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E-Waste Management Practices Through the Eyes of Responsible Departments at Malaysian Public Universities

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ABSTRACT

Electronic and electrical waste (E-waste) has been identified as the fastest-growing waste stream in the world. In Malaysia, forecasts indicate that it will soon reach 24.5 million units of e-waste by the year 2025. Today, higher learning institutions also contribute to the rapidly growing threat of e-waste. Besides mobile phones, the usage of Information and Communication Technology (ICT) equipment at universities keeps increasing and contributes to the increased quantity of e-waste, while the handling and disposal methods of e-waste still need to be improved. The purpose of this paper is to examine the current e-waste management system as well as to investigate the critical challenges constraining e-waste management at public universities in Malaysia. By using a qualitative approach, a number of interview sessions have been conducted with the responsible departments at six established public universities in Malaysia. It has been found that currently only e-waste generated from used electric and electronic equipment (EEE) which have been declared as university assets are being managed by the responsible departments at the six universities. All six universities are using the standard process of handling their e-waste since every single process needs to comply with the requirements of the Ministry of Finance (MOF). This remains the main constraint to flexibility or improvement of the current system. The universities are also facing some challenges, among others, lack of awareness and knowledge on how to properly handle e-waste among university citizens, no clear sustainable policy at the university, lack of facilities within the university compound to support the proper practice of e-waste disposal as well as lack of education and related training provided to the campus citizens. This paper also provides some recommendations for the improvement of e-waste management towards sustainability and offers an agenda for future research.

1. Introduction

Electronic waste (e-waste) has emerged as a critical environmental and social issue in the contemporary world, encompassing a broad spectrum of discarded electronic devices and

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components [1,2]. The term "e-waste" refers to electronic products that are no longer in use or have reached the end of their life cycle, including computers, smartphones, and other consumer electronics [3]. The significance of e-waste stems from the hazardous materials it often contains, such as lead, mercury, and other toxic substances [4]. These materials need to be recycled and disposed of safely. If not managed appropriately, they can seriously harm human health as well as the environment [5].

In recent years, there has been a rise in the global generation of e-waste, driven by rapid technological advancements, shortened product lifespans, and increased consumer demand for electronic gadgets [6]. International organizations, governments, and institutions have prioritized proper e-waste management as a critical environmental and public health issue in response to the alarming global growth in e-waste [2,7].

Academic institutions, as hubs of innovation and technology adoption, play a crucial role in addressing the challenges posed by e-waste [8]. The electronic equipment used in research, education, and administration within universities contributes significantly to the overall e-waste stream [9]. Therefore, adopting responsible e-waste management practices within academic institutions is not just a matter of environmental necessity but also aligns with their commitment to sustainability and social responsibility [10]. This paper seeks to explore the current state of e-waste management practices at Malaysian public universities, focusing on the perspectives of responsible departments involved in this process. In addition, this paper also pursues to identify challenges and opportunities for improving e-waste management in academic settings.

2. Literature Review

2.1 Overview of E-Waste Management

The increasing number of electronic devices and their related effects on the environment have made the effective management of e-waste a critical global concern (Smith, 2019). E-waste is broadly defined as discarded electronic equipment, and it includes a range of items such as computers, smartphones, and other electronic gadgets [2]. Growing e-waste volumes provide serious obstacles that call for efficient management strategies to mitigate health and environmental risks from inappropriate disposal [3].

According to the Global E-Waste Statistics Partnership [11], global e-waste will reach 74 metric tonnes by 2030. The increasing of e-waste poses numerous environmental and health challenges, as electronic products often contain hazardous materials like lead, mercury, and other toxic substances. Moreover, the improper disposal and recycling of e-waste contribute to soil and water pollution, posing risks to ecosystems and human health.

To address the growing concerns related to e-waste, various countries and international organizations have developed regulatory frameworks and standards. For instance, the European Union (EU) has implemented the Waste Electrical and Electronic Equipment (WEEE) Directive, which establishes guidelines for the proper collection, recycling, and treatment of e-waste within its member states [12].

