E-Waste Literacy: The Knowledge, Attitude, and Perception of MSU-IIT Students Towards E-Waste Management

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Abstract

E-waste management has been a challenge globally and has become a serious problem among developing nations. During the pandemic, the Philippines and other countries experienced a rise in information and communication technology usage, leading to an increased amount of obsolete electronic equipment. The absence of proper management of this waste therefore threatens the environment and human health. Mindanao State University - Iligan Institute of Technology (MSU-IIT) is likewise dealing with the issues that call for immediate attention within the university. Thus, this study assessed the knowledge, attitude, and perception (KAP) of e-waste management of students on campus. KAP surveys for the students, and key informant (KI) interviews of faculty and staff were the instruments for data collection. KAP data was collected using physical and online surveys. While KI interviews were conducted in-person. The results showed that the students across various colleges had a high level of knowledge (overall mean range of 3.58-4.16) specifically about the components of e-waste and its negative effects on human health and the environment. They also demonstrated a positive attitude (overall mean range of 3.88-4.40) toward learning and participating in any e-waste recycling and handling initiatives, and a positive perception (overall mean range of 3.73-3.95), emphasizing that institution has a responsibility to raise awareness and educate its constituents on proper e-waste management. Further, the study revealed that, although e-waste is condemned at the campus Supply Office, the process was deemed time-consuming, which ends up storing in different departments or offices. Hence, the institution should focus on improving its e-waste management system, wider dissemination of information, and implementation of further environmental education and initiatives such as e-waste recycling seminars, programs, and activities to achieve a safe educational environment.

Keywords: *Electrical and electronic waste, Waste management, Hazardous waste, Solid waste*

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Introduction

The consistent advancement in information and communication technology (ICT) has sustained global growth (Okoye & Odoh, 2014) and has driven the global electronics sector to become the world's largest manufacturing industry (Shah, 2014). As society becomes reliant on technology in education, electrical and electronic equipment (EEE), access to this has become less expensive which changed the communication process and enhanced the speed of obtaining information (Meneses & Galita, 2015), remarkably improving the quality of human lives. However, the growing demand for these consumer products, combined with the rapid pace at which technology is evolving, has inevitably increased the amount of obsolete, discarded, broken, or abandoned products (Hula et al., 2003; Ahmed & Rukhsar, 2017). These discarded EEE fall under the electrical and electronic waste category, generally known as e-waste (Kumar, 2015). Electronic or e-waste is the collective name for discarded electrical and electronic equipment that enters the waste stream from various sources (Chawla & Neelu, 2012). According to the Basel Action Network, e-waste is an extensive and growing variety of electronic devices that have been abandoned by owners, ranging from computers to big home appliances (e.g. air conditioners, refrigerators, cell phones, personal stereos, and other electronics) (Yu, 2015). These products contain various hazardous compounds such as cadmium, lead, flame retardants, and other toxic materials that, if not properly managed, can spread in the surrounding environment and threaten human health (Peralta & Fontanos, 2006; Cayumil et al., 2016; Azlan et al., 2021), potentially causing major illnesses including lung cancer, thyroid, and kidney damage. Therefore, appropriate handling of e-waste is essential (Azlan et al., 2021) and disposal in landfills is not suggested.

During the pandemic, the Philippines and other countries experienced an increased usage of ICT products. From 2020 to 2021 alone, the Philippines' Department of Health (DOH) statistics showed that there was a significant increase in imports of electronics from USD 26.642 B to USD 31.736 B (Albanza et al., 2022). With the shift to remote work and online learning set-ups during this period, the quantity of e-waste generated is further expected to rise in the future (Forti et al., 2020; Choi et al., 2021; Albanza et al., 2022). Additionally, Higher Education Institutions (HEIs) in the Philippines are currently upgrading their ICT facilities, resulting in increased purchase and use of electronic equipment for effective learning delivery (Dayaday & Galleto, 2022).

Studies suggest that knowledge acquisition could foster positive environmental attitudes, and these attitudes, once cultivated, are likely to stimulate pro-environmental actions (Casaló & Escario, 2018; Casaló et al., 2019). For instance, an informed population, equipped with knowledge about the environmental consequences of inappropriate e-waste disposal as well as the possible advantages of proper management, is more likely to develop a positive attitude towards sustainable practices. These cultivated environmental attitudes are expected to transcend into concrete pro-environmental actions, which might entail making conscientious decisions like recycling electronic products, engaging in e-waste management programs, or advocating for regulations that encourage appropriate disposal and recycling methods. Understanding the negative impacts of e-waste on the environment and human health acts as a stimulus for instilling environmental responsibility. Additionally, it is argued that the most effective way to safeguard both the environment and human health is through regulations and conscious sustainable consumption (Campit, 2017). More so, environmental education necessitates sufficient awareness, knowledge, skills, and attitudes to incorporate environmental considerations into everyday decisions concerning individual consumption, lifestyle, job opportunities, and civic works (Elder, 2003).

Consequently, the interplay of knowledge, attitude, and perception toward responsible practices in the field of e-waste management emphasizes the need for educational initiatives and public awareness campaigns. Hence, a high level of knowledge, positive attitude, and perception of MSU-IIT constituents would be beneficial to e-waste management. Integrating sustainability in education and emphasizing the adverse impacts of e-waste will motivate students to consider e-waste reduction and recycling, particularly boosting students' self-efficacy at a young age (Waheed et al., 2023). Therefore, in light of the discussion mentioned above, this study aimed to assess the knowledge, attitudes, and perceptions on e-waste management of MSU-IIT students. Specifically, this study sought to (1) assess the knowledge, attitude, and perception of MSU-IIT students on e-waste management; and (2) determine the e-waste management within MSU-IIT.

