E-waste education strategies: teaching how to reduce, reuse and recycle for sustainable development

Phillip Olla*

Madonna University,
36600 Schoolcraft Rd.,
Livonia, Michigan, USA
E-mail: Polla@madonna.edu
*Corresponding author

Joseph Toth

R.L. Polk & Co.,
26955 Northwestern Highway,
Southfield, MI 48033, USA
E-mail: jtoth@mymadonna.edu

Abstract: The constantly changing world of technology is the world's largest and fastest growing manufacturing industry. The vast growth and rapid product obsolescence has brought about the serious problem of e-waste, which is now the fastest growing form of waste in the industrialised world. E-waste encompasses a broad and growing category of electronic devices ranging from large household appliances such as refrigerators, microwave ovens and air conditioners to consumer electronics such as cellular phones, televisions, personal stereos and computers. Electronic equipment contains a variety of toxic ingredients, including hazardous heavy metals that pollute the environment and are very dangerous to human health. This paper discusses some of the principles that are being employed to alleviate the environmental impact of e-waste such as extended producer responsibility, design for environment (DfE), consumer driven solutions. This article also discusses educational strategies that can be employed to educate global audiences.

Keywords: electronic waste; e-waste; e-waste education; sustainable development; e-waste strategy.

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Biographical notes: Phillip Olla is the endowed Phillips Chair of Management and Professor of MIS at the School of Business at Madonna University in Michigan USA. His research interests include educational technologies, mobile telecommunication and health informatics. In addition to university level teaching, he is also a Chartered Engineer and has over ten years experience as an independent Consultant. He has a PhD in Mobile Telecommunications from Brunel University in the UK, an accredited press member of the British Association of Journalism, Chartered IT Professional with the British Computing Society and a member of the IEEE society.

Joseph Toth is a Marketing Solution Consultant for R.L. Polk & Co. in Southfield, Michigan. He is responsible for providing pre-sales technical support, product knowledge and product demonstration to current and potential customers. In his 25 years with Polk, he has worked in a variety of sales roles, including Account Service Representative, Account Executive and Account Director.

1 Introduction

The manufacturing of electrical and electronic equipment (EEE) is one of the fastest growing global industries. This rapid expansion is resulting in an increase of waste electric and electronic equipment (WEEE) which is also referred to as electronic waste (e-waste). The average lifespan of electric and electronic equipment is becoming shorter, while the amount of related waste is increasing (Karagiannidis et al., 2005; Feszty et al., 2003). E-waste has become one of the fastest growing areas of the international waste stream and is increasing at a much higher rate than all other such streams (Herat, 2007). The information communication technology (ICT) revolution, global economic progress, coupled with urbanisation and insidious appetite for consumer electronics such as personal computers (PC), cell phones and home electronics has increased both the consumption of EEE and the production e-waste. The main problem with e-waste generated from PCs is the fact that computers are manufactured from over 1,000 different materials (Herat, 2007). Some of these materials are toxic and not only cause environmental pollution but have been linked to human health problems (Chan et al., 2007). There are new practices being adopted globally that will lead to the sustainable management of e-waste such as: design for environment (Herrmann et al., 2002), innovative product design (Arnold, 2004), extended producer responsibility (Hume et al., 2002), standards and labelling, and recycling and remanufacturing (Fickes, 2004). However one of the most important practices to effectively deal with the e-waste stream is to educate people (Babu et al., 2007).

To tackle the future environmental problems that will eventually occur from improper management of e-waste, many developed countries and organisations have drafted legislation to address the reuse and recycling material recovered from EEE to reduce the amount of toxic materials disposed in landfills. Recycling of e-waste is important, because it allows the recovery of valuable material and reduces the amount of waste requiring disposal. One factor that should be considered with e-waste is the potential loss of resource from electrical and e-waste (King et al., 2006) in Europe alone an estimated 2.4 million tons of ferrous metals, 1.2 million tons of plastics and 0.65 million tons of copper was considered lost over a decade ago, this figure will have increased drastically based on the growth in consumer electronic over the last decade (AEA Technology, 1997).