On the international stage, the Basel Convention, a multilateral environmental agreement, aims to control the transboundary movements of hazardous wastes, including certain types of e-waste. Additionally, the International Electrotechnical Commission (IEC) [13], and the International Organization for Standardization (ISO) [14] have developed standards such as IEC 62474 and ISO 14001, respectively, to guide organizations in managing e-waste responsibly and sustainably.

These regulatory frameworks and international standards play a crucial role in promoting responsible E-Waste management practices, fostering a global approach to tackle the challenges associated with the increasing electronic waste stream.

2.2 E-Waste Management in Academic Institutions

E-waste management in academic institutions is a critical aspect of sustainable environmental practices. Studies examining e-waste management practices within academic institutions highlight the unique challenges faced by universities in handling electronic waste [5]. Academic institutions are often at the forefront of technological advancements, leading to increased e-waste generation from outdated or obsolete equipment [6]. Understanding the specificities of e-waste management in universities is crucial for developing tailored solutions that align with their distinct needs and operational dynamics. This is directly related to modern universities' aspirations to become digital learning environments [15].

Several studies have explored the challenges and opportunities associated with e-waste management in academic institutions. A study by Kitila and Woldemikael [16] assessed the impact of institutional policies on e-waste management in higher education, shedding light on the role of governance structures in influencing sustainable practices. Furthermore, the study conducted by Mor *et al.,* [17] examined the effectiveness of awareness campaigns and educational programs in promoting responsible e-waste disposal behaviours among university students and staff. Similarly, the work of Arain *et al.,* [18] investigated the e-waste generation patterns and disposal practices in universities, emphasizing the need for tailored solutions considering the unique nature of electronic waste in educational settings. Saldaña-Durán and Messina-Fernández [19], on the other hand, focused on an e-waste recycling assessment at university campus.

In Malaysia, a number of environmentally proactive universities in Malaysia have engaged in sustainable campus initiatives to increase e-waste awareness and control e-waste generation, hence, reducing possible negative environmental and human health impacts. For example, Multimedia University (MMU) has used iCycle blue bin system at the university and started collecting good electronic waste around the MMU campus. Kolej Universiti Islam Antarabangsa Selangor (KUIS) has developed KUIS community e-waste management system to encourage the involvement of KUIS residents to jointly manage e-waste while at the same time, they are able to collect points and redeem them either in the form of mentoring scores for students or KPIs for KUIS staff [20]. Sunway College, on the other hand, has its own ‘On campus e-Waste Disposal Collection Day’ for staff and students to dispose of their e-Waste items [21]. These are some of the examples of good initiatives that are supposed to encourage other universities to move forward to better handling and management of their e-waste.

These studies collectively contribute valuable insights into the current practices, and challenges faced by academic institutions regarding e-waste management and offer potential strategies for improvement.

3. Methodology

3.1 Research Design

This study adopts a qualitative research design to explore the complex nature of e-waste management practices at Malaysian public universities. Qualitative research is particularly suitable for exploring the perspectives, experiences, and behaviours of individuals within their natural context

[22]. By employing this approach, the research seeks to gain a deeper understanding of the complexities associated with e-waste management within academic institutions.

The selection of universities for this research is a critical aspect of ensuring a representative and diverse sample. Six major Malaysian public universities have been purposively selected for inclusion in this study: Universiti Utara Malaysia, Universiti Sains Malaysia, Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, Universiti Malaya, and Universiti Teknologi Malaysia. This selection is guided by the aim of capturing a comprehensive overview of e-waste management practices within the higher education landscape of Malaysia [8].

Semi-structured interviews serve as the primary data collection method in this qualitative research endeavour. Within each selected university, key departments responsible for e-waste management were identified. These departments typically include Information Technology (IT) departments, environmental and sustainability offices, and maintenance departments. Representatives from these departments, who play pivotal roles in decision-making processes or are involved directly in e-waste management and handling, were targeted for participation in semi-structured interviews. The goal is to ensure a holistic and in-depth exploration of the perspectives and practices of the entities directly involved in managing e-waste within academic institutions [10,23]. This purposive sampling strategy aims to provide a focused and insightful examination of e-waste management practices within the selected Malaysian public universities, offering valuable contributions to the understanding of sustainable practices in the higher education sector.

