Redefining the E-waste Management Framework at the University of Leeds: Challenges and Opportunities for Sustainability

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Keywords: Obsolescence, E-waste Awareness, Inter-Organisational Resource Utilisation, Institutional Responsibility.

Abstract

The rising gap between the amount of e-waste being produced and recycled is one of the major environmental concerns facing the world today. The UK stands second internationally in terms of the e-waste generated per capita. The dependence on electronics has increased, especially in institutions of higher learning, due to the expanding digitalisation of education (e.g., e-learning). Additionally, the sheer volume of research necessitates using cutting-edge electronics, while the frequent hardware/software upgrades result in a high rate of obsolescence. Despite being major e-waste producers, the universities typically lack the capability to ensure that their end-of-life equipment is handled sustainably. Thus, effective e-waste management at the university level is vital for achieving a circular economy. This study aims to critically evaluate the policies and practices concerning e-waste generation, handling, and disposal at the University of Leeds.

Based on a literature review, a set of open-ended questions was formulated. Next, semi-structured interviews were conducted with the University staff. The discussions attempted to gauge the level of e-waste awareness and evaluate the effectiveness of current practices. Finally, the anonymised data was qualitatively and quantitatively analysed to identify recurring experiences and opinions.

The results highlight several challenges, which include, inter alia, lack of time and capacity with the staff, diversity of electronic lab equipment across faculties and absence of a pan-University e-waste management unit. In addition, various drivers for sustainable e-waste management at the University are identified, such as better information dissemination, managing inventory of e-waste, and institutionalising responsibility for e-waste.

In conclusion, the study explores e-waste at the level of universities in an effort to bridge a significant research gap. It formulates a comprehensive framework to manage e-waste based on the best practices collated from universities across the globe, tailors it to the University's needs, and provides recommendations for e-waste monitoring.

INTRODUCTION

The global e-waste generation has skyrocketed from approximately 44.4 million metric tons (Mt) in 2014 to a staggering 53.6 Mt in 2019. This mounting surge shows no signs of abatement, with projections estimating an overwhelming 74 Mt by 2030. In stark contrast, merely about one-sixth of the total e-waste generated is formally collected and recycled worldwide. Further, the pace of growth in e-waste collection and recycling is gravely lagging, with a meagre increase from 7.5 Mt in 2014 to only 9.3 Mt in 2019. Thus, while the e-waste generated is mounting at a distressing rate of 2 Mt per annum, the e-waste formally collected and recycled is inching at a paltry rate of 0.4 Mt per annum (Forti et al., 2020). These statistics are a stark testimony to the urgent fact that the expansion of e-waste collection and recycling efforts is dramatically failing to keep pace with the burgeoning e-waste generation.

Continent-specific data indicates that in 2019, Europe produced an overwhelming 16.2 kg of e-waste per capita, higher than all other continents. Shifting the lens to individual country-level, in the UK, each inhabitant produced, on average, an alarming 23.9 kg of e-waste, marking the country as the second-highest per capita e-waste generator globally (Forti et al., 2020). These figures underscore the urgent need for bolstering sustainable e-waste management globally and, more critically, within the UK.

Article 3(1)(a) of the European Parliament's Directive 2012/19/EU defines the 'electrical and electronic equipment' (EEE) as that apparatus which depends on electric currents or electromagnetic fields to function, and the equipment used for generating, transferring and measuring such currents and fields and designed with a voltage rating of not above 1000 volts for alternating current (AC) and not above 1500 volts for direct current (DC). Further, Article 3(1)(e) of the Directive (2018) describes 'waste electrical and electronic equipment' (WEEE) as the EEE which the owner discards or intends to discard, including all sub-components of the product. The key term in this definition is 'discards'. It reflects the point in life-cycle of a EEE when it changes from being a valuable product for its owner to a useless excess without any intent of reuse. An EEE which is not 'discarded' but instead directed for reuse is not classified as e-waste (*Solving the E-waste Problem (Step) White Paper: One Global Definition of E-waste.*, 2014). The term 'sub-components' serves to encompass within the definition of WEEE even those parts or assemblies that may have been disassembled from the original EEE.

To harmonise the comparison of e-waste statistics across different nations, it is crucial to have a framework that systematically classifies, compiles, and interprets e-waste data into homogeneous categories. One such statistical classification system is provided by the EU Directive, which organises the WEEE into six broad categories as shown in *Figure 1*.

Components belonging to each of these six EU categories are becoming increasingly commonplace in any higher education institution (HEI). Despite this, universities often find themselves inadequately equipped to sustainably manage their end-of-life equipment. Thus, effective e-waste management within HEIs is a critical steppingstone towards achieving a

circular economy. In this vein, this study thoroughly examines the policies and practices tied to e-waste production, handling, and disposal at the University of Leeds. It aims to illuminate the current e-waste management landscape at the University, analyse its strengths and weaknesses, and propose effective strategies that can usher the University towards better e-waste management. This research not only has implications for the University of Leeds but can also serve as a valuable template for other HEIs facing e-waste challenges.