Review of Related Literature

Due to economic growth in developing countries and the advancement of information technology, the amount of waste electrical and electronic equipment (WEEE) or electronic waste (e-waste) is rapidly increasing (Yoshida *et al*., 2016), associated with the increased number of universities from 17,036 to 28,077 in 2018 globally (Chibunna *et al*., 2012), which are constantly integrating ICTs such as networking devices for high-speed Internet, Internet of Things devices, and computing devices for processing large volumes of information (Maphosa, 2021). Thus, developing countries have been adopting ICTs to improve access to information about health, education, commerce, and government services (Baldé *et al*., 2017). The integration of technology in teaching and learning is becoming more common. The advancement of technology and the adoption of ICTs helped especially during the outbreak of COVID-19. Lectures are provided and mediated using ICTs when face-to-face instruction is disrupted, yet contact between students and professors has become flexible and common through computer networks (Coleman, 2016). In order to enhance the educational experiences of students, several institutions have embraced online learning platforms, blended learning approaches, and digital resources. On top of that, the quantity and variety of electrical and electronic equipment (EEE) used to enhance teaching and learning in the twenty-first century have grown dramatically. Consequently, in many countries, a lack of e-waste rules and defined procedures has resulted in colleges and universities disposing of e-waste in an ecologically disastrous manner (Agamuthu *et al*., 2015).

According to the reviewed literature and studies, the factors that are crucial for effective e-waste management include people’s knowledge, attitude, and behavior (Manalo, 2022). Thus, by assessing the knowledge, attitude and behavior of students, educators and policymakers, tailored educational campaigns can be developed that addresses knowledge gaps and misconceptions about e-waste management, help identify factors or barriers that influence their willingness to participate in any e-waste initiative, and examine their actual behavior thereby providing insights into the practical challenges and opportunities for implementing sound environmental practices (Manalo, 2022). In the study of Ahmed and Rukhsar (2017), they stated that teachers have the responsibility to raise awareness about e-waste and its harmful effects and educate students on the proper disposal and effective e-waste management practices of discarded electrical and electronic products. Individuals who are more knowledgeable about specific problems, therefore, are more likely to make sound decisions than those who are less aware (Manalo, 2022).

Subsequently, a lack of knowledge about e-waste management leads people to unknowingly expose themselves to the harmful effects of e-waste (Nuwematsiko *et al*., 2021; Decharat & Kiddee, 2022). It is also suggested that factors such as education level and type of occupation could be linked to inadequate knowledge of the health risks posed by e-waste (Sharma *et al*., 2014; Mishra *et al*., 2017). Additionally, based on the study of Deniz *et al*. (2019), the general public has a limited understanding of the concept of e-waste, and even workers in the environmental industry lack adequate information about e-waste and its related issues. Hence, studying the knowledge, attitude, and perception of students can play a crucial role in bridging these gaps, ultimately leading to more informed and effective e-waste management practices and policies.

Methodology

Sampling Area

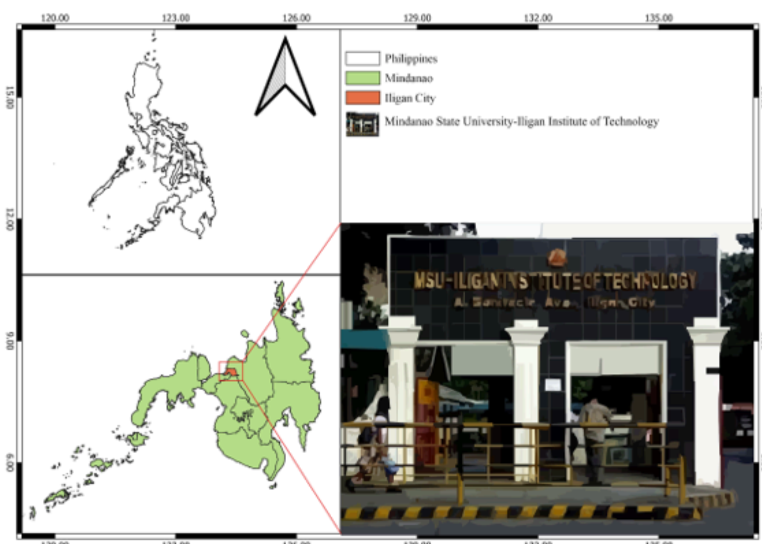

Figure 1. *Location map of the sampling site*

MSU-IIT is well-known for its scientific and technological excellence, as well as its commitment to extensive research and community engagement. It has 13,386 high school, college, and postgraduate students for the academic year 2023-2024 and is located at Andres Bonifacio Avenue, Iligan City. This study was specifically conducted at the seven colleges and the sole secondary school of MSU-IIT. The colleges include; College of Engineering and Technology (COET), College of Science and Mathematics (CSM), College of Computer Studies (CCS), College of Education (CED), College of Health and Sciences (CHS), College of Arts and Social Sciences (CASS), College of Economics, Business & Accountancy (CEBA), and the sole secondary school on campus, Integrated Developmental School (IDS); referred to as "centers" in this study (Figure 1.).

Research Design

This study utilizes a descriptive-quantitative research design. A survey was conducted to determine the KAPs of the students using a hybrid technique (online and physical surveys) through a random sampling method. While key informant interviews (KII) were carried out face-to-face with the selected faculty and staff who are knowledgeable about EEE management at the institution, particularly those who work in laboratories, libraries, and other technology-related positions.

In calculating the sample size for KAPs respondents per college, the student population for the academic year 2023-2024 was used as the total population (Table 1). Using Slovin's formula (through the Raosoft Sample Size calculator), the recommended sample size for the 13,386 total student population is 374 at a 95% confidence level and 0.5 margin of error. The proportion distribution of each college and IDS was computed to determine the target sample size per college.

