KNOWLEDGE AND DISPOSAL PRACTICES OF E-WASTE AMONG POLYTECHNIC ENGINEERING STUDENTS IN MALAYSIA

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ABSTRACT

Objective: This study examines knowledge and disposal practices of electronic waste (e-waste) among diploma-level engineering students in Malaysian polytechnics.
Research Method: Data were collected via an online Google Form from three polytechnics which are Politeknik Tuanku Sultanah Bahiyah (PTSB), Politeknik Seberang Perai (PSP), and Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). A total of 182 valid responses were obtained, with the instrument demonstrating excellent reliability (Cronbach's α = 0.98).
Findings: The results indicate that most students were able to define e-waste (83.5%) and recognise its health risks (83.0%), but fewer understood its chemical hazards (38.5%). For disposal behaviour, students showed the highest tendency to send damaged electronics to authorised collection centres (M = 3.54, SD = 1.25), yet unsafe practices such as discarding small items into general trash remained common (M = 3.30, SD = 1.33). A clear gradient was observed where students with higher knowledge demonstrated safer disposal practices.
Originality: While most studies on e-waste awareness have focused on university students, research involving polytechnic learners remains very limited. Polytechnic engineering students represent a more hands-on and technically oriented group, whose practical training may shape their disposal habits differently. By highlighting this underexplored population, the study contributes new evidence on how future technicians and engineers in Malaysia understand and manage e-waste, offering a more applied perspective to environmental education research.
Keywords: e-waste, knowledge, disposal practices, engineering students.

1. INTRODUCTION

The rapid growth of technology has greatly improved daily life but also created one of the world's fastest-growing waste streams; electronic waste (e-waste). Discarded items such as phones, computers, and household appliances contain both valuable and hazardous materials. When not properly managed, e-waste can release toxic substances like lead and cadmium, causing air, water, and soil pollution and posing serious health risks (Brindhadevi et al., 2023; Sangwijit et al., 2025). In Malaysia, the increase in electronic device usage has made e-waste management a growing concern. Although the government has introduced initiatives such as the *Household E-Waste Take-Back Program* and licensed collection centres, many users still dispose of small electronics in normal rubbish bins. This shows that awareness alone may not be enough to ensure safe disposal practices (Forti et al., 2022).

Previous studies have mostly focused on university students, while little is known about polytechnic students; a group that is more technical and hands-on in nature. Their training as future technicians and engineers may shape how they understand and manage e-waste differently. Studying this group can provide a more practical and industry-related view of e-waste behaviour in Malaysia's technical education setting. Therefore, this study aims to examine the level of knowledge and disposal practices of e-waste among diploma-

level engineering students in Malaysian polytechnics. It focuses on three aspects: students' understanding of e-waste and its impacts, their disposal habits and preferred channels, and the link between knowledge and disposal behaviour. The research addresses three main questions: (1) What is the level of e-waste knowledge among polytechnic engineering students? (2) How do they manage and dispose of e-waste items? and (3) Is there a relationship between knowledge and disposal behaviour?

2. LITERATURE REVIEW

Electronic waste (e-waste) has become one of the fastest-growing waste streams worldwide, fuelled by rapid technological innovation, urbanisation, and shorter product life cycles (Forti et al., 2022). Although e-waste contains valuable recoverable resources such as gold, copper, and rare earth metals, unsafe disposal practices release hazardous substances including lead, cadmium, and brominated flame retardants into the environment (Brindhadevi et al., 2023). Such contamination contributes to soil and water pollution, while prolonged exposure has been associated with respiratory problems, renal impairment, and neurological disorders (Sangwijit et al., 2025). Consequently, understanding the management of e-waste is crucial to evaluating its broader environmental, socio-economic, and public health impacts, both locally and globally.

2.1 GLOBAL SCENARIO

Globally, the generation of electronic waste (e-waste) has accelerated at an unprecedented rate, making it one of the fastest-growing waste streams worldwide. The Global E-waste Monitor 2022 reported that over 53.6 million tonnes of e-waste were generated in 2019, with projections exceeding 74 million tonnes by 2030 if current trends persist (Forti et al., 2022). A systematic review by Cucuzzella et al. (2024) revealed that although life cycle assessment (LCA) studies increasingly evaluate the environmental burdens of e-waste, most waste is still processed informally in low- and middle-income countries. Informal practices, such as open burning and acid leaching, often release hazardous pollutants into soil, water, and air, intensifying global environmental challenges. These findings underscore the urgent need for a paradigm shift towards circular economy models, stronger international cooperation, and sustainable product design to mitigate the escalating risks of e-waste.

Recent developments indicate growing international concern and media attention towards the issue. AP News (2024) highlighted that informal recycling hubs in Southeast Asia expose workers and surrounding communities to severe health risks, including lead and cadmium poisoning. Brindhadevi et al. (2023) further emphasized that poorly managed extraction and recycling activities continue to expose populations in Vietnam and other countries to toxic metals, with long-term impacts on human health. Collectively, these accounts demonstrate that while e-waste offers opportunities for material recovery, inadequate management and regulation at the global scale continue to pose severe environmental and health threats.