There are numerous initiatives underway in the USA and European Union (EU) to tackle the growing e-waste problem (Huisman and Magalini, 2007). However, e-waste is not a problem unique to developed nations (Huisman and Magalini, 2007). It is now undeniable that developing countries own a substantial share of EEE. It is estimated by Greenpeace that out of an estimated 20–50 million tons of e-waste discarded globally each year, Asian countries are responsible for an estimated 12 million tons. This figure is likely to increase substantially over the next decade due to the economic growth of China and India, who will have 178 million and 80 million new computers, respectively, out of the global total of an estimated 716 million new computer users by 2010 (Greenpeace, 2008).

Another EEE device that is experiencing an increase adoption in developing countries is the cell phone. Molly Sheeham (2003) highlights the fact that Uganda became the first African nation to have more mobile than fixed-line customers in 1999; a decade later reveals that over 30 other African nations have followed this trend. The task of creating a sustainable future must be shared between both developing and developed nations. Currently the main discussion points in the media surrounding e-waste and role of developing nation is focused on fact that e-waste is often sent for recycling and refurbishing in developing countries (Osibanjo and Nnorom, 2007) due to the cheap labour, it is estimated that 50–80% of the e-waste collected for recycling in the US is exported to countries such as China, India, Nigeria and Pakistan. There is no denying the problems created by exporting e-waste, but to truly address this problem both developing and developed countries must implement comprehensive education strategies that allow local population to understand the impact of e-waste on environmental population from their unique point of view. It is important to consider all countries as equal participants in the problem as well as the solution.

The aim of this paper is to provide an overview of the various practices that are evolving around the world to tackle the e-waste problem and to discuss educational strategies that can be implemented at various levels in society to enlighten people on the problems of e-waste. The paper is structured as follows: The first section provides an overview of what constitutes e-waste and discusses the health implications. This is followed by a discussion on some of the innovative concepts that are being implemented to tackle the problem such as designing for the environment, consumer awareness, along with innovative product design. Prior to the conclusion, a discussion on educational strategies is provided such as whole systems design, sustainable engineering, green IT and multi discipline e-waste introductory courses.

2 E-waste overview

The vast growth in EEE and rapid product obsolescence has brought about the serious problem of e-waste, which is now the fastest growing form of waste in the industrialised world (Grossman, 2006). There is no generally accepted definition of e-waste and there is not a consistent list of which electronic products constitute e-waste. Previous research on e-waste has focused on items such as cell phones, computers, monitors and consumer electronics (McCullar et al., 2004), while other researchers such as Puckett et al. (2002) and Basel Action Network (BAN) also include large household equipment as e-waste. A general definition of e-waste is 'e-waste encompasses a broad and growing range of electronic devices ranging from large household appliances such as refrigerators, air conditioners, mobile phones, personal stereos and consumer electronics to computers' [Puckett et al., (2002) p.5] The most specific definition was proposed by the EU, 'equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields... and designed for use with a voltage rating not exceeding 1 000 Volt for alternating current and 1 500 Volt for direct current' (European Union, 2003).

Many developing countries have taken on the business of ‘recycling’ e-waste imported from developed countries such as Canada and the USA. Workers strip off re-usable components and incinerate what’s left over. The result is a metal stream that is sold at a price based on the composition of the metals. The cost of this process is much less in developing countries because the laws to regulate recycling are more lax if they exist at all. The process of disassembling, smelting, cooling and recycling electronics is done carelessly and in an environmentally unfriendly manner (Dillon, 1999). This low cost to export e-waste is very appealing to countries such as the USA and Canada. Exporting allows developed countries to keep their landfills toxic-waste free which enables countries to meet the national standards of ‘recycling e-waste’ at a considerably lower cost than if it were done locally (Repa, 2005).

It seems clear that developing components that are environmentally friendly is not only the ethical position to take in addressing the problem of e-waste but also, in the long run, the most cost effective. Companies would benefit from government grants for research and development along with tax break incentives for developing new environmentally friendly components, this would help companies realise monetary gains from moving forward in this direction (Jacobsohn, 2003).