Table 1. *Sample size proportion of each college for KAP respondents.*

Colleges	Population	Proportion	Sample Size (n=374)	Actual Sample
COET	3172	0.24	89	75
CASS	2331	0.17	65	64
CED	2223	0.17	62	62
CSM	1977	0.15	55	55
CEBA	1324	0.10	37	24
CCS	1000	0.07	28	28
CHS	437	0.03	12	12
IDS	922	0.07	26	25
Total	**13386**	**1.00**	**374**	**345**

Data Collection and Analysis

There are two different types of data collected in this study, (1) the KAPs of the students, and (2) the MSU-IIT e-waste management practices. The KAPs survey tool was adapted and modified from Dayaday & Galleto (2022) and was divided into four individual sections: (i) respondents' socio-demographic profile; (ii) knowledge of e-waste management; (iii) attitudes on e-waste management; and (iv) perception of e-waste management. Sections II-IV used a 5-point Likert scale where "1" represented "Strongly Disagree" to a "5" represented "Strongly Agree", and follow-up questions were answerable by "Yes" or "No". This tool was pre-tested and analyzed through Cronbach alpha for the questions' reliability and internal consistency. Before conducting the survey, a letter was sent to each center's dean to request approval. Additionally, a consent form and an introduction outlining the purpose of the survey were included in the survey tool for the participants' reference. The data was collected employing both physical and online surveys through the Jotforms platform of the MyIIT students' portal. A total of 345 students answered the survey.

For the KI interviews, the questionnaire was divided into two parts; (i) the respondents' socio-demographic profile; and (ii) the e-waste management questions. Interviews were conducted in-person.

All data collected was coded and tabulated in Google Sheets. The 5- and 2-point Likert scale and KII data were analyzed descriptively using mean, and the mean of the 5-point Likert scale data of KAP was interpreted using the mean range from the study of Manyange *et al.* (2015). Also, Pearson's correlation matrix was used to analyze the association between the knowledge, attitude, and perception of all participants.

Results and Discussions

Demographic profiles of respondents

Table 2. *Distribution of student respondents' socio-demographic backgrounds.*

Demographic variables		Frequency (n=345)	Percentage
Gender	Male	145	42.03
	Female	200	57.97
Age	18-21 years old	276	80
	22 – 25 years old	51	14.79
	26 – 30 years old	15	4.34
	> 30 years old	3	0.87
Educational background	SHS Students	25	7.25
	Undergraduate Students	286	82.90
	Graduate Students	34	9.85
College	CASS	64	18.55
	CCS	28	8.11
	CEBA	24	6.96
	CED	62	17.97
	CHS	12	3.49
	COET	75	21.73
	CSM	55	15.94
	IDS (High school)	25	7.25
Years of residency	> 10 years	4	1.16
	5 – 10 years	46	13.33
	2 – 4 years	179	51.88
	6 months – 1 year	116	33.63

The results show that 57.97% of the respondents are female, with the majority (80%) aged 18-21 years old (Table 2). Predominantly, 82.90% were undergraduate students, 9.85% graduate students, and the remaining 7.25% were senior high school students. The majority (51.88%) have resided in the institution for 2 to 4 years already, followed by the relatively fresh students who have just entered the institution in 6 months to 1 year (33.63%).

Noticeably, some respondents stayed in the institution for more than 5 years. These are those who took their secondary and senior high studies at IDS and proceeded to college, as well as those graduate students who took their baccalaureate degrees in the university and proceeded to higher studies. Further, the average age of the KAP respondents is 20.52 with a minimum age of 18 years old and a maximum age of 47 years old while the average years of residency is 2.76 with a minimum value of 6 months and a maximum value of 17 years.

Level of Knowledge in E-waste Management

The overall mean scores of the students from different centers indicated that they all agreed with the claims, signifying that they all had a high level of knowledge, with CCS having the highest overall mean score of 4.16 and IDS having the lowest mean score of 3.58 (Table 3). This could be attributed to several factors that align with the nature of computer studies and technology-focused disciplines. Technology-focused programs in education acknowledge environmental effects of electrical and electronic devices (Mccrie, 2017), which may imply why CCS students strongly agree that unmanaged e-waste can cause environmental pollution and harm human health (statement 5). Immersed with computer-related coursework and hands-on experience with electronic devices, these students may inherently recognize the components of these EEE and its effects (statements 4 and 5). Students from other colleges also acknowledged the e-waste materials and their effect on the environment.

Moreover, senior high students (IDS) are not familiar with the term "e-waste" and its definition (3.24), albeit they know that e-waste is generally hazardous and could degrade the environment. This suggests that the curriculum for senior high may not be as comprehensive, and possibly lacks emphasis on environmental education, especially on solid waste management. Hence, strengthening environmental education in senior high school is critical for establishing a foundation of environmental knowledge that can be developed further in college. Comparably, college students have likely been exposed to more diverse and advanced interdisciplinary courses, which significantly improves their environmental knowledge (Ma *et al*., 2023).

On the other hand, most of the students from the different colleges revealed that they are not familiar with e-waste handling and management. The same findings were highlighted in the study of Nuwematsiko *et al.* (2021) where participants showed poor knowledge of e-waste management, specifically on the disposal and handling practices. This indicates that although environmental issues may become widely known, such as the hazards of e-waste, this knowledge still does not result in behavioral changes. While most consumers know of the risks associated with e-waste handling (Ritu & Shalini, 2013; Bhat & Patil, 2014; Borthakur, 2015), the lack of knowledge on sustainable solutions to this issue remains (Bamberg & Möser, 2007). Even with the increasing volume of e-waste in developing countries, only few countries have implemented particular legislation and established sufficient recycling infrastructure. This implies the need for targeted educational interventions that provide practical guidance and information on e-waste recycling processes (Maphosa, 2021).