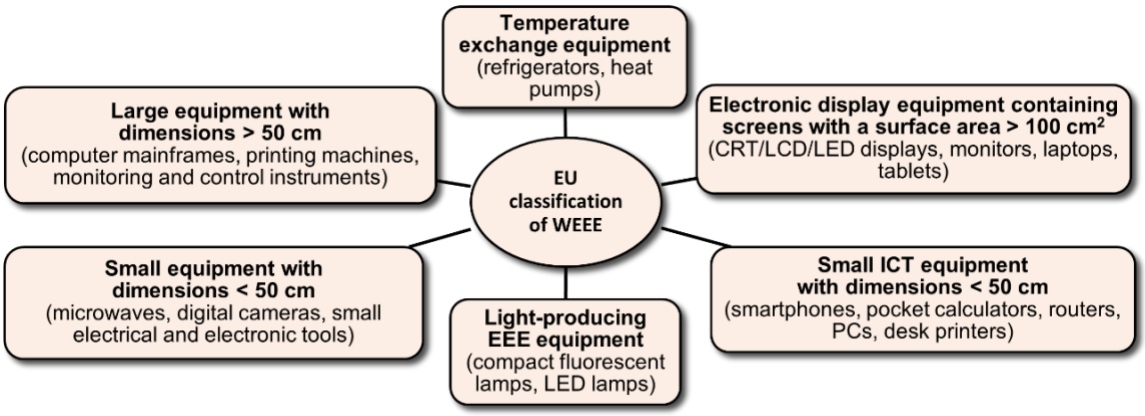

Figure 1. Classification of WEEE into six categories as per EU Directive.

LITERATURE REVIEW

1. Factors driving the surge of e-waste generation in universities

HEIs globally are emerging as significant sources of e-waste. This trend can be attributed to multiple factors. First, as HEIs transition towards digital instruction and e-learning modalities, there is a growing reliance among students and staff on devices such as laptops, tablets, and smartphones, amplifying the generation of e-waste. Dayaday and Galleto Jr. (2022) note that the COVID pandemic has significantly intensified this drift. Compounding this is the inherently short useful lifespans of e-devices – rapid technological advancements lead to their swift obsolescence. For instance, Woidasky and Cetinkaya (2021) reported that only 12% of the surveyed university students utilised their laptops for the full environmentally optimal lifespan of 7 years. In contrast, the prevalent duration of laptop use among students was significantly shorter, averaging 4.7 years in 2018.

Third, the universities often have numerous research and development (R&D) facilities which house a wide array of state-of-the-art EEE. The sheer scale of their research endeavours involves considerable consumption of electronic laboratory equipment, which eventually culminates in e-waste. Fourthly, ceaseless march of scientific progress and the ensuing surge in research techniques necessitates that universities stay competitive by frequently upgrading their R&D hardware/software, further amplifying e-waste generation. Last, the universities are sprawling institutions which periodically revamp their infrastructure facilities by replacing old IT networks, security and lighting systems, adding yet another dimension to the e-waste challenge. In this regard, some HEIs have adopted a leasing model to procure their ICT

equipment, ensuring that the leasing company assumes responsibility for the e-waste at the end of the equipment's lifecycle (Agamuthu et al., 2015). However, this has merely transferred the e-waste management onus from the university to the provider rather than limiting the e-waste generation. For these reasons, universities need to acknowledge and embrace their institutional responsibility in addressing and mitigating the e-waste challenge.

2. Global Best Practices: Insights from Case Studies

To better understand e-waste management in HEIs, this sub-section investigates the e-waste management practices adopted by universities across different continents, offering a panorama of diverse strategies and contextual nuances. This analysis underscores the distinct challenges encountered by each institution, their inventive resolutions, and the resultant outcomes. The aim is to distil actionable insights and assemble a repository of the most effective e-waste management strategies pertinent to university environments. This will ultimately help conceptualise a comprehensive e-waste management blueprint that, while especially tailored for the University of Leeds, could be an archetype for other HEIs grappling with similar e-waste challenges.

2.1 Universidad Autónoma de Nayarit (UAN), Mexico, North America (Saldaña and Messina, 2021): The university runs a novel initiative termed 'Recyclatron', which is not just an e-waste disposal programme but also an educational platform for students. This student-run biennial programme has exponentially amplified e-waste collection from a modest 605 kg to a staggering 19,430 kg in just four cycles. The initiative has also heightened e-waste awareness, leading to about a seven-fold increase in student participation - from 2.8% to 20% over four editions. Moreover, the university has approved participation in Recyclatron as equivalent to an elective course, thereby embedding e-waste management into the academic curricula. Such stakeholder participative approach illustrates a promising strategy for other HEIs to emulate in their e-waste framework.