The sacrifices being made from the disposal and recycling of e-waste are high. Many articles, blogs and environmentalists websites report on recycling centres located mostly in underdeveloped Asian countries; describe thousands of children, unmasked and unprotected, dipping components in acid baths to remove the metals or incinerating toxic materials, breathing the fumes without any form of protection. Populations of people are living among thousands of piles of electronic scrap that when broken are emitting toxic fumes (Miller, 2005). Not only are these dump sites seriously polluting the environment but they are causing alarming increased rates of cancer, retardation and neurological disorders. It seems that governments are willing to sacrifice the health and safety of the environment and foreign citizens for the sake of convenient, cost effective disposal of ‘obsolete’ technology in favour of the latest innovation (O’Connell, 2007). In developing countries, when these materials are discarded into landfills the acidic conditions cause these harmful materials to leak out pass through the liners of the landfills going right into groundwater. These materials can also harm the environment by damaging the air and the soil. Dangerous materials such as Lead, cadmium and mercury are all found within e-waste. Lead is found in the glass of computer monitors and in printed circuit boards. If exposed to lead this could lead to damage to the central nervous system and kidneys. In addition effects on the endocrine system have been observed, leading to serious negative effects on children’s brain development.

Cadmium is found in the older models of cathode ray tubes (glass panels in computer monitors) and also in plastics. Cadmium is classified as toxic, if exposed to the human body it poses an irreversible risk to health causing kidney failure. In addition, mercury, found in thermostats, position censors, relays, switches, discharge lamps, batteries and printed wiring boards has shown to invade living organisms and travel through the human body causing negative effects on the brain. Hexavalent chromium, is found in untreated steel plates can cause strong allergic reactions to the human body. PVC is found in the cabling and computer housings and when introduce to intense heat or fire generate dioxins and furans can contribute to air pollution and respiratory ailments. Brominated flame retardants are found in printed circuit boards and plastics that cover TV and computers. If exposed to these toxic chemicals, it can cause harmful effects to the neurological system along with a higher risk of getting cancer of the lymph nodes.

3 Tackling the e-waste problem

The e-waste strategy illustrated in Figure 1 was adapted from the 2000 for England and Wales waste strategy DEFRA (2007). The four levels presented are in order of preference to ensure environmental sustainability (Defra 2007):

Level 1 Waste reduction (such as extending product durability)

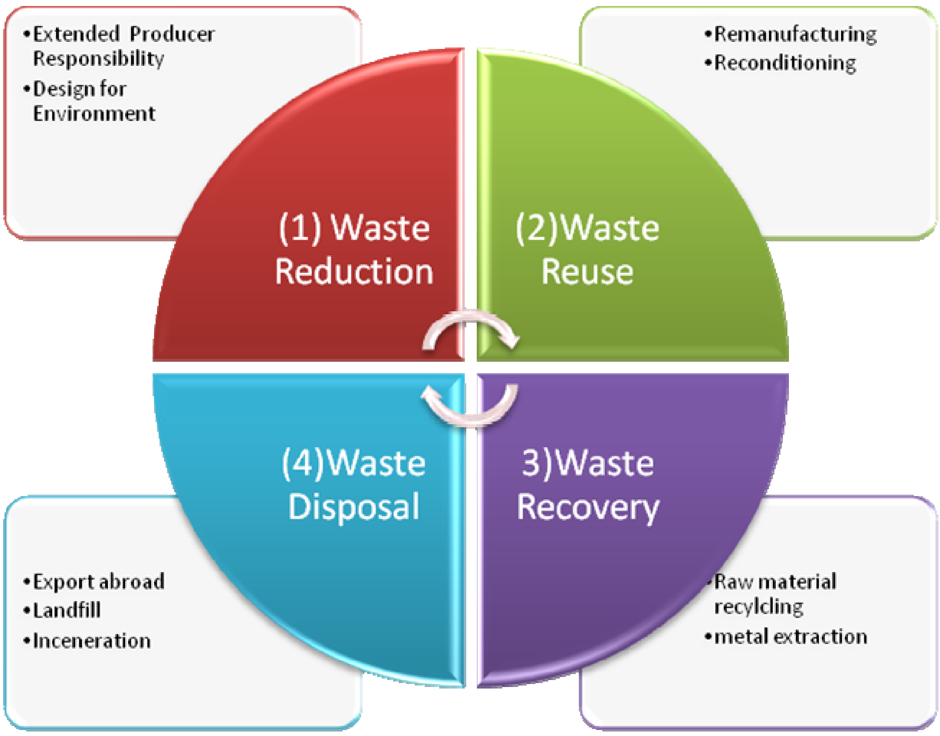
Level 2 Waste re-use (such as remanufacturing products for a second life)

