i didnt *[sic]* know that you could
2	No where to recycle at.
3	i give it to goodwill
4	i never see recycling bins
5	never throw away electronics
6	have not had to
7	sell it
8	all of the above
9	I don't know the risks or where and what to recycle
10	I never have any electronics to recycle
11	Unaware of any facilities that participate in recycling electronics
12	I do
13	I just keep them because I'm not sure how to recycle them properly.
14	Facilities at work makes this easier but at home I don't always recycle b/c of convenience
15	I recycle electronics
16	I'm keeping them in a pile so as to make good use of a single trip, as well as trying to find appropriate facilities that won't ship it off to a developing country with lower/unenforced enviro *[sic]* law.
17	Don't know where to recycle electronics
18	I do recycle electronics.
19	I don't know what is recyclable and how to recycle them.
20	not sure what else to do with them
21	How do I recycle electronics?
22	No recepticles *[sic]* to put them in.
23	I recycle them
24	Not sure where to recycle them.
25	Not sure where to recycle them.
26	I haven't had many to throw away.
27	I have not done the research to find and recycling plant near me but I do use rechargeable batteries I am not if that count.
28	we haven't had any to recycle other than TV's. We've kept out old computers for kids, phones too.
29	I don't really ever need to get rid of my electronics.
30	It's not convenient, don't know where to recycle electronics
31	I didn't know you could.
32	I have had nothing electronical *[sic]* to throw away in recent memory.
33	Unaware of the ways to recycle electronics
34	I have not had any that needs throwing away yet
35	I sell mine.
36	don't have any to recycle

Table 5. (cont.)

37	Never had to throw a emectronic *[sic]* away.
38	My dorm is proactive in recycling old cell phones and used printer ink cartridges
39	really did not know what types of electronics you could recycle or where to recyle *[sic]* them at except for batteries. I give them to my dad. He recycles those.
40	I'm not sure which electronics are recyclable
41	I am currently an out of state student in Greensboro, North Carolina and don't exactly know my way around here. I also don't drive, so it makes in even more dificult *[sic]* for me to find a place where I would recycle some, if any, of my electronics. My parents, on the other hand, haven't had to dispose of many large, old electronics like TVs or Computers, but most of the time they will throw bateries *[sic]* away in a trash can. However, they will recycle ink cartriges *[sic]* from printers.
42	I do not know about it. where or how
43	I didn't know I could recycle electronics.
44	Never have had the opportunity to discard any electronics.
45	no one has ever truly educated me on how to recycle or what to do with electronics no longer useful to me
46	I don't know where I can go to recyle *[sic]* them.
47	recycle as much as possible, batteries, cell phones, etc.
48	I don't know how.
49	i do recycle
50	I have a bag of electronics looking for a place to recycle. I will not throw them away.
51	I am not aware of any places to take old electronics to have it recycled.
52	I don't know how or what programs are available.
53	I have no way of recycling it bc *[sic]* city doesn't have a recycling program
54	I normally donate to an organization like Goodwill.
55	I don't really know where to go or how to recycle them, and finding that information is difficult.

Students were asked what they do with an old TV, and just over half (52.9%) responded that they "give it to someone" (see Figure 13). Only 7.3% and 7.7% take the TV to an HHW facility or save it until a collection event, respectively (see Figure 13). This is unfortunate because so many more students either throw the TV out with the trash (15.3%) or take it to a landfill (6.9%) (see Figure 13). The "other" option was chosen by 9.9% of the students and their typed responses can be found in Table 6.

Table 6. Open-ended responses to the survey question "which best describes what you do with an old TV?"

#	Other (please specify)
1	I'll either give it to someone who can use it or I would sell it
2	leave it sitting around
3	sit on side of street
4	call WM
5	donate
6	Sell it
7	Recycle through Good Will
8	Take it to the local dump
9	We've never gotten rid of a television so far.
10	I let my mother dispose of them.
11	Goodwill
12	I have not gotten rid of a TV, but if I needed to would not know what to do with it
13	I've never thrown away a television before or had one that needed to be disposed of.
14	Donate to Habitat for Humanity Restore or Goodwill
15	my community has a e-waste pick up day as well as a place to drop off electronics.
16	haul it to the side of the road and let the garbage company deal with it
17	i don't know
18	The only old TV that my family had ever had was a rental from comcast, which we returned when we moved to our current house. I don't know any other TVs that we had or did with them for that matter.
19	sell it or take it to salvation army or goodwill or carolina thrift
20	I never had to get rid of a tv!
21	Never threw one away
22	Give it to Goodwill
23	store it away.
24	store it in my attic or crawlspace
25	Take to Goodwill
26	If it still worked, I would drop it off at Goodwill. If it didn't, I would see if any major retailers like Best Buy had a recycling program. This is what I did when I bought my new laptop.
27	Take it to where it can be recycled such as Best Buy or anyother *[sic]* place.