2.2 University of Kansas (KU), USA, North America (2023): KU's e-waste recycling programme provides secure disposal of university e-waste, encompassing everything from desktops and mobiles to lab equipment. Managed by a central E-waste Team and departmental representatives, a standout element is its focus on data security – departments can obtain a Certificate of Destruction for recycling data-sensitive items, addressing today's data breach concerns. While many items are recycled without fees, some entail charges, subtly promoting a reduction in e-waste generation. Overall, the well-oiled machinery and commitment to data security set a benchmark in e-waste management for HEIs.

2.3 University of Bamenda, Cameroon, Africa (Ivo Fon, 2018): The study proposes multiple sustainable strategies for university e-waste management. Donating functional hardware to under-resourced institutions not only curbs e-waste but also bridges the digital divide. Strategically positioning distinct 'E-Waste Bins' throughout the campus

enhances accessibility, reducing the perceived inconvenience of disposal. A study by Arain et al. (2020) emphasises that cost and convenience are key factors shaping a university community's e-waste recycling choices. Furthermore, establishing a dedicated storage area for end-of-life ICT devices is prudent. Since some of these device components may remain operational, this storage can act as a source for spare parts, curbing needless expenditures on new acquisitions.

2.4 Griffith University (GU), Australia: Over time, GU has continually refined its e-waste strategy. In the early 2000s, end-of-service computers comprised a major e-waste fraction. Operational computers found new homes via public auctions or were redistributed to underprivileged students through the 'Student Equity Scheme'. Meanwhile, non-functional units were sold to scrap merchants. In recent years, the establishment of e-waste recycling stations within libraries has seamlessly integrated e-waste management into students' daily routines (Griffith University Library, 2021). Furthermore, GU's green-partnership with Ricoh for toner cartridge recycling – where university members simply label the used cartridge with 'please recycle' and deposit it at specific collection spots – showcases how 'producer buy-back' models can be implemented in university settings (Griffith University, 2023).

2.5 Universiti Kebangsaan Malaysia (UKM), Asia (Chibunna et al., 2012): UKM has adopted a centralised e-waste management system managed by its Asset Department. A distinct facet of their strategy is the refurbishment of salvageable computers, which are either subsequently integrated back into UKM or donated to educational establishments. Despite these measures, UKM grapples with accurately tracing its end-of-life EEE. This highlights the pressing need for a streamlined e-waste tracking mechanism to accurately evaluate any university's overall e-waste footprint.

Globally, the research literature on e-waste within HEIs is scarce. Even the literature which exists predominantly revolves around the volume and type of e-waste and the consumption and recycling behaviours of the student community. A domain which remains conspicuously overlooked is researching the organisational and functional dimensions of the university's e-waste management systems. By investigating such structures' intricacies and operations dynamics from the staff's perspective, this study aims to fill this knowledge gap. The goal is to offer a deeper understanding of the strategies and methods which universities can employ to tackle e-waste. This can pave the way for more efficient, scalable, and adaptable e-waste management frameworks, befitting the unique requirements and challenges of a particular university.

RESEARCH METHODOLOGY

This study adopts a qualitative research methodology, employing interviews as the primary data collection method, followed by a thematic content analysis approach for data interpretation. Through this rigorous qualitative approach, the study aims to gain in-depth insights and a comprehensive understanding of the subject matter.

Online semi-structured interviews were conducted via Microsoft Teams. This virtual platform is convenient and ensures precise data capture through recording and transcription. The research methodology rests on semi-structured interviews because these allow the interviewer to ask probing questions, request clarifications, and establish interconnections among different topics (Queirós et al., 2017). Though time-consuming, this approach facilitated the collection of nuanced insights and a comprehensive contextual picture of the research area (Ivo Fon, 2018; Choy, 2014). In contrast, quantitative options such as surveys and questionnaires offer quicker data collection, numerical insights, statistical analysis capabilities, and broader reach; but often lack the flexibility required for interviewees to express their perspectives in detail due to limited opportunities for follow-up questions (Ivo Fon, 2018; Choy, 2014). As such, the decision to employ a qualitative methodology was driven by the aim to gain a thorough understanding of e-waste management practices within the University context.

This study focused exclusively on analysing the perspectives of University staff tasked with e-waste management, intentionally excluding student input. The objective was to gain insights into the University's e-waste management framework, encompassing the entire lifecycle of university-owned EEE – from acquisition to end-of-life disposal. This investigation also considered any initiatives aimed at prolonging the equipment's lifespan through reuse and repair, for example. Interviewees were chosen from staff members across relevant faculties within the University, based on their presumed involvement in e-waste management. Despite contacting several staff, only seven agreed to be interviewed. These staff members are primarily involved in managing a diverse range of laboratory equipment, including EEE, spanning from everyday benchtop tools to highly specialised systems.