The collected data comprising information from in-depth interviews underwent thematic analysis, a systematic and iterative process widely employed in qualitative research [24]. The thematic analysis involves identifying, analysing, and reporting patterns or themes within the data, allowing for a nuanced exploration of key concepts and issues related to e-waste management practices [22]. Interview transcripts and relevant documents were meticulously reviewed and coded, extracting recurring themes and patterns. The analysis involved the creation of codes representing key concepts, followed by the organization of these codes into broader themes. This method ensures a structured and comprehensive exploration of the diverse perspectives and practices surrounding e-waste management within the responsible departments of Malaysian public universities [22,24].

3.2 Data Analysis

This study is specifically centred on e-waste management practices within Malaysian public universities. Six prominent public universities have been selected for comprehensive analysis: Universiti Utara Malaysia, Universiti Sains Malaysia, Universiti Putra Malaysia, Universiti Kebangsaan Malaysia, Universiti Malaya, and Universiti Teknologi Malaysia. These universities represent a diverse cross-section of academic institutions in Malaysia, allowing for insights into the variations and unities in e-waste management practices across the higher education sector [25].

The participants of the interviews were purposely selected, who are directly involved in e-waste management and handling at their universities. Their point of view and information related to university e-waste management could assist the research team in obtaining a deeper understanding of the current e-waste management system at public universities in Malaysia. The list of respondents is shown in Table 1.

Table 1
Profile of Interviewed Participants

Institution	Position	Department
UUM	1) Administrative Assistant	1) IT Department (UUMIT)
	2) Administrative Assistant	2) Dept. of Development and Maintenance (JPP)
USM	Director	Dept. of Development and Asset Management (JPPA)
UKM	Director	Dept. of Development and Infrastructure (JPP)
UPM	Head of Operation and Service Section	Occupational Safety and Health Management Office (PPKKP)
UM	Evaluation Officer	Dept. of Development and Estate Maintenance (JPPHB)
UTM	Deputy Director	UTM Campus Sustainability (UTMCS)

A total of 7 interview sessions were conducted within 6 months, the interview records were then transcribed and examined carefully to find out the categories or main themes. From the analysis, two main themes were identified:

i. challenges
ii. drivers

Each main theme was divided into two sub-themes:

i. internal factors
ii. external factors

The grouping was visually created using hierarchical node trees, as illustrated in Figure 1 so that the organization and relationship of themes were clearly seen.