Table 3. *Knowledge of MSU-IIT students on e-waste management*

Statement	IDS n=25 Mean	CSM n=55 Mean	COET n=75 Mean	CHS n=12 Mean	CED n=62 Mean	CEBA n=24 Mean	CCS n=28 Mean	CASS n=64 Mean
1. I am familiar with the term "electronic waste" and its definition.	3.24 ± 1.05	4.04 ± 0.98	3.76 ± 1.16	3.67 ± 0.89	3.74 ± 0.96	4.25 ± 0.85	4.18 ± 0.94	3.81 ± 0.97
2. I know e-wastes are discarded electrical or electronic devices.	3.64 ± 1.22	4.20 ± 0.76	4.01 ± 0.95	3.58 ± 1.16	3.71 ± 0.91	4.25 ± 0.90	4.43 ± 0.74	3.78 ± 0.97
3. I know electrical and electronic devices contain hazardous materials.	4.16 ± 0.62	4.42 ± 0.63	4.41 ± 0.87	3.92 ± 1.08	3.94 ± 0.96	4.50 ± 0.88	4.57 ± 0.50	4.14 ± 0.91
4. I know e-waste contains some precious metals like copper, iron, gold, silver, and platinum.	4.28 ± 0.61	4.42 ± 0.79	4.39 ± 0.94	3.92 ± 0.79	3.89 ± 0.96	4.42 ± 0.93	4.61 ± 0.50	4.05 ± 0.98
5. I know e-waste pollution can affect human health.	3.96 ± 0.79	4.55 ± 0.69	4.48 ± 0.79	4.25 ± 0.87	4.19 ± 0.88	4.50 ± 0.88	4.61 ± 0.83	4.30 ± 0.90
6. I know unmanaged e-waste can cause soil, air, and water contamination, hence, environmental pollution.	4.04 ± 0.79	4.47 ± 0.79	4.39 ± 0.90	4.42 ± 0.79	4.18 ± 0.97	4.42 ± 0.88	4.50 ± 1.00	4.22 ± 1.03
7. I know e-waste should be separated from any other waste.	4.16 ± 0.80	4.42 ± 0.90	4.29 ± 0.98	4.33 ± 0.65	4.32 ± 0.88	4.42 ± 1.02	4.61 ± 0.74	4.25 ± 1.01
8. I know e-waste management is important for environmental protection.	4.32 ± 0.56	4.53 ± 0.72	4.36 ± 0.91	4.42 ± 0.90	4.32 ± 0.90	4.50 ± 0.93	4.54 ± 0.79	4.41 ± 0.81
9. I am familiar with how this e-waste is managed and discarded.	2.48 ± 0.92	3.20 ± 1.16	3.01 ± 1.17	2.33 ± 1.30	3.21 ± 1.13	2.92 ± 1.21	3.46 ± 1.23	3.11 ± 1.18
10. I know that damaged electronic equipment (computers, laptops, printers) on the campus is being condemned in the Procurement Plan and Development of the MSU-IIT.	2.64 ± 0.95	3.33 ± 1.23	3.20 ± 1.26	2.25 ± 1.06	3.24 ± 1.29	3.08 ± 3.08	3.32 ± 1.31	3.22 ± 1.16
Overall Mean	**3.58**	**4.02**	**3.92**	**3.61**	**3.81**	**4.01**	**4.16**	**3.85**

Legend: Strongly agree (4.20-5.00), Agree (3.40-4.19), Not Sure (2.60-3.39), Disagree (1.80-2.59), Strongly disagree (1.00-1.79)

The students are also not familiar with the "take-back" policy and although there is an existing "take-back" policy in the university in which the Supply office takes charge, the students are not yet aware of this. The "take-back" policy in the university is carried out through a Memorandum Receipt (MR)-system, it typically involves the issuance of MRs to employees receiving EEE; when a device reaches its end-of-life (EOL) or requires replacement, the university Supply Office, acting as the responsible division, initiates the take-back process. Once the MR is fully processed, the university is responsible for its proper disposal or recycling. As mentioned, the storage process of e-waste in the university is vague and lacks proper facilities. Consequently, the insufficiency of a structured e-waste management system prevents individuals from learning about proper e-waste management practices (Nuwematsiko *et al*., 2021). Establishment of efficient communication channels, and ensuring policy implementation and enforcement are crucial steps in fostering environmental knowledge and policy adherence (Utilities One, 2017). Apparently, the wrong mindset and attitude towards environmental issues, coupled with a lack of education may lead to serious environmental problems over time, and this could be addressed through increased environmental awareness and environmental education (Deniz *et al*., 2019). Although, in some cases, even with existing environmental education programs, students are still less likely to bring up environmental concerns or participate in actual programs (Nyika & Mwema, 2021). Several factors may contribute to students' reluctance to voice environmental concerns or engage in programs, including ineffective environmental education teaching strategies that may not be interesting or relevant to them, a lack of open channels of communication between students and educators that may discourage them from doing so, and a sense of personal insignificance and helplessness that may lead them to believe that their small actions will not have a significant impact on larger environmental issues. If one is unaware and feels irrelevant to the issues, it is uncertain that one will consciously care about them or act in an ecologically friendly manner (Gifford & Nilsson, 2014); hence, profound environmental knowledge is one of the most significant predictors of environmentally friendly actions (Liu *et al*., 2020).