The groundwork for the interview came from review of existing e-waste literature. The design followed the qualitative approach suggested by Queirós et al. (2017), setting the stage for engaging discussion and allowing impromptu follow-up questions. Three main topics steered the interviews: e-waste awareness among university staff, current management practices, and possible improvements. Strict protocols maintained participant anonymity, with informed consent and interview data stored securely in a password-protected OneDrive folder. Thematic analysis was employed to analyse the data, involving the categorisation of information into distinct themes, identification of recurring patterns and opinions, and comparison and contrast of experiences. The prevalent feedback was quantified to assess the magnitude of challenges presented. This approach provided a comprehensive, insightful picture of e-waste management at the University.

RESULTS

1. Information deficit on e-waste

During the semi-structured interviews, all seven interviewees displayed limited knowledge regarding e-waste management within their respective faculties. A majority, i.e., five respondents, showed either marginal or no awareness of the WEEE Procedure (2020) from the University's Sustainability Service. Further, while two respondents were uncertain about how to source details on e-waste disposal, five underlined that the University's current mechanism of disseminating e-waste information through a newsletter was ineffective.

Further intensifying this knowledge deficit, the majority of interviewees voiced concerns about an apparent lack of information on the 'type' and 'availability' of equipment already at their disposal across university faculties. This issue has led to duplicated purchases, ultimately leading to inefficiencies in resource allocation.

2. Impact of repair options on e-waste

Certain faculties, like the Faculty of Engineering and Physical Sciences (FEPS), have an effective system for EEE repair. The electrical and mechanical workshops within FEPS are equipped with technicians, tools, and materials. Such in-house workshop services incentivise staff to opt for repair rather than purchase new equipment, thereby curtailing e-waste. Three interviewees attested to the critical role of such workshops in reducing e-waste. Moreover, FEPS respondents acknowledged that, since they possess basic equipment maintenance skills, sometimes they themselves conduct routine checks and repairs, thereby prolonging equipment life and minimising e-waste. A FEPS staff even illustrated a success story wherein they rebuilt their equipment with some assistance from the workshops.

Other factors that facilitate repair and help reduce e-waste are ready availability of spares from original equipment manufacturers and a pan-University platform for sharing repair solutions. For example, two interviewees highlighted instances where the industry practice of discontinuing spares compelled them to purchase new equipment instead of repairs, thereby adding to e-waste. Moreover, two interviewees shed light on how, during the COVID pandemic, a Microsoft Teams channel facilitated communication between technicians, serving as a platform for seeking repair-tips on malfunctioning equipment.

3. Effect of equipment sharing on e-waste

Five interviewees underscored the lack of cross-faculty exchange of EEE within the University. This leads to duplicative equipment acquisitions and hence higher e-waste, as each faculty independently procures analogous equipment. Moreover, four participants raised concerns that schools external to FEPS encounter difficulties in leveraging the critical repair services provided by FEPS technicians and workshops. Three respondents explained the primary reason behind these limitations as the absence of a system for charging equipment/service transactions between faculties. For example, if faculty A requests a repair service from faculty

B, there is no cross-charging mechanism whereby faculty B can claim the cost of repair from faculty A. The secondary reason is the lack of a centralised EEE-inventory management and tracking mechanism. One interviewee emphasised that upon the conclusion of a research project, the equipment purchased specifically for that project's execution often lies unused, ultimately contributing to e-waste.

Apart from inter-faculty resource sharing, interview data reveals that a different set of factors governs the sharing of equipment between different schools of a given faculty. For instance, one interviewee opined that intra-faculty resource sharing is influenced by faculty size. Relatively smaller faculties typically demonstrate a stronger culture of resource sharing. Another interviewee highlighted the presence of a tool called 'Qreserve' which facilitates equipment sharing within schools of the Faculty of Biological Sciences (FBS). This digital platform provides staff with the capability to track the usage of equipment, facilitating efficient reservation and utilisation of resources. Contrarily, one respondent lamented that certain schools tend to function in an insular fashion, impeding intra-faculty sharing of EEE.

4. Impact of reuse on e-waste

Reuse of a faculty's end-of-life equipment may either be done by organisations outside the University or by students/faculties within the University. About half the interviewees echoed the limited opportunities for external reuse of University's equipment. This increases potential for e-waste generation. Two interviewees recounted previously active donation schemes. However, intensively used University equipment (e.g., microscopes), tends to become non-functional towards its end of life, rendering it of negligible value for further reuse. This makes the practice of donation less feasible. Regarding intra-university reuse initiatives, only two respondents were aware of an internal reuse website – WARPiT.