2.2 MALAYSIAN SCENARIO

Malaysia faces similar challenges to the global trend, with a sharp increase in e-waste generation over the past two decades. Between 2005 and 2023, Malaysia generated approximately 2.62 million tonnes of e-waste, yet only around 21% was officially recovered in 2023 (Malay Mail, 2025). Existing legislation such as the Environmental Quality (Scheduled Wastes) Regulations 2005 primarily covers industrial e-waste, while household and institutional waste streams remain insufficiently regulated. Empirical studies reveal that while public awareness and attitudes toward e-waste are relatively high, actual practices remain inconsistent. Yahya et al. (2022) found that communities in Selangor with higher education levels and female respondents demonstrated greater knowledge of e-waste recycling. Similarly, Tukiman and Mustaffa (2021) reported that knowledge and attitudes positively correlated with e-waste disposal practices in Tebrau, Johor, but many residents

lacked access to formal recycling facilities. More recent findings in Penang suggest that government influence, subjective norms, and moral obligation significantly shaped e-waste management awareness, while knowledge alone was not a strong predictor of sustainable behaviour (Goh and Sukri, 2025).

Malaysia's e-waste challenge is further compounded by gaps in legislative coverage and institutional enforcement. Shad, Ling, and Karim (2020) highlighted that Malaysia's regulatory framework, while guided by the Environmental Quality (Scheduled Wastes) Regulations 2005, remains limited compared to more robust systems in countries like Singapore and Indonesia, particularly in addressing household-level e-waste. This gap underscores the importance of adopting international best practices and strengthening compliance with the Basel Convention to curb illegal transboundary e-waste flows (Shad et al., 2020).

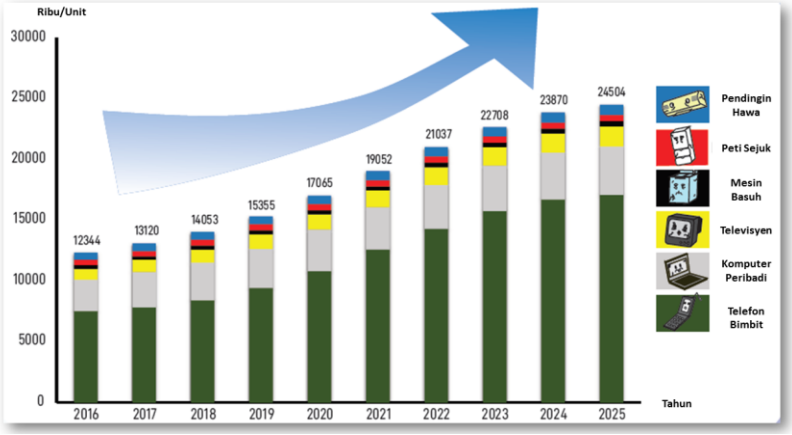

Figure 1: Projection of e-waste generation in Malaysia.
Source: (Department of Environment Malaysia, 2025)

On the socio-economic front, Omar et al. (2025) stressed that improper e-waste handling not only leads to environmental degradation but also results in economic losses, as valuable secondary raw materials such as gold, copper, and rare earth elements are not efficiently recovered. In addition, the Department of Environment Malaysia (2025) projects a steady rise in e-waste generation in the coming years, signalling the urgency for Malaysia to expand formal collection channels and strengthen enforcement at the household level (see Figure 1). Complementing these insights, Malaysia's waste management system continues to face structural barriers such as inadequate infrastructure, weak enforcement, and limited incentives for participation in formal recycling. Collectively, these findings indicate that while Malaysia has made progress, holistic interventions that integrate legal reform, economic incentives, and behavioural change are urgently needed.

2.3 IMPACT ON HEALTH

The health impacts of e-waste mismanagement are becoming increasingly evident across Southeast Asia. In Malaysia, a recent wastewater-based epidemiology study in Sungai Petani detected elevated concentrations of iron, nickel, zinc, and cadmium in all samples, indicating widespread community exposure to hazardous heavy metals (Ruzi et al., 2024). Despite this, there remains a notable gap in Malaysian research that directly links contamination to e-waste dumping or informal recycling sites, particularly concerning organic pollutants and electronic components. This underscores the need for targeted field investigations in such contexts. Regionally, Sangwijit et al. (2025) conducted a cross-sectional study in Thailand and reported significantly higher urinary lead and cadmium levels among e-waste workers compared to nearby residents, with associated health outcomes such as musculoskeletal pain, neurological disorders, sleep disturbances, and anxiety. Similarly, Brindhadevi et al. (2023) highlighted that uncontrolled e-waste recycling

and metal extraction practices in Vietnam exposed surrounding populations to toxic elements including lead, cadmium, and mercury, which are linked to renal impairment, respiratory illnesses, and neurotoxicity. Taken together, these findings suggest that inadequate e-waste management presents not only serious environmental risks but also substantial and long-term threats to public health.