As this research has shown, the key to reducing the amount of electronic devices being landfilled is to increase the amount of outreach and education going to the public about the dangers associated with this behavior. Many of the responses in Table 6 show a high amount of students either did not know that electronic devices can be recycled or did not know where to recycle them. However, this could be due to the fact that students were all college students and may not be familiar with or aware of programs available in Guilford County. Citizens need to be made aware of what electronic items are made of so that they understand more appropriately the dangers associated with landfilling EOL electronics. If more citizens knew about the dangers to human health from landfilling, and the amount of recyclable materials and precious metals inside electronic items, then more citizens would likely take the necessary steps to dispose of their electronic items responsibly.

5.2 Recommendations

Further research is needed to determine the best method to provide outreach and education materials to a sufficient number of people. The materials should explain to citizens why they should recycle EOL electronics and how and where to dispose of EOL electronics. It is also recommended that similar research be conducted at more universities and on the community level. To better understand why students do not currently recycle EOL electronics, it is recommended that survey answer options be formulated to allow for more options, including the option that they "do currently recycle" EOL electronics. It is also recommended that, for further study, a similar survey be distributed on the grounds of a HHW facility or at an EOL electronics collection event to gauge the level of understanding among current homeowners and those who currently recycle EOL electronics.

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APPENDIX A

Survey Instrument

1. Please check all of the following materials that you KNOW are used in electronics:

___ Precious Metals
___ Corrosive Acids
___ Hazardous Material
___ Valuable Material
___ Environmental Contaminants
___ Diamonds
___ Biodegradable Material
___ Combustible Material

2. What is true about electronics in the landfills? (Check all that apply)

__ wastes space in the landfill
__ wastes value of scrap reusable material
__ birds carry computer parts away
__ causes increased odors
__ contamination from leaking
__ can affect health of nearby humans

4. Have you ever heard the terms “e-waste” or “e-scrap”?
a. Yes, “e-waste”b. Yes, “e-scrap”c. Neitherd. Both

3. How important is recycling electronics to you?
a. Not importantb. Somewhat importantc. Critical

5. If you do not currently recycle electronics, why not?
a. Not convenientb. Easier to throw awayc. I do not worry about it
d. I throw it away without thinking about ite. Other_________________

6. If you do not currently recycle electronics, would you recycle more if you knew more about the problems of not recycling electronics?
a. Yesb. No

7. Does the term “e-waste” have any affect on how you dispose of electronics?
a. Yesb. No

8. If electronics were referred to publicly as “e-scrap” instead of “e-waste”, would you dispose of them any differently?
a. Yesb. No

9. Which best describes what you do with old batteries when you replace them?
a. throw them in the garbage canb. save them for recycling

10. Which best describes what you do with an old TV?
a. throw it out with the trashb. take it to an HHW facilityc. take it to a landfill
d. save it somewhere until a collection evente. give it to someonef.
Other_________________

APPENDIX B

NC A&T SU IRB Approval

NC A&T DIVISION OF RESEARCH AND ECONOMIC DEVELOPMENT
1601 East Market Street
Greensboro, NC 27411
(336) 334-7314
Web site: http://www.ncat.edu/~divofres/compliance/irb/index.php
Federalwide Assurance (FWA) #00000013

To: Bethany Clark

From: Behavioral IRB

Date: 5/20/2010

RE: Notice of IRB Exemption
Exemption Category: 2.Survey, interview, public observation
Study #: 10-0064

Study Title: Evaluation of the Current Knowledge, Attitude and Perception of End-of-Life Electronics among Citizens of Guilford County, North Carolina and Select North Carolina Universities Located in Guilford County

This submission has been reviewed by the above IRB and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b).

