The 21st Century Learning Environment Tools as Electronic Waste

R. Moletsane, C. Venter

***Abstract*—The proliferation of 21st-century learning environments tools has transformed education making it easier and accessible everywhere. Learners and educators of today no longer have to rely on the textbook as the ultimate source of information. They use equipment such as mobile phones, desktops and laptops to collect and find the information they need at the same time also use digital equipment such as video conferencing equipment, digital projectors and many more in their smart classrooms. These tools that support and make 21st-century learning environments a reality when they are outdated or obsolete they are toxic. Learners who have used 21st-century learning equipment have been found to have higher thinking skills relative to those who used traditional learning methods. These learning tools are here to stay. In this narrative review paper, the following databases were searched: Google Scholar, Elsevier, and grey literature. This paper reviews the impact of unwanted 21st-century learning environments equipment on the environment and human health and suggests the intervention. Electronic waste is toxic and harmful to the environment and health particularly when not managed properly. Some of the factors that contribute to poor management of electronic waste include: laxer regulation, lack of infrastructure, poverty, absence or limited awareness about electronic waste harmful effects on the environment and wellbeing. This paper concludes electronic waste awareness be part of the curriculum. Regulation regarding electronic waste be in place and enforceable.**

***Index Terms*—21st-century learning environments, electronic waste, electronic waste and regulation, environment and wellbeing**

I. Introduction

TODAY WE are living in a technology-driven world. Almost every aspect of our life centers on the use of technology. Today Information and Communication Technology [ICT] is penetrating the classroom around the world at an accelerated pace [1]. Educators are continually facing the challenge of teaching learners that are using technology that is forever evolving. According to Oosthuizen [2], the contemporary education system needs to recognize the way 21st-century learners learn and live for the system not to fail. Learners of today no longer rely on the textbooks as the ultimate source of information.

They use multiple sources and tools to collect and find information they need. Learners are also educated with the intention of them being able to demonstrate 21st century skills [2]. 21st-century learning environments need to support technology equipped learners with unrestricted access to curriculum and just-in-time assessments to enable independent and collaborative learning as teams [3]. To fill the gap between how today's learners learn it is essential to integrate technology tools in the process of learning [4]. According to Jacobsen [5], technological tools such as digital storytelling can support the 21st-century learning environments.

With reference to McGuire and Alismail [6] learners who used multimedia tools in learning have found to have higher level thinking skills relative to those who used traditional learning methods. It is inarguably clear that ICT is the backbone of 21st-century learning environments reference. Some of the specific benefits of 21st-century learning tools are the following: global awareness: allow learners to work and learn with others as teams from diverse religion, cultures, ideologies and lifestyles in an environment that embraces openness and mutual respect. Financial literacy: refers to the skills that an individual will need to make informed business decisions. Health literacy: refers to the knowledge one would need to access and use high-quality information to make informed health-related decisions. Environmental literacy: help learners with information that will allow them to protect the environment and the ecosystem from challenges such as electronic waste and to conduct business in a sustainable manner [7].

The unprecedented rate at which ICT tools are evolving has resulted to a situation where manufacturers are unable to keep to the demand of these ICT tools by the consumers [8] Educational institutions and other sectors are eager to stay current so the demand for new products is increasing [8]. The race to get current ICT tools has brought numerous challenges caused by the aging or unwanted ICT products. The problem is known as electronic waste [9]. Electronic waste (e-waste) soaring volumes characterized by short lifespan for example has led to e-waste being distinguished as one of the fastest growing categories of municipal solid waste [10]. In the following developing countries, it is predicted that a discarded number of computers will increase by 500% in the year 2020 compared with their levels recorded in 2007 [11]. Telstra [12] suggested that e-waste generated from the ICT equipment amount to 30% of total global waste. Much has been said about the benefits of 21st-century learning environments. The downside of these 21st-century tools starts at every lifetime stage ranging from manufacturing and design, use and disposal [13]. The life

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stages of electronic equipment do not exclude production phase where the total weight of fossil fuels used to manufacture a single personal computer exceeds 240 kilograms [14]. With the introduction of each 21st-century learning tool created another becomes obsolete and must be disposed [15]. When 21st-century learning tools become outdated and placed improperly, they pose environmental and health hazards [9]. According to [16] these tools should be disposed in ways that have minimal or no impact to the environment and human health. E-waste is dangerous because is not decomposable [17]. According to Mmereki, et al. [11], e-waste is challenging to work with due to its various toxic materials. It contains both hazardous substances, brominated flame retardants, other coolants with substantial potential to pollute and contaminate the environment and valuable substances—platinum, gold silver and plastics for example [16, 18].