5. Storage as an approach to deal with e-waste

Two interviewees elucidated that equipment, once unrepairable or obsolete, is discarded to free up space (Arain et al., 2020). Further, the fate of an equipment after it develops a malfunction is traced in *Figure* . A surprising discovery was that a notable majority – five out of seven respondents, did not know nor felt the need to know, what happens to e-waste after it is handed over to the Estates department.

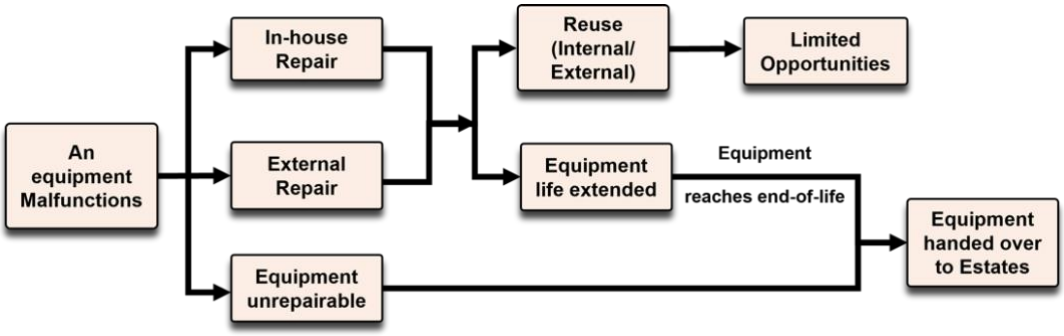

Figure 2. Fate of an EEE after it develops a malfunction.

Three interviewees mentioned having too much equipment stored up in their faculties because they are unsure how to dispose of them properly. One participant said equipment is usually disposed of only when storage capacity is exhausted. However, a minority of interviewees differed and appreciated the above workflow for preventing dysfunctional items from cluttering up and wasting valuable space.

The main findings have been quantitatively summarised below in *Figure* .

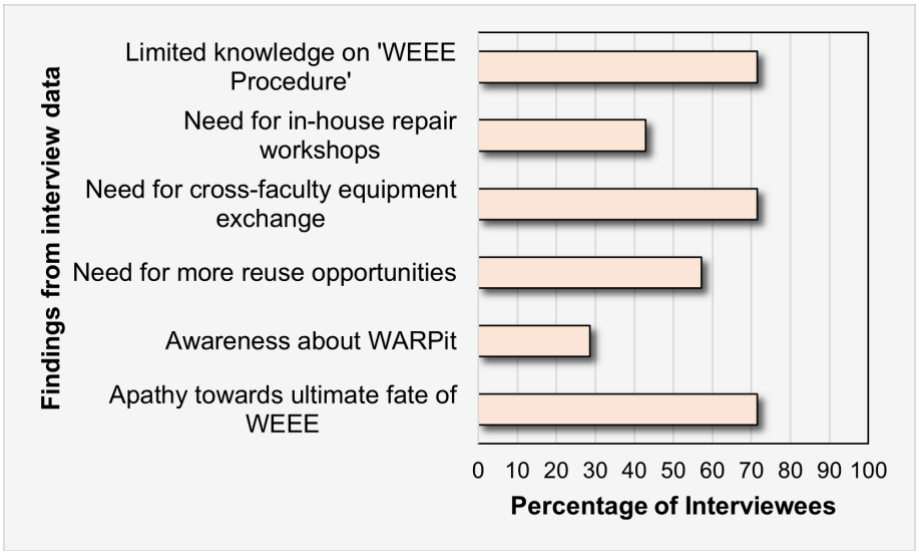

Figure 3. Findings versus the percentage of interviewees who voiced them.

DISCUSSION

1. Reasons for information deficit on e-waste

The knowledge gap on e-waste among staff can be traced back to three primary factors.

1. Omission of an explicit mention of e-waste management from their professional responsibilities renders their understanding of this critical aspect largely superficial and contingent on a need-to-know basis. The organisational hierarchy, visible in the respondents' perspectives, further perpetuates this knowledge gap. For instance, hierarchy requires lab managers/technicians to merely implement the directives from higher-ups rather than deeply understanding the gravity of the e-waste challenge.
2. Despite a general willingness to abide by the rules, overwhelming workloads lead to a scarcity of time and capacity among staff members. This in turn not only restricts them from grasping the intricacies of the University’s e-waste framework, but also engenders a noticeable reluctance to assume responsibility for compliance.
3. The difficulty in accessing information on e-waste disposal signals a deficiency of readily available user-friendly resources. The University's newsletter-based approach to disseminating e-waste information inadvertently places all the responsibility of interpreting the guidelines onto the staff members. However, encumbered by their extant responsibilities, the staff members find it challenging to extract and assimilate pertinent information, amplifying the problem of e-waste ignorance.