Level 3 Waste recovery (such as raw material recycling)

Level 4 Waste landfill (as the last resort).

The sections below will discuss some of these concepts in more detail.

Figure 1 E-waste disposal strategy (see online version for colours)



4 Extended producer responsibility

Extended producer responsibility (EPR) is seen as the rational expansion of the polluter pays principle. This stems from the argument that the potential impact on the environmental and society are actually determined at the design phase; where key technology and material choices are made (Gertsakis et al., 2000). EPR is defined as the principle that manufacturer and importers of products should bear a significant degree of responsibility for the environmental impacts of their products throughout the product life-cycle, including impacts from the selection of materials, the production process and from the use and disposal of the products at the end of life-cycle' (OECD, 2001). This principle is likely to be implemented to satisfy the WEEE directive on waste EEE. Since August 2004, all EU OEMs (original equipment manufacturers) along with any company that imports into the EU are legally bound to take significant responsibility for the treatment and disposal of post-consumer products (EU, 2003). The objectives of the WEEE Directive include: Reducing the waste arising from end-of-life EEE; Improving and maximising recycling, re-use and other forms of recovery of wastes from end-of-life EEE and minimising the impact on the environment from their treatment and disposal.

5 Consumer driven solutions

If consumers are properly educated to be aware of the consequences of e-waste, they are likely to not only participate in appropriate initiatives but also spread the word about the dangers of e-waste while promoting alternatives solutions to their disposal. An example of a consumer driven solution is concept of free cycle. Free cycle is a US based initiative that works via the use of internet based technologies. Members use features of Yahoo groups such as blogs, e-mails and distribution lists to post details of unwanted items, and other members can act in response to the offers. The company suggests that a conservative estimate of one pound per item exchanged through the group, thereby saving 40 tons per day from landfills (Angel, 2005).

Another aspect to the consumer driven approach is 'responsible purchasing'. This stems from the notion that if consumers are aware of the environmental impact of their purchases, they will be inclined to choose between manufactures for the most environmentally friendly products. Greenpeace has been publishing a 'guide to greener electronics' since 2006. This guide available online at Greenpeace.com (http://www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up), ranks EEE manufacturers of personal computers, mobile phones, TV's and games consoles according to their policies on toxic chemicals, recycling and climate change. Consumers know have the option to make purchases based on how green a manufacture is, this concept would also benefit from expansion of the program to provide individual device ratings.

6 Innovative EEE designs

In the future engineers and designers of EEE will have to consider e-waste when developing new products, creating mechanical and electrical design interfaces will become more challenging considering regulations from the EU legislation on WEEE and Restriction on Hazardous Materials (ROHS) directives. The fundamental engineering challenge will need to addresses three important themes (Arnold, 2004): The systematically design new electronic products with a high degree of certainty that they will function properly; new product designs must be compliant with new EU directives involving environmental protection and recycling; and all designs must meet stringent US and international electromagnetic compliance requirements.

7 Recycling

Recycling is a series of activities by which discarded materials are collected, sorted, processed, and used in the production of new products (NRC, 1999). A quick review of some of the PC manufactures recycle policies shows that there is no uniform approach by companies and the recycling policies vary between counties and states with countries. Many companies are now offering recycling of old product upon purchase of a new computer. Some companies such as Hewlett-Packard (HP) at first glance seem to take recycling seriously. HP has a recycling facility in Roseville, California that recycles computers. The computer is fed into a machine that separate the steel, aluminium, precious metals and plastic for reuse. Before being fed into this machine goggled workers remove hazardous components such as batteries and circuit boards. However HP does not offer a totally free take back program; rather, they take back some items and often charge a fee for most other items. Dell and Sony are currently offering a free take back program for no charge but they are currently the only company doing so. Apple, Asus and Toshiba offer programs free to some users and for some products while Gateway and Lenovo offer programs that require the consumer to pay.