When e-waste is buried into or onto the land the accumulation of toxic heavy metals such as lead and cadmium eventually leaches into the soil and water [19]. The contaminated water and soil affect any living organ causing a range of severe health risks [17]. Literature suggests that communities and specifically people who are directly involved with e-waste are unaware of the dangers to the environment and health caused by the e-waste [10]. The aim of this paper is to review the environmental and health dangers caused by improper management of e-waste generated by the 21st-century learning tools and suggest intervention. The article is structured as follows: In Section II the learning environment is defined followed by the definitions of e-waste in Section III. Continental details of electronic waste generated are provided in Section IV. In Section V and Section VI Electronic waste challenges in the developing and developed countries and Environmental and health impacts of 21st-century learning environments are discussed. The paper concludes in Section VII.

II. Defining Learning Environment

The term learning environment suggests a place and space—school, classroom or library. 21st-century learning environment usually takes place in physical locations like these. These physical locations are identified with computers, smartboards, local area networks, or laptops for every learner [20]. 21st-century learning tools include laptop computers, mobile phones and smartphones [7]. With the introduction of Web 2.0 technology and complex interconnected technology-driven world 21st-century learning environments need no longer to be physical [3, 20]. 21st-century learning environments can be online, virtual and remote—available anywhere and anytime [21]. Students can turn any environment into a learning environment through technology [22]. According to Huang, et al. [23] 21st century learning environment "is a learning place or activity space that can sense learning scenarios, identify the characteristics of learners, provide appropriate learning resources and convenient interactive tools, automatically record the learning process and evaluate learning outcomes in order to promote effective learning". Zhu, et al. [24] added that the 21st-century learning environment is both formal and informal—allow learners to obtain new knowledge even while engaged in leisure activities. In this paper 21st-century learning environment is any context—be virtual, online or physical— that is technology driven and that allows and accommodate different learning styles of learners for them acquire 21st-century skills and knowledge effectively.

III. Definitions of Electronic Waste

There is no universally accepted definition of e-waste [25]. Following are some of the definitions of e-waste captured from the literature. According to Balakrishnan, et al. [26] e-waste is any equipment or tool that is dependent on electric or electromagnetic fields in order to function correctly. Sinha-Khetriwal, et al. [27] defines e-waste as any electrical powered appliance that has reached its end-of-life. So, as there appears to be no standard definition of e-waste, for this study, e-waste is defined as any electric and electronic equipment that has been discarded or unwanted by the owner, regardless of working state or not, that also contains both toxic and valuable materials. The focus of this study is in category three of electronic waste labelled "IT and Telecommunications equipment". According to the European Union directives on Waste of Electrical and Electronic Equipment (WEEE), there are ten categories of electronic waste [28]. Sometimes WEEE is used interchangeably with e-waste [29].

IV. Continental Details of Electronic Waste Generated

About 44.7 million metric tonnes (Mt) of e-waste was generated global wide in 2016. By the year 2020 e-waste generated around the world is expected to grow to 52.2 Mt with an annual growth rate of 3% to 4% [30]. Surprisingly Asian countries surpassed developed countries quantities of e-waste generated in 2016. Asia generated around 18.2Mt. The reason behind Asia's rise as the primary generator of e-waste is increasing the number of affluent consumers with an ever-increasing taste to buy electronic gadgets [31]. European countries including Russia and the Americas generated 12.3Mt and 11.3Mt. In the Americas, North America was the highest generator at 7Mt followed by South America with 3Mt and Central America with 1.2Mt [32]. The downside in Africa is that in 2016 only 0.004 of e-waste generated was reported to be collected and recycled. European countries top the list regarding e-waste documented to be properly collected and recycled. In the next paragraph discussion is on some of the e-waste challenges facing all regions of the world.