Additionally, when the students were asked about their knowledge of e-waste policies and legislation in the country, only 4.93% answered “yes”. This finding highlights a potential gap in institutional knowledge since the majority of participants appear to be unaware of the statutory regulations on e-waste. The lack of information might jeopardize the institutions' capacity to match their actions with legal obligations and environmental norms.

In the Philippines, there are two main regulatory frameworks for e-waste management. According to the Environmental Management Bureau (EMB), the Philippines established a national and legal framework for e-waste management in 1990 with the enactment of Republic Act (RA) 6969 or the Toxic Substances and Hazardous and Nuclear Waste Control Act. However, there are no explicit e-waste regulations, no adequate recycling facilities, and there needs to be a more qualified workforce in the country (Peralta & Fontanos, 2006). Regardless of the existing or proposed e-waste management rules, effective implementation and enforcement of these policies are required to guarantee appropriate treatment and disposal of e-waste in an ecologically sound manner (Celestial *et al*., 2018). Thus, there is a need for increased awareness and environmental education about e-waste not just in academic institutions but also in the general public.

Level of Attitude on E-waste Management

The mean scores of students’ attitudes toward e-waste management across different colleges showed that CCS students exhibit the most positive attitude toward e-waste management (overall mean = 4.40), while IDS students showed the least positive attitude (overall mean = 3.88) (Table 4). As mentioned in the knowledge level, the CCS students are exposed to this kind of EEEs making them aware of its effects on both the environment and human health and thus, this may have influenced their positive attitude among others. Specifically, the CCS students, along with other colleges, display a positive attitude toward raising awareness of the impacts of e-waste, and they are willing to participate and support any initiatives that promote e-waste recycling and responsible disposal. This supports the premise that as people gain environmental knowledge, they develop an environmentally friendly attitude that drives them to engage in responsible environmental behavior (Rennie, 2007).

Table 4. *Attitudes of MSU-IIT students on e-waste management.*

Statement	IDS n=25 Mean	CSM n=55 Mean	COET n=75 Mean	CHS n=12 Mean	CED n=62 Mean	CEBA n=24 Mean	CCS n=28 Mean	CASS n=64 Mean
1. I am aware of the problem with proper e-waste management in the country.	2.96 ± 0.93	3.64 ± 1.02	3.44 ± 1.15	3.17 ± 1.19	3.50 ± 0.97	3.33 ± 1.20	4.14 ± 0.89	3.44 ± 1.13
2. I am aware of the problem with proper e-waste management at MSU-IIT.	2.72 ± 0.79	4.31 ± 7.03	3.17 ± 1.19	2.67 ± 0.98	3.19 ± 0.97	3.17 ± 1.09	3.64 ± 1.03	3.25 ± 1.07
3. I believe e-waste management should be a common responsibility of individuals.	4.28 ± 0.54	4.38 ± 0.68	4.28 ± 0.76	4.17 ± 0.83	4.37 ± 0.83	4.54 ± 0.88	4.36 ± 0.83	4.39 ± 0.58
4. I feel a personal responsibility to properly dispose my electronic devices to minimize e-waste.	3.84 ± 0.80	4.27 ± 0.83	4.29 ± 0.85	4.00 ± 0.60	4.26 ± 0.87	4.33 ± 0.92	4.32 ± 0.67	4.36 ± 0.63
5. I am willing to be involved in setting up a responsible and safe recycling scheme in the institution.	3.88 ± 0.67	4.51 ± 0.54	4.17 ± 0.84	4.00 ± 0.74	4.34 ± 0.85	4.17 ± 0.82	4.32 ± 0.61	4.27 ± 0.72
6. I am willing to actively participate in e-waste management initiatives provided by the university.	3.84 ± 0.80	4.38 ± 0.56	4.08 ± 0.85	4.08 ± 0.51	4.27 ± 0.83	4.17 ± 0.87	4.39 ± 0.63	4.27 ± 0.62
7. The environmental impact of electronic waste concerns me, and I believe it is essential to address.	4.04 ± 0.73	4.49 ± 0.60	4.27 ± 0.72	3.92 ± 1.08	4.34 ± 0.79	4.38 ± 0.88	4.54 ± 0.51	4.34 ± 0.65
8. I believe that raising awareness about the impact of e-waste is crucial for fostering responsible disposal habits.	4.40 ± 0.50	4.64 ± 0.59	4.48 ± 0.68	4.17 ± 0.83	4.29 ± 0.80	4.46 ± 0.88	4.75 ± 0.44	4.34 ± 0.65
9. I am open to learning more about the proper e-waste disposal methods and its implications.	4.28 ± 0.68	4.67 ± 0.55	4.53 ± 0.70	4.33 ± 0.89	4.37 ± 0.79	4.33 ± 0.87	4.68 ± 0.48	4.33 ± 0.74
10. I see myself as having a role in contributing to the responsible management of e-waste.	3.84 ± 0.75	4.25 ± 0.73	3.99 ± 0.83	3.92 ± 0.67	4.03 ± 0.85	4.00 ± 0.98	4.39 ± 0.63	4.09 ± 0.77
11. I will support any university-led initiatives aimed at promoting e-waste recycling and responsible disposal.	4.32 ± 0.48	4.49 ± 0.57	4.27 ± 0.76	4.08 ± 0.79	4.31 ± 0.82	4.38 ± 0.88	4.57 ± 0.50	4.38 ± 0.68
12. A material recovery facility can lessen the e-waste pollution in the environment at MSU-IIT.	4.20 ± 0.65	4.49 ± 0.66	4.39 ± 0.68	4.08 ± 0.79	4.16 ± 0.85	4.33 ± 0.92	4.64 ± 0.49	4.30 ± 0.73
Overall mean	**3.88**	**4.38**	**4.11**	**3.88**	**4.12**	**4.13**	**4.40**	**4.15**

Legend: Strongly agree (4.20-5.00), Agree (3.40-4.19), Not Sure (2.60-3.39), Disagree (1.80-2.59), Strongly disagree (1.00-1.79)

On the other hand, the students are not aware of the challenges of e-waste management at the national and university level, however, they showed high knowledge of the effects of e-waste. This knowledge fosters a positive attitude in which most scholars consider knowledge as a prerequisite for any attitude (Liu *et al.*, 2020). Acknowledgement of environmental knowledge is essential for developing positive environmental attitudes (Zsóka *et al.,* 2013) thereby promoting behavioral shifts such as shift to green products and choices

(Polonsky *et al*., 2012). This again suggests the importance of environmental education since it has the greatest potential to influence students' attitudes and behavior through eco-friendly practices (Boyes *et al*., 2009).