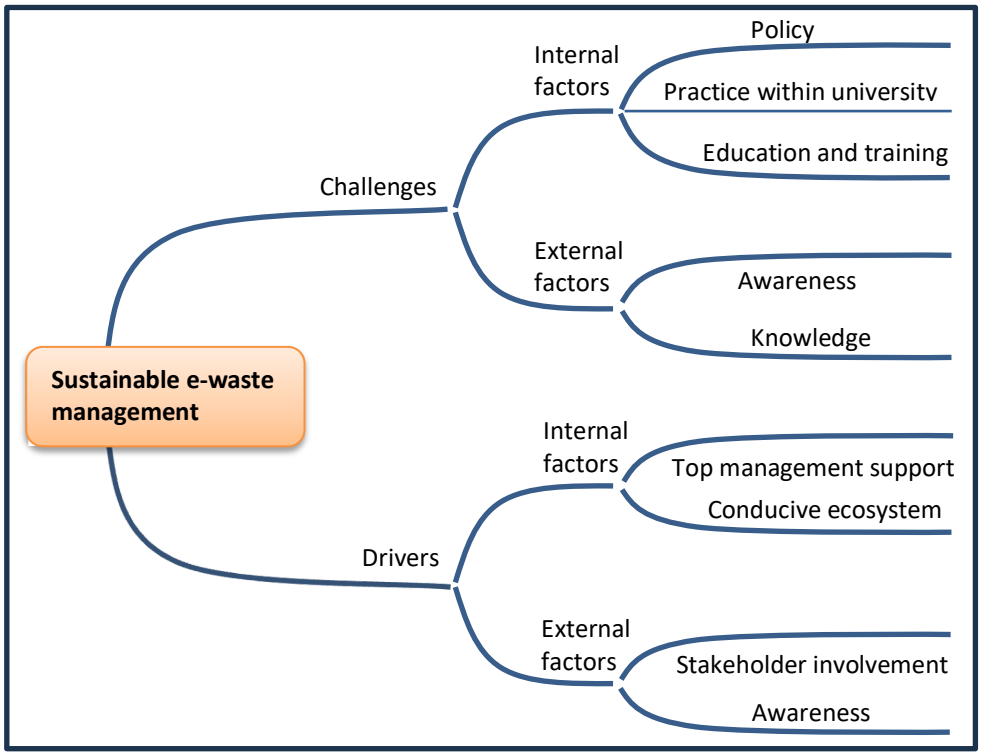

Fig. 1. Emergent themes

Based on the emergent themes, sustainable e-waste management faces challenges rooted in both internal and external factors. Internally, the formulation of robust policies, consistent practices, and effective education and training programs are vital. Externally, the level of awareness and knowledge among the broader community influences the success of e-waste management initiatives. Addressing these challenges comprehensively is essential for fostering a sustainable approach to e-waste management.

On the other hand, the drivers for sustainable e-waste management are diverse, with internal factors such as top management support and a conducive ecosystem complemented by external factors like stakeholder involvement and awareness. A balanced integration of these drivers ensures a comprehensive and effective approach to managing electronic waste responsibly.

4. Findings

4.1 Current State of E-Waste Management at Malaysian Public Universities

In general, the e-waste management system in public universities in Malaysia is subjected to the Standard Operating Procedures of the Ministry of Finance (MoF). Currently, only used electric and electronic equipment (EEE) categorized under the university assets are being managed from the collection until it is handed over to the assigned contractor for further process, every single process needs to comply with MOF's requirements. This, to some extent, remains the main constraint to flexibility or improvement of the current system.

The current e-waste management system, basically, started with the collection process of used EEE or e-waste from different departments within the universities. Before the e-waste is sent to the repair centre, a team of trained technicians conducts a thorough inspection of the used EEE. Their expertise enables them to assess the condition of each electronic device. This step is crucial in determining the best course of action for each piece of e-waste.

The e-waste repair centre, either managed by the Department of Development and Maintenance or the Information Technology Unit of the universities, employs skilled technicians who specialize in diagnosing and repairing various electronic devices. The technicians prioritize repairing university assets, ensuring that these valuable resources are utilized to their full potential before considering other electronic equipment. Then, repairable equipment undergoes a systematic refurbishment process, during which damaged or non-functional components are replaced with new ones and, therefore could be reused by anyone in the university or be donated to outside organizations. If university assets or other electronic equipment are beyond repair or deemed obsolete, they are opened for bid by qualified outside contractors. Basically, universities invite qualified outside contractors, recycling companies, and refurbishment centres to submit bids for unrepaired electronic devices, and the bidding process is announced publicly prior to that. Finally, the highest bidder will be selected, which further requires the contractor to arrange the transfer of unrepaired electronic devices to their facility for further process of disposal.

Figure 2 illustrates the flow of the current e-waste management system at public universities in Malaysia. The flow was derived from the interview outputs with all the participants from the six universities. As the asset management procedures are subjected to the MoF's requirements, the flow remains the same for all government agencies including public universities in Malaysia.