V. Electronic Waste Challenges in the Developing and Developed Countries

There are three main channels in which problems of electronic waste can be divided into economic, informative and administrative difficulties. Administrative challenges encompass lack or ignorance of legislation and laws that govern the realization of proper management of electronic waste and political will from the organizations. Economic

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problems include absence or poor infrastructure and facilities to properly manage electronic waste in a manner that has minimal or no impact to the environment and the human health. Often lack of infrastructure or recycling facilities is caused by the absence of adequate capital and skilled labour. Thirdly informative challenges are to do with lack of awareness or knowledge about the negative impacts of electronic waste on the environment and human health [33]. Technology is evolving at an unprecedented pace. New products are now smaller, smarter and convenient to use [16]. The demand for these new products also grows exponentially. According to the acceleration of new equipment production and demand has led to equipment with a short lifespan and low quality and planned to obsolesce [30]. Not all e-waste is collected or documented. According to Global Electronic waste Monitor [32] it was estimated that 31.4Mt of e-waste generated globally in 2016 was untraced and not reported. This undocumented or untraceable e-waste account to 86% of total e-waste generated in 2016. Only 20% of e-waste produced in 2016 was said to be collected and properly recycled. We need statistics on e-waste in order to promote safe treatment of e-waste, reduce e-waste generation, prohibit illegal disposal, reduce carbon footprint and create jobs. Finally, e-waste statistics would enable us to measure the success of the existing e-waste legislation and laws and prepare for future improvements of legislation and economic development [34].

There are more than 190 countries in the world and only 40% of these countries collect international statistics on e-waste leaving most of the world's population with little more than anecdotal awareness of where their e-waste ends up [35]. Moreover not all world countries and populations are covered by e-waste legislation. In 2014 and 2017 about only 44% and 66% of the world's population was covered by legislation respectively [32].

A. Electronic waste challenges and the developed countries

The European countries have e-waste management systems that work well above all other nations of the world in scope and compliance [36]. Developed countries are characterised by capital, well equipped recycling facilities, skilled workers and knowledge about the negative impact e-waste has on the environment and human health [16]. Ledwaba and Sosibo [36] urged that countries such as Sweden, Belgium and Switzerland all have exceeded their minimum requirements for e-waste collection and recycling. Another developed country found in Asia and worth noting in terms of how it manages its e-waste is Japan. Japan is the first country in the world to introduce waste management strategy called extended producer responsibility [37]. This strategy aims to place the burden of electronic equipment on the manufacturers and brand owners beyond the point of sale. Producers should take responsibility for their products when they become e-waste [38]. Although things look positive towards the developed countries regarding e-waste management, in the developing world things look different. Developed countries clean their backyards at the expense of the developing nations [16]. Developed countries make shipments of large containers filled with illegal e-waste to the developing countries such as in Africa and Asia [39]. About 90% of all e-waste generated across the globe is improperly managed either by illegal trade or dumping every year and much of it ends in Africa or Asia [40]. The developed countries are partly responsible for the health and environmental issues caused by e-waste in those countries based on the following: they make shipments to parts of the world where they exactly knew challenges faced by those nations aside from specific difficulties to e-waste. One of the major reasons for companies of the developed world to divert their e-waste to the developing countries is the cost associated with formal recycling, strict legislation and laws in their countries [39]. Unavailable statistics or records on e-waste and lack of understanding the scale of the e-waste problem exacerbates illegal shipments and allow developed countries to take delight of "total massacre " caused by e-waste especially in the developing countries.

B. Developing countries and electronic waste problems

The most concerning issue of electronic waste is the rate at which electronic waste is increasing in the developing nations. The alarming volume of electronic waste in the developing world is attributed to the locally produced electronic waste and the enormous amounts of electronic waste shipped by the developed countries [41]. The United States companies are at free will to export their e-waste to the developing nations. This bad behavior is made possible by the United States as the only developed country that has not ratified the Basel Convention treaty. The Basel Convention is an international treaty that prohibits transboundary movement of toxic waste, mainly from developed countries to the developing nations [8]. If a country has not ratified this treaty, it means that is not obligated to abide by treaty rules and regulations.

According to Masara [41], developing countries need access to information and technology like other developed nations, but due to the lack of necessary capital, they cannot afford the new advanced equipment. Hence populations in these countries resort to second-hand equipment. The high demand for second-hand equipment has opened the illegal door dumping of electronic devices such as mobile phones, tablets, personal computers and laptops. According to Masara [41] it is legal to export used goods to developing countries for reuse. Unfortunately a large number of dysfunctional units are reported shipped to Africa and Asia under the pretext they are quality second-hand equipment.