8 Public awareness campaign

Public awareness of the e-waste problem is only a start; the public has to be willing to support the companies that help to properly dispose of the e-waste even if the cost of their products is slightly higher. Consumers hold the power but need to be educated with the facts. The fact is recycling starts with the individual. With a little effort and an internet connection the average individual could learn where to recycle their electronic products. Groups such as Electronics Take back Coalition, (www.electronicstakeback.com) lobby for manufacturer responsibility laws and are currently in only nine US states and Computer Recycling for Education, (http://www.ecycle-it.com/ewaste.htm) is an organisation that truly brings the problem out in the open by educating the consumer on the hazards of e-waste along with how to recycle. Awareness of a problem is the first step to a solution to e-waste.

9 Design for the environment (DfE)

An important concept that has the potential to tackle the e-waste predicament is the Design for Environment (DfE) concept (Mead et al., 1999). The Design for the Environment (DfE) Program is a global initiative that is overseen by either government or non profit organisations within a country. DfE organisations typically work in partnership with a variety of stakeholders to reduce risk to people and the environment by preventing pollution. The remit of a DfE program can be broad covering chemical risk reduction, energy efficiency to facilitate positive and sustainable changes (http://www.epa.gov/dfe/index.htm). DfE characteristically encourages green chemistry, manufacturing of consumer products such as detergents and paints along with the producing safer electronics. The Office of Pollution Prevention and Toxic's (OPPT) DfE program at the US Environmental Protection Agency (EPA) uses the office's chemical assessment tools and expertise to inform companies of substitutions to safer chemistries.

DfE programs are important because manufacturers are placing greater emphasis on the recyclability of materials used in consumer electronics such as PCs along with investigating the impact of the physical design on the recyclability of the equipment. There is a new trend of reducing the amount of different plastics in PC units to make it easier to recycle along with reviewing the type of plastic used to guarantee that there is a market for the recycled resin (Hargroves et al., 2007). Sheeham (2003) suggested that is if manufacturers were to design EEE such as computers and cell phones for easy disassembly and recycling, it would make the breakdown easier irrespective of the recycling location (Sheeham, 2003).

The US EPA safe electronic program assists industry to focus on products and processes that reduce solders' environmental impacts, including releases of toxic chemicals and reductions of potential risks. With annual worldwide tin/lead solder use at about 180 million pounds, the transition to lead-free solders presents a significant opportunity for risk reduction. This program will help the electronics industry comply with the EU Directive to phase out lead in electronics. The use of these concepts in the EEE manufacturing, information technology and communications industries continues to grow significantly [RMIT & Product Ecology, (2004) p.34], which leads to progress in design for recyclability.

10 Strategies for educating consumers on e-waste

To educate the consumer sector on global e-waste, countries need to take an integrated approach that is unlike the traditional straight-line educating techniques in use today. Educational messaging needs to be supported by multiple channels and needs to come at various stages over time to address various diverse audiences.

The straight-line process focuses on each educational step in sequence and traditionally is not flexible enough to address situations at different stages (e.g., youth years, family life and mature years). In addition, the process is tailored to communicate the same messages to all recipients (e.g., government, manufacturers, businesses and public) and those recipients are tasked to filter through that information to educate them selves. If the straight-line process was created to address all sectors, the complexity and sophistication would be so great that it would be very difficult to manage and deliver educating messages.

The integrated educational process is a networking process that uses the intelligence, insight and knowledge presented in the research to drive educational curriculum. It will be this curriculum that will deliver the right message to the right audiences at the right time. Since the messaging is targeted to specific audiences (e.g., government, manufacturers, businesses and public); the right criterion will have a greater impact to address current state and influence future actions within the global environment.