UAN's success stories exemplify the significance of engagement and **education** to bridge knowledge gaps. Notably, Recyclatron underscores the significance of holistic approaches, seamlessly weaving awareness into education. Their integration of e-waste management into academic curricula displays the transformative power of education. Similar strategies like awareness drives, campaigns, and workshops emerge as tools to address e-waste knowledge deficits among university staff. These initiatives are broad-reaching, impactful, and go beyond bridging information gaps, playing a pivotal role in reshaping attitudes and behaviours toward responsible e-waste management. By merging learning with active engagement, universities can bolster staff awareness and nurture a culture of conscientious e-waste management.

2. Factors inhibiting repair services at University

Several factors hinder effective services for EEE repair at the University and hence increase e-waste. First, faculties like FBS and the Faculty of Environment, which are not equipped with workshops or technically skilled staff, tend to purchase new equipment rather than repair, thereby increasing e-waste. For example, a non-FEPS interviewee described how other faculties, which lack in-house technical support, rely on external general engineers for equipment repairs. However, to offset the substantial call fees of these engineers, faculties must defer servicing until a sufficient backlog of requests accumulates. This 'wait-and-accumulate' approach causes delays and deteriorates University's academic outcomes. Therefore, in situations of urgent need, faculties may opt to purchase new equipment instead of waiting for repairs, thereby inadvertently contributing to the growing e-waste. Second, regrettably, the Microsoft Teams initiative displayed limited impact and engagement since its usage remained confined to a few staff members.

Interestingly, two participants working with cutting-edge R&D equipment asserted that although they undertake repair, they do not contribute to the e-waste stream. Their argument was that their repairs only replaced sub-components but not the overall equipment. However, this premise underscores a notable lacuna in comprehending what precisely constitutes as e-waste. As previously outlined, even when merely sub-components of a larger EEE are disassembled and replaced, they do, in fact, contribute to the WEEE.

3. Factors affecting sharing of equipment and repair services

Further, discussions highlight the lack of a pan-University platform that facilitates mutual sharing of EEE and repair services between different faculties. Such a platform requires a seamless inter-faculty mechanism for charging transactions, both in terms of personnel and material resources. In its absence, non-FEPS faculties are obliged to rely on external general engineers for services, rather than using the workshops available within FEPS. As outlined above, this often contributes to higher e-waste than utilising in-house repair services.

Regarding intra-faculty exchange of EEE, relatively smaller-sized faculties often exhibit a stronger culture of resource sharing since lower strength of staff leads to closer interpersonal relationships, ease of communication, and fosters a stronger sense of community. In cases

where schools are functioning in a compartmentalised manner, tools such as ‘Qreserve’ are helping break the barriers for sharing EEE and reducing e-waste.

The varying operational styles of faculties underscore the influence of organisational structure on sharing equipment and repair services. Institutions like KU and UKM, with their centralised e-waste teams and departments, present intriguing models that emphasise the potential advantages of a pan-University approach. This implies that a separate entity dedicated to managing EEE could facilitate efficient sharing of equipment and repair services across faculties, overcoming the challenges posed by distinct operational styles. Such centralisation could expedite the identification of available resources and the process of repair, aligning well with the interview findings. Additionally, the need for effective tracking mechanisms, as highlighted by UKM, further accentuates the importance of centralised coordination. As future proposals for improvement are considered, these insights from diverse institutional setups, like KU and UKM, can offer valuable perspectives for enhancing e-waste management strategies.

4. Conditions inhibiting reuse of University equipment

A predominant challenge in reusing retired University equipment by external organisations is that the WEEE guidelines mandate comprehensive decontamination and servicing of equipment before redistribution, thereby complicating the reuse process. Another impediment is ascertaining the University’s liability for its WEEE being reused by external parties. For instance, FEPS prohibits the redistribution of its end-of-life equipment either intra-university or to external students/educational institutions due to health and safety concerns arising from potential misuse or malfunctioning of equipment. In stark contrast, other universities, such as GU, have successfully embraced external reuse through donations or resale, showcasing that a balance between guidelines and reuse feasibility can be achieved. Considering this, the University of Leeds could explore avenues similar to the "Student Equity Scheme". This case study indicates the potential for the University of Leeds to broaden its reuse initiatives and navigate liability concerns more effectively.

Additionally, one respondent mentioned WARPiT, an internal marketplace designed to redistribute resources within a university. They pointed out that while this platform has proven successful for items such as office furniture, it does not currently accommodate EEE. However, other universities, notably Cambridge, have extended WARPiT to encompass a wider range of articles, including printers, electric heaters, freezers, and even laboratory equipment. This reveals that online platforms like WARPiT can facilitate redistribution of equipment, thereby cutting down on unnecessary procurement and reducing e-waste.