The developing countries are characterized by lack of recycling facilities, capital, skilled labour and lack of knowledge about the negative impact e-waste has on the environment and human health [42]. According to Ruediger Kuehr, head of the United Nations University's Sustainable Cycles Programme what concern most are the increasing volumes of e-waste in countries that lack the infrastructure to manage e-waste in a manner that has minimal or no impact to the environment [31]. The main problem of e-waste arises when it is not adequately managed as it

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increases exposure to extremely toxic substances leading to adverse effects on the ecosystem and human health. According to Kumar, et al. [43] in India e-waste challenges includes collection, transportation, recycling facilities and escalating volumes of e-waste generation. Growing population also add the train to the current e-waste challenges. In 2013 and 2001 the population was 1, 252 billion and 1, 028 billion respectively. In 2016 India population was 1,324 billion [44]. Since 2013 to 2016 the population has grown by 70 million people. On the other hand South Africa as a developing country has its challenges. In South Africa both informal and formal sectors to manage e-waste exist. Collected e-waste mainly ends with government linked recycling facilities where processing is done. Although South African legislation on e-waste is not comprehensive relative to the developed countries, it is slowly moving into the right direction. First and foremost the Constitution of South Africa is the principal legislation that ensures that fundamental human rights of its citizens are upheld at all times. Law dedicated to the e-waste after Constitution of the land of South Africa includes: environment and Conservation Act (No.73 of 1989), Occupational Health and Safety Act (No.85 of 1993), and the Hazardous Substances Act (No.15 of 1973) [36].

In developing countries e-waste is not properly managed [42]. E-waste in these countries is primarily managed by informal sector and recycled by hard labour activities in the backyards at the expense of the workers and the environment [36]. The workers are usually without protective gear and engage in labour intensive activities using hammers and chisels to dismantle and retrieve valuable items form electronic equipment. Discarded electronic equipment market is the source of valuable metals such as gold, copper, aluminium and other metals. The market was estimated at US$65billion in 2016 worldwide [35]. E-waste problem in some developing countries is considered not a priority to other national challenges such as poverty and illiteracy. E-waste is a collective problem. Developing countries cannot fold their arms and expect the developed countries to clean their yards. That won't happen in this age and time. Keep blaming developed nations won't do any good. The developing countries have a right to raise their voices and say "No to your burden!!!"

VI. Environmental and Health Impacts of 21 st Century Learning Environments Equipment

Major problem with 21st-century learning equipment is that when they are obsolete they become e-waste [15]. There is growing concern around the world regarding e-waste because of its harmful effects on the environment and health [45]. Literature on 21st-century learning environments seems to ignore the negative impact of supporting tools on the environment and human health when they are obsolete and tend to embrace their beauty in transforming education [23, 24]. The truth of the matter is that obsolete 21st-century learning tools when not managed properly they become harmful to the environment with adverse consequences to human and animal health. The main problem is the toxicity of the materials in these gadgets. Regardless of the complexity and the increasing amount of e-waste generated around the world yearly, e-waste is poorly managed particularly in the developing countries [46]. E-waste problem is global [16]. E-waste problem is a complex issue that requires multiple solutions and involvement of everyone [47].

When electronic waste is not properly disposed of it can pollute the environment—soil, air and water. Air: burning electronic equipment cables in the open can release toxic fumes into the air such as hydrocarbons. Water or soil: the indecomposable heavy metals over time can seep into soil or water thereby poisoning life in the water or contaminate water taken by animals and people. When these heavy metals from electronic waste leach into the soil it can poison crops and destroy plants and expose humans to some irreversible health defects human [48, 49].

VII. Conclusion

The proponents of the 21st-century learning environment give little attention to the adverse effects of e-waste on ecology and wellbeing. The main problem with 21st-century learning equipment is that they contain toxic and are indecomposable. The e-waste problem in developed regions seems to follow the right direction. The regulation in these countries is strict and e-waste is adequately managed. Capital and infrastructure make it possible. On the other hand regions that are developing are characterised by poor managed e-waste. The contributing factors include absence of infrastructure and capital, limited or absent e-waste regulation, and limited to absent awareness about e-waste harmful effects on wellbeing and the ecology. Given the limited awareness and dangers inherent to e-waste, this paper suggests more education about e-waste dangers on environment and health.

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