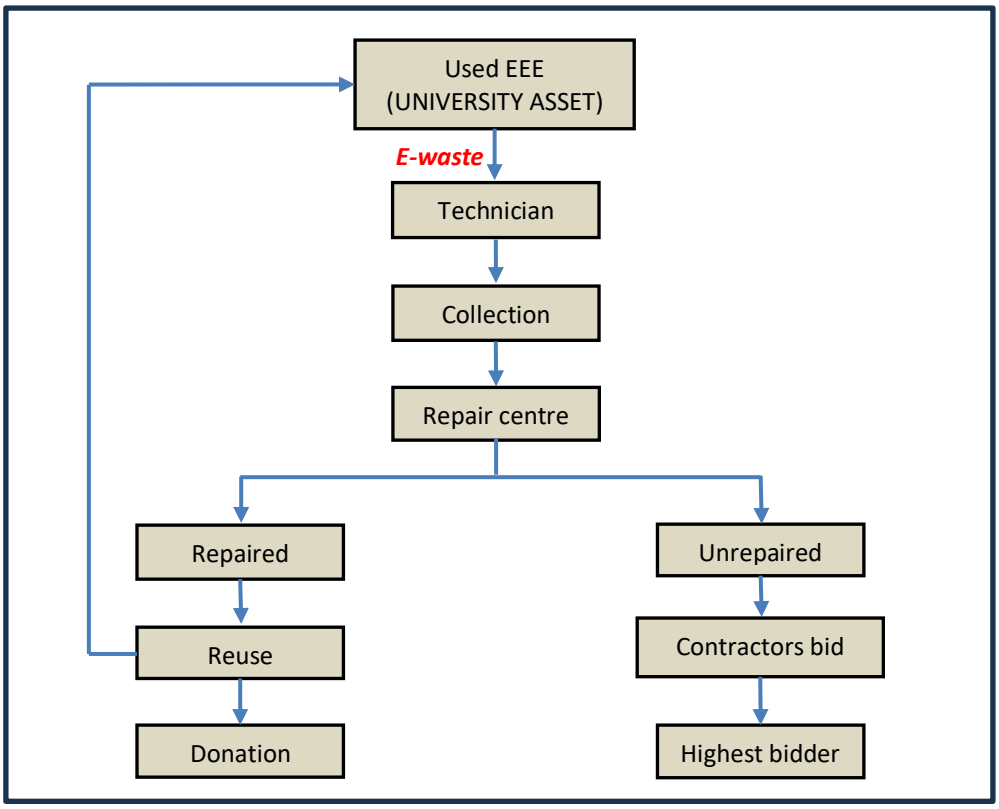

Fig. 2. The flow of the current e-waste management system at public universities in Malaysia

4.2 Common Challenges Faced by Responsible Departments

Responsible departments within Malaysian public universities encounter several common challenges in managing e-waste. Limited financial resources pose a significant barrier to implementing comprehensive e-waste disposal and recycling initiatives [25]. The dynamic nature of technology, characterized by rapid obsolescence, worsens the challenge, requiring effective strategies to keep pace with the changing landscape of electronic devices [5]. Inadequate infrastructure for e-waste disposal, coupled with a lack of standardized procedures, further compounds the difficulties faced by responsible departments in ensuring the responsible disposal of electronic equipment [10]. Addressing these challenges requires strategic planning and collaboration among departments within the university.

4.2.1 IT departments

In the context of e-waste management, IT departments within Malaysian public universities play a pivotal role in arranging disposal and recycling initiatives. These departments are often at the forefront of managing end-of-life electronic equipment, ensuring their proper disposal, and minimizing environmental impact. Initiatives may include establishing collection points for obsolete devices, organizing e-waste awareness campaigns, and partnering with certified recycling facilities [5,7]. These efforts reflect a commitment to sustainable practices and responsible e-waste management within academic institutions.

Beyond disposal and recycling, IT departments contribute to sustainable e-waste management through the integration of environmentally conscious practices in the procurement of electronic equipment. This involves adopting criteria such as energy efficiency, recyclability, and adherence to

environmental standards when selecting IT assets [10,23]. The integration of sustainability considerations in IT procurement not only influences the environmental impact of the devices during their lifecycle but also aligns with broader institutional goals of promoting responsible consumption and environmental protection.

4.2.2 Environmental and sustainability offices

Environmental and Sustainability Offices within Malaysian public universities are central to formulating and implementing policies and programs related to e-waste management. These offices often serve as the institutional drivers for integrating sustainable practices into various facets of university operations [25]. Policies may outline guidelines for the proper disposal and recycling of electronic equipment, ensuring compliance with environmental regulations and standards [24]. Programs could include educational initiatives, awareness campaigns, and training sessions aimed at fostering a culture of responsible e-waste management within the university community [5].

Collaboration is integral to the success of e-waste management initiatives, and Environmental and Sustainability Offices actively engage with other university departments and external partners to enhance the effectiveness of their programs. Collaborations with IT departments ensure the seamless integration of e-waste disposal strategies into existing workflows, while partnerships with external recycling entities facilitate the proper recycling and disposal of electronic devices [23]. Such collaborative efforts contribute to a more holistic and comprehensive approach to e-waste management, reflecting the interconnected nature of sustainability initiatives within academic institutions [10].