5. Limitations of using storage for e-waste management

One interviewee pointed out that large e-waste items, like standing incubators, can neither be handed over to Estates nor stored for an extended time. Hence, the faculty must find alternative ways to dispose of such e-waste. The divergent viewpoints of the interviewees

regarding availability/non-availability of storage space reveal that the efficacy of using storage as an e-waste handling mechanism varies from faculty to faculty. These challenges contrast with the University of Bamenda's recommendation to establish a dedicated e-waste storage facility. The limitations of the current decentralised storage system may stem from the lack of a unified approach to storage due to faculties operating independently. A decentralised approach could potentially hinder efficiency and optimal resource utilisation that a more centralised system might provide, aligning with the University of Bamenda's proposition.

6. E-waste landscape at the University of Leeds (IT Exec Team, 2022; Communications and Engagement Team; IT Services)

The University of Leeds possesses a wide array of EEE. There are 48 common access printers and 80 display screens dispersed throughout the campus. Furthermore, over 1800 PCs are situated in cafes and computer suites. Around 250 lecture halls are equipped with at least one computer monitor, projectors, and audio-video capture devices. Moreover, few battery recycling bins exist on campus, such as in the School of Electronic and Electrical Engineering. Following GU's practices, expanding with e-waste recycling stations within libraries would further emphasise the University's commitment to robust e-waste management. Besides, the coming year is poised to see the planned replacement of approximately 10,000 desktop and laptop computers. This ambitious turnover, necessitated by a backlog caused by COVID disruptions, targets upgrading to more energy-efficient hardware and updated software.

In the interviews, it was discovered the availability of specific statistics on laboratory equipment disposal was not readily accessible from the participants. This information gap underlines the complexity of university e-waste management. Furthermore, this observation also highlights the intricacies of tracking e-waste, potentially suggesting an area for further research and improvement in information sharing.

7. Recommendations

The high potential for e-waste generation necessitates an institutional shift in knowledge management and communication through the following actions:

1. Modelled from KU and UKM, the University should invest in a centralised, pan-University E-waste Department which institutionalises the following functions under one umbrella:
    1.1. ***Quantify the amount and qualify the type of e-waste generated per faculty:*** Establishing precise e-waste statistics would create a systemic picture of the University's e-waste flows, depicting how and where e-waste is generated/disposed of. Insights from such material flow analysis (MFA) could feed evidence-based actionable policies to the University's 'WEEE Procedure'. For example, MFA can help identify e-waste hotspots and inform the placement of recycling stations and targeted equipment repair/sharing initiatives.
    1.2. ***Administer a centralised EEE inventory management and sharing system (IMSS):*** Drawing inspiration from 'Qreserve' tool, the IMSS should list all available equipment

across faculties. This system not only expedites the identification and sharing of existing resources between staff, but also holds the potential to seamlessly interface with a purpose-built centralised storage facility, augmenting the procurement of essential spare parts.

1.3. ***Manage a central repair workshop, equipped with skilled technicians****:* Replicating the successful workshop model within FEPS, this e-waste department can house a central workshop to offer repair services across all faculties of the University.

2. The University should set up an online 'cross-charging' platform for facilitating inter-faculty monetary transactions, whereby faculties can charge each other for equipment loaned/repairs services offered. This platform is a prerequisite for operationalising the IMSS and the central repair workshop.
3. Five interviewees indicated that e-waste should be managed from the top. Hence, the University must establish an empowered, dedicated e-waste team, tasked with the authority to administer the central e-waste department and the accountability to ensure compliance. Supplementing this, the University should incorporate e-waste management into the job description of relevant staff in faculties. This would encourage them to understand the issue deeply, transcending their 'need-to-know' engagement.
4. To leverage the potential of intra-university reuse, the University should promote platforms like WARPiT, and expand its scope to include end-of-life EEE.
5. To unlock external reuse opportunities, the University should establish a robust regulatory framework addressing liability concerns. Concurrently, engaging with platforms like 'Unigreen' could facilitate secure collection, storage, and resale of unwanted WEEE at optimal returns for the seller university. Introducing such a regulatory framework not only paves the way for reuse through resale but also extends opportunities for donation, incorporating initiatives like the 'Student Equity Scheme' at Griffith University.
6. The University should take the following steps to cultivate e-waste consciousness:

6.1. Given the busy staff schedules, the University should set aside an exclusive time slot, separate from everyday work, just for e-waste management training. This will enable them to grasp the intricacies of the e-waste framework, thus enhancing their compliance. Besides, it will help dispel the prevalent misconceptions like 'replaced sub-components do not contribute to e-waste'.

6.2. Since the University's newsletter-based approach to e-waste communication places a significant interpretative burden on staff, a handy resource, such as an internal app or an interactive e-learning module is needed to make essential information easy to comprehend and practical to implement. It should also educate the staff about disposal routes for large end-of-life equipment, particularly which cannot be stored for long, and which fall beyond the jurisdiction of Estates.