Although changes in attitudes and beliefs are essential motivators for engaging in any environmental activity, they are deemed inadequate to reliably impact behavior (Szerényi *et al*., 2011). Thus, in an academic institution such as MSU-IIT, it is not enough to recognize the students' lack of knowledge of proper e-waste recycling and handling but this calls for increased actual engagement of students in e-waste management activities such as seminars, info- and e-waste collection drives, to re-enforce the students' knowledge and positive attitudes towards the importance of proper management practices (Maphosa, 2021), eventually shifting their behavior and creating positive change.

Level of Perception on E-waste Management

The students from different colleges exhibit positive perception (Table 5). In the statement 8, the students from all colleges strongly agree that the reason why e-waste rapidly increases is due to technology and heavy reliance on electronic devices, with CHS having the highest mean of 4.67 and CASS having the lowest mean of 4.20. Students recognize the link between technology advancements, electronic device usage, and the subsequent growth in e-waste. This understanding is critical in addressing the underlying causes of e-waste generation. Institutions that rely significantly on technology must handle this problem holistically by implementing responsible procurement rules, adopting circular economy principles, and establishing effective asset management systems. The students also strongly agree that MSU-IIT has the responsibility to educate and disseminate information about proper e-waste management to its community. According to Ma *et al.* (2023), higher education institutions are responsible for developing university curricula related to environmental education. In this sense, the institution must be proactive and take the lead in environmental awareness initiatives to raise students' knowledge of environmental issues. Further, courses on environmental science and sustainability should emphasize concrete and actionable ways of protection and mitigation measures for environmental problems (Alam, 2023).

With the students' knowledge of e-waste containing harmful materials that can threaten human health, they disagree in disposing of e-waste with general waste. This finding underscores their positive perception, which may be a result of enhanced public health awareness raised by sensitization campaigns against other health risks like plastic use, and inappropriate mobile phone use (Bhat & Patil, 2012; Azodo *et al*., 2017). The statement "*e-waste recycling is harmful to the environment*" also has a low mean score, which means that the majority of the students are not sure whether recycling these materials is harmful or not. There is a safe technique to recycle e-waste known as formal recycling, yet only 17.4% utilize it, while the remainder employ the harmful method known as informal recycling (Liu *et al*., 2023). Informal recycling of e-waste is more common in most developing countries, which often involves burning or dismantling electronic devices, leading to environmental pollution and health risks (Bhat & Patil, 2012). Currently, many nations share common challenges, such as a lack of policies, strategies, legal instruments, or definitions; inadequate engagement from stakeholders; and the limited capacity and ability of responsible institutions (Forti *et al*., 2020). Unfortunately, most developing countries lack the capacity, i.e. infrastructure and technology, needed to properly recover valuable metals from e-waste (Acquah *et al.*, 2019). These limitations thus prompt the industry, environmental authorities, and policymakers to resolve such barriers and thereby practice formal recycling, and encourage sustainable practices and circular economy to lessen the detrimental effects of e-waste.

Table 5. *Perception of MSU-IIT students on e-waste management.*

Statement	IDS n=25 Mean	CSM n=55 Mean	COET n=75 Mean	CHS n=12 Mean	CED n=62 Mean	CEBA n=24 Mean	CCS n=28 Mean	CASS n=64 Mean
1. Storing e-waste is harmful.	3.88 ± 0.60	3.95 ± 0.89	4.09 ± 0.79	4.00 ± 0.60	3.95 ± 0.71	4.17 ± 0.96	4.18 ± 0.94	3.84 ± 0.91
2. E-waste should be disposed with general waste.	2.32 ± 1.11	2.24 ± 1.20	2.63 ± 1.45	2.25 ± 0.62	3.02 ± 1.44	2.83 ± 1.49	2.71 ± 1.49	3.22 ± 1.30
3. E-waste can be disposed of through 3R which is "Reduce, Reuse and Recycle".	3.76 ± 0.93	3.45 ± 1.12	3.57 ± 1.13	3.83 ± 0.72	3.61 ± 1.06	3.71 ± 1.16	3.79 ± 1.03	3.97 ± 0.94
4. E-waste can be recycled.	3.96 ± 0.93	3.65 ± 0.95	3.91 ± 0.93	3.83 ± 0.72	3.69 ± 0.86	3.92 ± 0.97	4.14 ± 0.59	3.81 ± 0.85
5. E-waste recycling is harmful to the environment.	2.68 ± 0.90	3.29 ± 0.94	3.17 ± 1.12	3.25 ± 1.14	3.37 ± 0.96	3.58 ± 1.06	3.07 ± 1.21	3.36 ± 1.03
6. E-waste recycling has negative effects on human health.	2.96 ± 0.89	3.67 ± 0.84	3.27 ± 1.11	3.50 ± 0.90	3.58 ± 0.78	3.58 ± 1.18	3.43 ± 1.20	3.52 ± 0.99
7. There are health effects associated with e-waste.	4.04 ± 0.45	4.20 ± 0.63	3.96 ± 0.86	4.08 ± 0.51	3.95 ± 0.82	4.29 ± 0.91	4.07 ± 0.90	4.03 ± 0.78
8. The rapid increase in technology and the heavy reliance on electronic gadgets contribute to the increase in e-waste.	4.36 ± 0.70	4.47 ± 0.72	4.51 ± 0.69	4.67 ± 0.49	4.27 ± 0.77	4.42 ± 0.88	4.54 ± 0.64	4.20 ± 0.84
9. I have personal attachments to electronic equipment even when out of use.	3.64 ± 1.08	3.45 ± 1.14	3.47 ± 1.18	3.25 ± 1.14	3.39 ± 1.09	3.54 ± 1.38	3.54 ± 1.32	3.63 ± 1.09
10. E-waste needs to be managed more effectively to reduce environmental pollution.	4.36 ± 0.57	4.62 ± 0.56	4.47 ± 0.66	4.33 ± 0.65	4.27 ± 0.77	4.46 ± 0.93	4.54 ± 0.58	4.39 ± 0.77
11. I believe that MSU-IIT has the responsibility to educate its community about the proper handling of electronic waste.	4.44 ± 0.58	4.67 ± 0.55	4.55 ± 0.66	4.25 ± 0.62	4.35 ± 0.73	4.50 ± 0.88	4.61 ± 0.57	4.48 ± 0.73
12. Proper e-waste management should be widely disseminated to the IIT constituents.	4.4 ± 0.50	4.67 ± 0.55	4.56 ± 0.64	4.33 ± 0.65	4.39 ± 0.73	4.42 ± 0.93	4.68 ± 0.55	4.42 ± 0.73
Overall mean	**3.73**	**3.86**	**3.85**	**3.80**	**3.82**	**3.95**	**3.94**	**3.91**