Reaching targeted audiences for educational purposes is sometimes a difficult task; however, Figure 2 illustrates how the strategic approach simplifies the process by creating awareness at the time the electronic buying experience starts and during the ownership experience by then communicating from the highest levels down to re-enforce and continue the educational process. Figure 2 illustrates how the educational strategy can be approach across multiple media mediums.

Figure 2 E-waste educational strategy actors (see online version for colours)

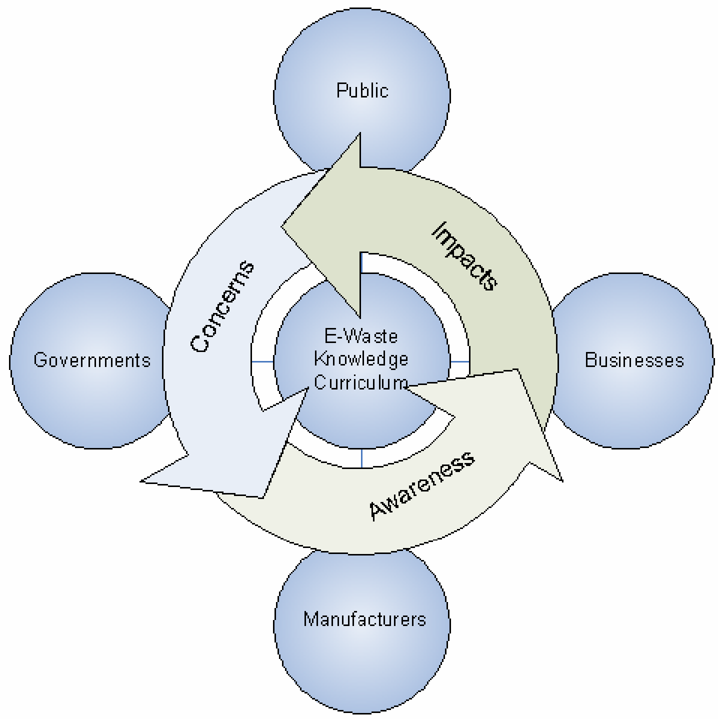
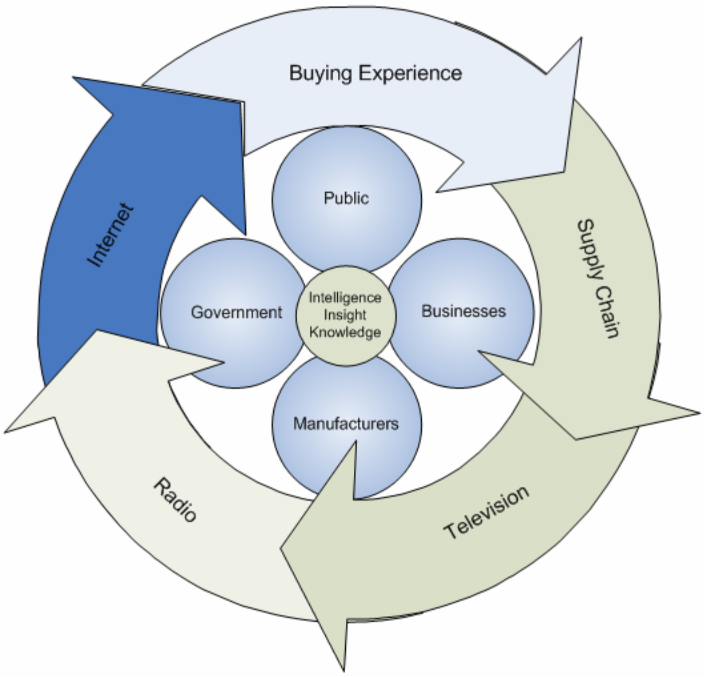


Figure 3 E-waste educational strategy through multiple mediums (see online version for colours)



10.1 E-waste education strategy 1

The first stage of the educational strategy will be to educate the buyer at the time of the electronic product purchase. Educating the buyer at the time of purchase solidifies a more meaningful message, broadens direct coverage and delivers options to educate your audiences with critical insight and information. Even companies that purchase mass volumes of electronics need to be educated as to their options and process to reduce the impacts of e-waste.