6.3. To address the prevailing apathy towards the ultimate destination of WEEE, University should conduct regular awareness campaigns. These would help shift e-waste from an 'out of sight, out of mind' issue into a shared commitment.

7. The University should negotiate with manufacturers to extend the availability of spares and support, ensuring that repair remains the preferred option over replacement. Opportunities also exist for environmentally conscious collaborations with companies to launch producer-buy-back schemes.

CONCLUSION

The presented research underscores the prevailing knowledge gap regarding e-waste management at the University of Leeds. The causative factors behind this were: absence of explicit e-waste responsibilities in job descriptions, overwhelming workloads, and lack of readily available e-waste know-how. Furthermore, the study illuminated several challenges obstructing the repair, equipment sharing/reuse within and outside the university, contributing significantly to e-waste production.

A shift towards comprehensive e-waste can be achieved through the proposed recommendations arising from this study. Prominent among these are: a centralised E-waste Department, an empowered management team, the promotion of platforms for intra-university reuse of EEE, and the cultivation of an e-waste-conscious environment through training and resource provision. Additionally, the pursuit of external reuse opportunities, facilitated by a robust regulatory framework, and negotiations with equipment manufacturers are also suggested to combat e-waste generation.

The study provides a roadmap not only for the University of Leeds but potentially for other similar institutions confronting e-waste challenges. Future research may focus on complementing the staff-based interviews with student-based surveys. This would help identify opportunities for reducing e-waste generation by the student community as well.

REFERENCES

Agamuthu, P., Kasapo, P. and Mohd Nordin, N.A. 2015. E-waste flow among selected institutions of higher learning using material flow analysis model. *Resources, Conservation and Recycling.* **105**, pp.177-185.

Arain, A.L., Pummill, R., Adu-Brimpong, J., Becker, S., Green, M., Ilardi, M., Van Dam, E. and Neitzel, R.L. 2020. Analysis of e-waste recycling behavior based on survey at a Midwestern US University. *Waste Management.* **105**, pp.119-127.

Chibunna, J.B., Siwar, C., Begum, R.A. and Mohamed, A.F. 2012. The Challenges of E-waste Management Among Institutions: A Case Study of UKM. *Procedia - Social and Behavioral Sciences.* **59**, pp.644-649.

Choy, L. 2014. The Strengths and Weaknesses of Research Methodology: Comparison and Complimentary between Qualitative and Quantitative Approaches. *IOSR Journal of Humanities and Social Science.* **19**, pp.99-104.

Dayaday, M.G. and Galleto Jr., F.A. 2022. Electronic Waste (E-Waste) Management of Higher Education Institutions in South Central Mindanao, Philippines: 10.32526/ennrj/20/202200053. *Environment and Natural Resources Journal.* **20**(5), pp.534-542.

Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) 2018. Official Journal of the European Union L 150.

Forti, V., Baldé, C.P., Kuehr, R. and Bel, G. 2020. *The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential.*

Ivo Fon, M. 2018. *Disposal of E-Waste. Case Study: University of Bamenda.*

Univerisity of Kansas. 2023. *e-Waste Recycling.* [Online]. Available from: https://technology.ku.edu/catalog/e-waste-recycling

Griffith University Library. 2021. *Recycle at the Library!* [Online]. [Accessed June]. Available from: https://blogs.griffith.edu.au/library/2021/05/18/recycle-at-the-library/

Queirós, A., Faria, D. and Almeida, F. 2017. STRENGTHS AND LIMITATIONS OF QUALITATIVE AND QUANTITATIVE RESEARCH METHODS. *European Journal of Education Studies; Vol 3, No 9 (2017).*

Saldaña, C. and Messina, S. 2021. E-waste recycling assessment at university campus: a strategy toward sustainability. *Environment, Development and Sustainability.* **23**.

Waste Electrical and Electronic Equipment Procedure 2020.

IT Services. *Clusters.* [Online]. Available from: https://it.leeds.ac.uk/it?id=clusters

Solving the E-waste Problem (Step) White Paper: One Global Definition of E-waste. 2014.

IT Exec Team. 2022. *IT update | Your questions answered.* [Online]. Available from: https://forstaff.leeds.ac.uk/news/article/7821/it_update_your_questions_answered?notags=true

University of Leeds Communications and Engagement Team. *Display screens.* [Online]. Available from: https://comms.leeds.ac.uk/resources/display-screens/

Griffith University. 2023. *Staff Printing Changes.* [Online]. [Accessed June]. Available from: https://www.griffith.edu.au/printing/staff-printing#mfd

WEEE2 – Definition and Understanding of the 6 Categories. 2018.

Woidasky, J. and Cetinkaya, E. 2021. Use pattern relevance for laptop repair and product lifetime. *Journal of Cleaner Production.* **288**, p125425.