Legend: Strongly agree (4.20-5.00), Agree (3.40-4.19), Not Sure (2.60-3.39), Disagree (1.80-2.59), Strongly disagree (1.00-1.79)

Table 6 shows the Pearson correlation between knowledge, attitude, and perception. It can be seen that all variables are positively correlated. Knowledge is strongly correlated to attitude (r=0.637), while knowledge to perception (r=0.512) and attitude to perception (r=0.563) are moderately correlated. This implies that the students' attitudes toward e-waste were strongly influenced by their knowledge, and eventually their knowledge and attitude influenced their perception of e-waste management. It was claimed that attitude and knowledge were unique predictors of practice (Decharat & Kiddee, 2022). Therefore, the more knowledgeable they are, the more positive their attitude will be, and this will significantly influence their perception and improve their e-waste management practices (Lawal *et al.*, 2021).

Table 6. *Pearson correlation between knowledge, attitude, and perceptions of MSU-IIT students*

		Knowledge	Attitude	Perception
Knowledge	Pearson's r	—		
Attitude	Pearson's r	0.637	—	
Perception	Pearson's r	0.512	0.563	—

Legend: Very strong (0.80-1.00), Strong (0.60-0.79), Moderate (0.40-0.59), Weak (0.20-0.39), Very weak (0.00-0.19) (Riduwan *et al.*, 2014)

Lastly, when the students were asked if they think that the university could benefit from the precious materials such as copper, iron, gold, silver, and platinum that can be salvaged from e-waste, the majority said "yes" (73%). Further asked about how the institution could benefit from it (Figure 2), and they suggested that these precious materials could be used for upscaling in innovation and research (33%), a source of income by selling (25%), repurposing for instructional and for laboratories (22%), and others (20%) such as conserving natural resources, promoting environmental responsibility, and avoiding the storage of these wastes. One respondent said, *"Recovering and reusing these valuable materials doesn't just offer a revenue opportunity but also supports sustainable practices, promoting environmental responsibility and efficient resource use. Also engaging in proper e-waste recycling can bring economic and environmental benefits to institutions."* It is indeed beneficial to the institutions only if there are efficient recycling infrastructure and programs implemented and IEC efforts relevant to programs on e-waste material recovery. Being one of the premier research institutions in the country with different research centers, the realization of this kind of program is possible. With this, MSU-IIT can not only gain income from the harvested e-waste materials but also this program can achieve the institution's sustainability goals and be known as a leader in green technology. The goal of green technology solutions for sustainable energy practices can be specifically attained by emphasizing on the beneficiation and efficient use of metallic materials from e-waste (Sharma *et al.,* 2020). Additionally, integrating machine learning for intelligent storage management systems can further enhance the efficiency of energy storage devices (Priyadarshi *et al.,* 2022), therefore, MSU-IIT may leverage collected e-waste resources to establish itself as a leader in green technology.

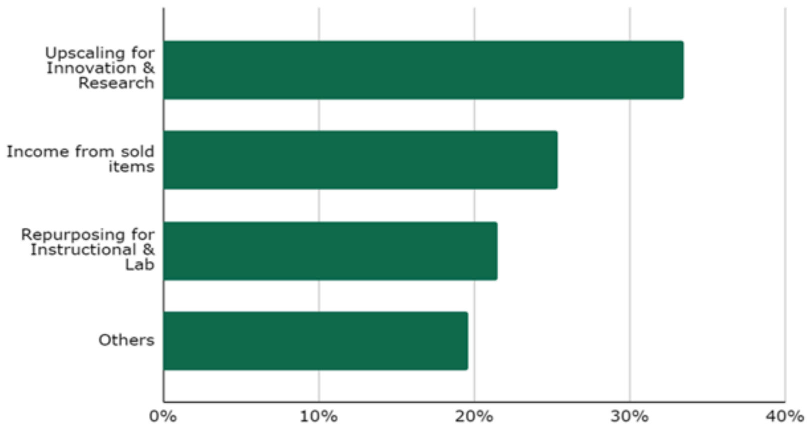

Figure 2. *Benefits of e-waste in the institution.*

In addition to spreading information about environmental challenges, environmental education for sustainable development also enhances the value of ecology to foster problem-solving abilities and improve attitudes and views of ecosystems (Liu & Guo, 2018). As a leader in innovation, MSU-IIT could offer premier environmental education on the synergy of e-waste and green technology development, improving not just the knowledge, skills, and attitudes of its constituents but offering change to the whole country as well.