Study Description:

The specific aims of this thesis are to assess the level of knowledge citizens have of the contents of electronic items, measure their understanding of the importance of recycling EOL electronics as opposed to land filling, and to determine if calling EOL electronics 'scrap' would change the way they dispose of EOL electronics

Investigator's Responsibilities:

If your study protocol changes in such a way that exempt status would no longer apply, you should contact the above IRB before making the changes. The IRB will maintain records for this study for 3 years, at which time you will be contacted about the status of the study.

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Evaluation of the Current Knowledge, Attitude and Perception of End-of-Life Electronics among Citizens of Guilford County, North Carolina and Select North Carolina Universities Located in Guilford County

Study Title: Evaluation of the Current Knowledge, Attitude and Perception of End-of-Life Electronics among Citizens of Guilford County, North Carolina and Select North Carolina Universities Located in Guilford County
PI: Bethany Clark
Dear Respondent,

I am inviting you participate in a research project to study the current knowledge, attitudes, and perceptions that citizens and college students in Guilford County currently have about end-of-life (EOL) electronics. Along with this letter is a short questionnaire that asks a variety of questions about your personal knowledge, thoughts, and understanding of EOL electronics. I am asking you to look over the questionnaire and, if you choose to do so, complete it and give it back to me. It should take you about five minutes to complete. You must be 18 years of age to participate.

The results of this project will be used to assess the level of knowledge citizens have of the contents of electronic items, measure their understanding of the importance of recycling EOL electronics as opposed to land filling, and to determine if calling EOL electronics 'scrap' would change the way they dispose of EOL electronics. Through your participation I hope to understand the type of information needed to increase recycling of EOL electronics and if the terminology associated with electronics recycling affects disposal practices. I hope that the results of the survey will be useful for developing the most useful outreach and education tools and I hope to share my results by publishing them in a scientific journal and sharing the results with the City of Greensboro and the News & Record Newspaper.

I do not know of any risks to you if you decide to participate in this survey and I guarantee that your responses will not be identified with you personally. I promise not to share any information that identifies you with anyone outside my research group which consists of me, my academic advisor, and the members of my thesis committee. Please do not enter your name into the questionnaire.

I hope you will take the time to complete this questionnaire. Your participation is voluntary and there is no penalty if you do not participate. Regardless of whether you choose to participate, please let me know if you would like a summary of my findings. To receive a summary, please email me at blclark2@ncat.edu.

If you have any questions or concerns about completing the questionnaire or about being in this study, you may contact me via email at blclark2@ncat.edu. You may also contact my research advisor at adiouf@ncat.edu. This project has been approved by the Institutional Review Board (IRB) at North Carolina A&T State University.

If you have any questions about your rights as a research study participant, you may contact the chair of the IRB through Compliance Office at (336) 334-7995 or rescomp@ncat.edu.

If you agree to participate, you may click the link provided to begin the survey and complete the survey.
If you wish, you may skip any question, stop at any time or withdraw by clicking the exit link at the top of any online survey page.
You do not have to enter your name on the survey.

Sincerely,

Bethany Clark, NC A&T State University M.S. Student

APPENDIX C

UNCG IRB Approval

THE UNIVERSITY *of* NORTH CAROLINA
GREENSBORO

Office of Research Compliance

2718 Beverly Cooper Moore and Irene Mitchell Moore
Humanities and Research Administration Building
P. O. Box 26170, Greensboro, NC 27402-6170
336.256.1482 *Phone* 336.256.1482 *Fax*
www.uncg.edu/orc/

To: Bethany Clark
NC State University Alumni

August 13, 2010

Dear Ms. Clark:

The IRB for the Protection of Human Participants in Research at The University of North Carolina at Greensboro (UNCG) is willing to accept the approval of project entitled "Evaluation of the Current Knowledge, Attitude, and Perception of End-of-Life Electronics among Citizens of Guilford County, North Carolina and Select North Carolina Universities Located in Guilford County" through NC A&T State University. Access to participants on this campus must be cleared through the appropriate department prior to you collecting data on the UNCG campus.

If you have any questions, please contact me at ecallen@uncg.edu or (336) 256-1482.

Sincerely,

Eric Allen, Director
Office of Research Compliance

Cc: Dr. Martha Nyikos, Literacy, Culture & Language Education