4.3 Opportunities for Improvement and Potential Collaborations

Despite the challenges, there exist promising opportunities for improvement and innovation in e-waste management practices. Leveraging advancements in recycling technologies offer the potential to enhance the efficiency and sustainability of e-waste disposal processes [6]. Educational initiatives and awareness campaigns can be expanded to promote responsible e-waste disposal practices among the university community, fostering a culture of sustainability [5]. Furthermore, the integration of circular economy principles into e-waste management practices opens paths for reusing and refurbishing electronic devices, contributing to resource conservation and waste reduction [1].

Collaborations and partnerships represent a key route for addressing challenges and benefits from opportunities in e-waste management. Strengthening collaboration between IT departments and Environmental and Sustainability Offices can enhance the integration of sustainability considerations into IT procurement processes [7]. Partnerships with external recycling entities and government agencies can facilitate the responsible disposal and recycling of e-waste, providing access to specialized expertise and resources [23]. Inter-departmental collaboration within universities and collaborations with industry stakeholders can foster the development of innovative solutions and best practices for sustainable e-waste management [8].

5. Recommendations

To enhance e-waste management practices within Malaysian public universities, it is crucial to implement strategic initiatives that address the identified challenges. First and foremost, universities should invest in the development of comprehensive e-waste management plans that encompass

proper disposal, recycling, and sustainable procurement practices [7]. Implementing efficient collection systems and designated e-waste disposal points across campuses can facilitate the responsible disposal of electronic devices [5]. Additionally, promoting the circular economy approach by encouraging the refurbishment and reuse of electronic devices can contribute to reducing e-waste and conserving resources [1].

The formulation and enforcement of robust e-waste management policies are essential for fostering a culture of responsibility and sustainability within Malaysian public universities. Policies should describe clear guidelines for the disposal and recycling of electronic equipment, outlining the responsibilities of various departments [24]. Integrating sustainability criteria into the university's procurement policies can further support responsible e-waste management by influencing the selection of environmentally friendly electronic devices during the procurement process (Yazan *et al.,*). Regular policy reviews and updates to align with evolving technological landscapes and environmental standards are also essential [25].

Educational initiatives play a crucial role in fostering awareness and a sense of responsibility regarding e-waste management. Universities should develop targeted awareness campaigns, workshops, and training sessions to educate the university community, including students, faculty, and staff, about the environmental impact of e-waste and the importance of responsible disposal practices [26]. Integrating sustainability and e-waste management topics into the academic curriculum can further embed these principles within the educational framework of the university [6].

6. Conclusion

This study has provided a comprehensive exploration of the current state of e-waste management at Malaysian public universities, focusing on the perspectives and practices of responsible departments. Key findings indicate a significant volume of e-waste generated within academic settings, driven by technological advancements and shortened product lifecycles. Responsible departments, particularly IT and Environmental and Sustainability Offices, have implemented various initiatives, including disposal and recycling programs and sustainable procurement practices. However, they face challenges such as limited financial resources, rapid technological obsolescence, and inadequate infrastructure.

The findings of this study have important implications for both future research and practice in e-waste management within academic institutions. Primarily, the identified challenges underscore the need for innovative solutions and collaborative efforts to address financial constraints, technological obsolescence, and infrastructure limitations. Future research should investigate deeper into the effectiveness of specific e-waste management strategies, considering the unique contextual factors within academic settings.

Practically, the recommendations provided, including the development of comprehensive e-waste management plans, robust policies, and educational initiatives, offer a roadmap for Malaysian public universities to enhance their sustainability practices. Implementation of these strategies will not only contribute to a reduction in e-waste but also align with broader goals of environmental stewardship and responsible resource management [7].

In conclusion, this study serves as a foundational exploration of e-waste management practices at Malaysian public universities. Future endeavours should build upon these findings, refining and expanding strategies to create a sustainable and environmentally responsible framework for e-waste management in academic institutions. This research contributes to the ongoing discourse on

sustainable practices within the higher education sector, emphasizing the importance of responsible e-waste management in the face of evolving technological landscapes.

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