E-waste management in MSU-IIT

E-waste handling

The university practices a Memorandum Receipt (MR)-system for the ICT equipment issued to the faculty or staff (Figure 3). The "MR system" is the standardized procedure that the institution implements to ensure accountability and accurate documentation of the distribution of EEE inside the institute. Once the equipment or product issued to certain faculty or staff reaches its end-of-life, they are responsible for requesting its condemnation in the Supply Office. However, the condemnation process takes time. One informant said, *"the slow process of condemnation of EEE ends up storing e-waste in the offices, departments' stock rooms, and sometimes in hallways."* If an employee retires, they must turn over their equipment to a senior official in the office so that the institution can continue to track it down. But occasionally, there are discarded EEE that have not been transferred to a senior official of a retired employee, therefore e-waste is stored in specific offices. The log in the MR system calls for a re-evaluation of the process to strengthen its implementation and further avoid this scenario. Ratification of the system could also expedite the accounting of e-waste subjected to probable upcycling, take-back, or disposal.

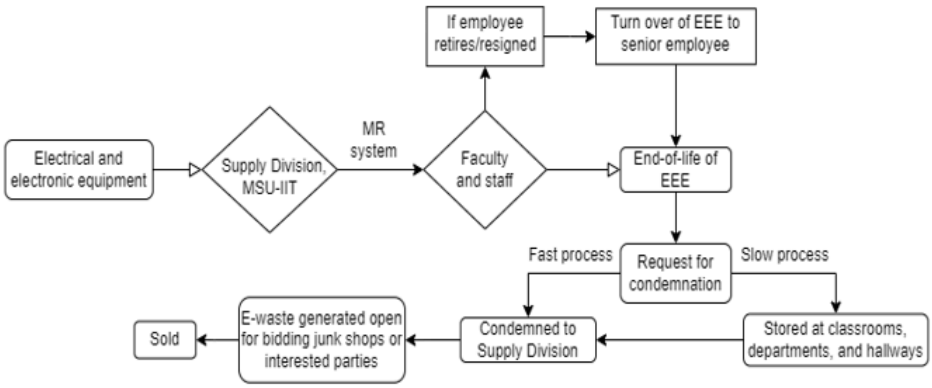

Figure 3. *Pathway of EEE to e-waste generation in MSU-IIT.*

E-waste collection and disposal

Most of the e-waste generated in the university are system units, laptops, printers, monitors, and other ICT equipment. Additionally, the solid wastes generated on the campus are delivered to the sanitary landfill of the city. Some of the hazardous waste is disposed of to the landfill which is stored in a “tank”. However, most of the hazardous waste that is not delivered to the landfill is either burned by the utility workers or personally disposed of by the students who generate the waste. Unfortunately, some of these hazardous wastes are mostly chemicals or waste used in laboratories.

Further, the supply office receives most of the bulky, condemned e-waste. These are thereafter put up for sale or bidding to various junk shops and interested parties. The office reported that they earned ~Php 352,200 in 2022 from generally condemned wastes such as e-waste, books, containers, and others. The e-waste sold in this year (2022) was from those generated and stored starting in 2018. To note, this activity occurs only every two to three years depending on the quantity of waste to be auctioned, entailing that the university must assign a dedicated and appropriate storage facility for these hazardous wastes. For this study, however, the location of the campus’ general storage facility for e-waste was not disclosed. Nonetheless, the university should take aggressive action in addressing this matter; identifying a dedicated facility for these types of wastes. Prior environmental evaluation of the proposed area must also be carried out to ensure environmental safety, as well as training and capacity building of the staff to be assigned to manage this facility must also be conducted.

Conclusion

The study emphasizes the need for improved e-waste management systems and awareness in the institution, recognizing that although environmental knowledge influences attitude, it is not enough to promote environmentally friendly practices since there is still a lack of knowledge on the formal recycling methods, and policies and legislation on e-waste management. This highlights the need for further environmental education and initiatives such as e-waste recycling seminars, programs, and activities. Fortunately, these students showed an interest to actively participate in efforts to develop efficient electronic waste management in the institution and are eager to learn about proper methods of disposing of electronic trash and the associated risks. Additionally, the facility should ought to set an emphasis on raising awareness by conducting workshops, seminars, and other pertinent events where students may learn about electronic waste management. This justifies the dissemination of information on electronic waste management more widely, especially to those at the grassroots level—faculty and staff who often use EEE, and students enrolled in the institution—in order to ensure effective implementation. With this, the institution can build a sustainable environment and gain income from e-waste which helps in providing a safe educational environment.

The university could also consider initiating collaborative efforts with local authorities, NGOs, partner industries, and other institutions to develop comprehensive e-waste management systems that facilitate proper handling and recycling. Through this, improved e-waste management practices may be achieved, minimize environmental hazards, and foster a culture of responsible EEE consumerism. Achieving the SDG 2030 Agenda is also contingent on this, particularly SDG 11 for sustainable cities and communities, and SDG 12 for responsible consumption and production. SDG 12.4 has the most potential synergy in accelerating the SDG implementation which focuses on the management of chemicals and waste.

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