10.2 E-waste educational strategy 2

This stage of the process draws support from the businesses and manufacturers that create and sell the electronic products to the industry. It will be their responsibility to enforce process to educate and deliver valued solutions to all audiences. Implementing additional processes and solutions will automatically add cost to the development and supply chain, so the recommendation is to implement a disposal or educational retainer surcharge to offset the additional expense. Buyer's educational insight will increase when they are paying a surcharge on the products they are purchasing and they may think twice before they inappropriately throw the product away. Where this may seem as a hassle to some commercial entities or businesses, it can actually be a positive branding technique and create a better one-to-one relationship with consumers and customers.

10.3 E-waste educational strategy 3

This stage of the process will rely on traditional media channels (e.g., radio, television, newspaper) to deliver high level awareness and create solid branding to the topic. To create such advertising, budget always seems to be an issue; however, the strategy will look to the media companies to give back to the global environment. This strategy will also utilise current non-profit organisations and forums to continue their efforts and support the educating actions.

10.4 E-waste educational strategy 4

This stage labels the internet as the centralised information enterprise to facilitate the global mission and vision related to educating the audiences. Since the internet is the only solution that truly has a global reach for diversified intelligence, it is the best central headquarters for core educating information. All educational media channels will direct and push focus to the internet to retrieve consistent standardised information. The biggest obstacle to this strategy is to determine who is going to manage a consistent source of information that all countries can utilise.

10.5 E-waste educational strategy 5

This stage is the last high level stage of the process; global governments will need to enforce compliancy among channels. This means that the participating governments will be under responsibilities to educate and oversee processes related to e-waste. This strategy will most likely be the component necessary for eliminating the road blocks under strategy 4.

Educating audiences is the first step in attacking the global e-waste concerns; however, it is not the stand-alone solution, it needs the acceptance and actionable solutions to support its follow through.

11 E-waste curriculum development strategies

E-waste is considered to be a significant threat to populating the environment and has been described as one of the key pollution issues that need to be addressed under the banner of sustainable development. Educating the population in Sustainable development activities has been a topic that has received considerable attention since the United Nations Decade of Education for Sustainable Development was launched in 2005. UNESCO has released toolkits and learning material that integrate the principles, values, and practices of sustainable development into all aspects of education and learning. It is anticipated that these educational efforts will bring about a changes in behaviour to encourage a sustainable future for both the present and future generations (UNESCO 2008).

For e-waste education to be effective it should cover a wide range of themes across multiple disciplines such as engineering, environmental sciences, Information technology, public health and media; however the engineering, design professions will play a significant role in moving society to a more sustainable future. The courses discussed below were developed by the Natural Edge Project to provide engineers and IT professionals with a core understanding of sustainability issues and opportunities as they relate to their practice (Hargroves, et al., 2007). Due to the proliferation of e-waste the Natural Edge Project supported by Griffith University in Australia and Dell, HP, UNESCO and a variety of non-profit and government organisations has developed online courses introducing and discussing the challenges of e-waste. The benefits of these courses is that they can be adapted to engage with a variety of influential age brackets including high school youths and undergraduate university students. More advance programs are also available for graduate classes and professional development for working professional. These programs presented in Table 1 are intended to offer teachers, lecturers, trainers and self learners with a collection of comprehensive research material that has been peer reviewed to speed up the use of core sustainability concepts and activities across multiple disciplines (Stasinopoulos et al., 2007).

12 Sustainable engineering: using whole system design concept

Whole System Approach (WSA) is a process through which the inter-connections between sub-systems and systems are actively considered and solutions are sought that addresses multiple problems via one and the same solutions. Teaching the concept of WSA to engineering and design students is vital to ensure cost effective reduction in the current negative environmental impacts of EEE. Engineers and designers need to know how to implement WSA concepts to ensure sustainable designs. Considering the 'end of life' process of a product at the design phase will have tremendous benefits to environmental sustainability. WSA to sustainable design can help to achieve greater eco-efficiency savings in new designs. This is because 'by the time the design for most human artefacts is completed over 80–90% of their life-cycle economic and ecological costs have already been made inevitable' (Hawken et al., 1999).

Table 1 Examples of e-waste educational courses

Educational courses			
Course	*Source*	*Level*	*Theme*
E-waste education course	http://www.naturaledgeproject.net/EWasteHome.aspx	High school University	These courses endeavour to facilitate learning to help bring about changes in perspectives and values on e-waste issues and highlight the opportunities available to make a positive difference.
Sustainability education for media	www.unesco.org/webworld/en/media-partners-education	Journalist and media professionals and educators	UNESCO in partnership with the Thompson Foundation have released a training manual and resource kit aimed at media practitioners.
Sustainable engineering/whole systems design	http://www.naturaledgeproject.net/ (curriculum and course notes)	University level (senior undergraduates)/professionals	Provides introductory, technical design teaching material to demonstrate how advances in energy, materials and water efficiency can be achieved through applying a whole system approach to sustainable design.
Sustainable IT	http://www.naturaledgeproject.net/ (curriculum and course notes)	University level (senior undergraduates)/professionals	Sustainable IT: reducing carbon footprint and materials waste in the IT environment.

13 Green IT: reducing waste in the IT environment

Green IT is a multi-component approach to establishing and sustainable operating an IT business function. Sustainable IT is becoming increasingly important in the eyes of many organisations. A recent survey of both the government and corporate sectors companies found that 80% of IT decision makers believe that implementing sustainable IT in their organisations is important and 49% cite positive reputation as one of the greatest benefits. However, 51% of IT decision makers cite cost as a barrier to implementing Sustainable IT technologies, 25% cite complexity of implementation and maintenance, and 21% cite potential disruptions to current IT systems (Stasinopoulos et al., 2007). Another important idea is the concept of product service systems: This concept is also known as sustainable services and systems or eco-efficient services. This concept encourages customers to purchase the services of some or all of their IT hardware and software components through leasing, renting, sharing or pooling while the vendor maintains the ownership, responsibility and stewardship of the products. The aim of this concept is to eliminate aged technology with minimal environmental impact allowing customers to maximise their investment on their IT systems.

14 E-waste education introduction courses

The list of modules shown in Table 2 can be introduced at the high school level or in undergraduate courses through case studies, research projects or group discussion to illustrate the challenges of e-waste in society. These modules can be developed to engage a variety of age bracket. Topics that cover e-waste education on a general level can be introduced into a variety of disciplines such as media, journalism, social sciences and general education courses. These courses will endeavour to facilitate learning to help bring about changes in perspectives and values regarding the global e-waste issues and highlight the opportunities available to make a positive difference.

Table 2 E-waste modules for possible introduction into high school or university curricula

Level 1	*Senior high school level learning*
Theme 1	Lecture 1: Techno trash – an e-waste introduction
Theme 2	Digital delights – consumers and e-products
Theme 3	Shifting design methodologies
Level 2	*First year undergraduate level learning*
Theme 1	Responsible actions – product stewardship
Theme 2	Dealing with e-waste – real challenges
Theme 3	A global movement – who is doing what and where?

15 Concluding remarks

The overall goal is to guide, educate and implement global techniques and preventative solutions that will help to translate e-waste into safe and reusable forms. It will take the voice and support of people from different countries to implement changes and to address the hard realities of what the environment will be faced with in the years to follow.

Education is one of the most important strategies to address e-waste because most people in the developing world are unaware that a problem even exists. However, when the problem is presented with guidance and insight, its importance may be realised. This knowledge along with statistics to support it can be a very valuable resource for implementing strategic plans, addressing future policies and developing laws. The topics and themes presented in this article are examples of innovative approaches to addressing the e-waste educational challenges such as incorporating whole system design concepts into engineering and implementing green IT concepts to reduce waste and infrastructure costs. From a non technology perspective, e-waste education should be incorporated into social sciences such as citizenship classes, journalism, media and general education.

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