3. METHODOLOGY

This study adopted a non-probability convenience sampling method to investigate the knowledge and practices of e-waste management among diploma-level engineering students in Malaysian polytechnics. The method was appropriate given the accessibility of respondents and the study's exploratory nature, allowing efficient data collection across multiple campuses while representing the target group within Malaysia's technical education system. The research framework was guided by the Knowledge, Attitude, and Practice (KAP) model (Launiala, 2009), focusing only on the Knowledge (K) and Practice (P) components to assess students' understanding and disposal behaviours.

A self-developed questionnaire was designed, informed by the KAP framework and previous e-waste studies (Yahya et al., 2022; Tukiman and Mustaffa, 2021; Yaacob et al., 2025) as well as official guidelines from the Department of Environment Malaysia (2025). The instrument measured knowledge and practices related to e-waste through structured items.

The knowledge section contained ten objective questions with dichotomous scoring (1 = correct, 0 = incorrect). Total scores were converted into percentages and classified into three categories based on Malaysian grading standards (MOE, 2019), as shown in Table 1.

Table 1: Categorisation of Knowledge Scores

Category	Score Range	Level Description
Low	0–49%	Poor knowledge
Moderate	50–79%	Basic knowledge
High	80–100%	Good knowledge

Source: (Ministry of Education, 2019)

The practice section consisted of ten Likert-scaled items (1 = never, 5 = always), assessing behaviours such as recycling, storage, and use of formal collection channels. Higher mean scores reflected more sustainable practices. The full structure of the questionnaire is summarised in Table 2.

Table 2: Structure of the Questionnaire

Section	Description	Number of Items	Focus
A	Demographic Information	5	Gender, age, programme, year of study, polytechnic
B	Knowledge of E-waste	10	Definition of e-waste, hazards, regulations, recycling channels
C	Practices of E-waste Disposal	10	Recycling behaviour, storage, disposal methods, use of formal channels

The study targeted diploma-level engineering students from three polytechnics: Politeknik Tuanku Sultanah Bahiyah (PTSB), Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS), and Politeknik Seberang Perai (PSP). A total of 182 valid responses were collected through Google Forms using convenience sampling. Although the sample size was below the 357 recommended by Krejcie and Morgan (1970) for populations exceeding 5,000, it was deemed sufficient for descriptive research due to the relative homogeneity of the student population (Cohen et al., 2007).

A pilot test involving 10 students was conducted to ensure clarity and reliability of the instrument. The practice scale achieved a Cronbach's alpha of 0.98, which indicates excellent internal consistency and exceeds the minimum threshold of 0.70 (Tavakol and Dennick, 2011). Ethical considerations were observed, including voluntary participation, informed consent via the survey preamble, and guaranteed anonymity of responses.

Data were exported from Google Forms into Microsoft Excel for cleaning and analysis. Descriptive statistics were used to summarise findings. For knowledge, item-level frequencies and percentages were calculated, and respondents' total scores were grouped into Poor Knowledge, Basic Knowledge, and Good Knowledge categories (see Table 1). The overall mean knowledge score was also reported. For practice, item mean and standard deviations were computed, and an overall practice mean was derived. Reliability statistics were reported from the pilot test. The use of descriptive analysis was considered appropriate, as the study aimed to provide a baseline understanding of students' knowledge and practices rather than predictive or inferential insights (Cohen, Manion, and Morrison, 2007).

4. RESULTS AND DISCUSSIONS

This section presents and discusses the main findings of the study, focusing on four key aspects: the demographic profile of respondents, their level of knowledge on e-waste management, their disposal practices, and the relationship between knowledge and practice. The analysis provides insight into how well polytechnic engineering students understand e-waste and how this understanding influences their actual disposal behaviour, offering an overview of their awareness and commitment toward sustainable waste management.

4.1 DEMOGRAPHIC

The demographic information of the respondents is presented in Table 3. Demographic information is important as it provides an overview of the respondents' background and characteristics.

Table 3: Respondents Demographic Information

Variable	Category	Frequency (n)	Percentage (%)
Institute	PTSB	159	87.4
	POLIMAS	14	7.7
	PSP	9	4.9
Programme	Civil Engineering	136	74.7
	Other Engineering Disciplines	46	25.3
Semester	Early (1–3)	114	62.6
	Late (4–6)	68	37.4
Ethnicity	Malay	153	84.1
	Chinese	8	4.4
	Indian	19	10.4
	Siam	2	1.1
Gender	Male	92	50.5
	Female	90	49.5
Total Respondents		**182**	**100.0**

Table 3 summarises the demographic profile of respondents. The majority were from Politeknik Tuanku Sultanah Bahiyah (PTSB, 87.4%) and enrolled in Civil Engineering programmes (74.7%). Most students were Malay (84.1%) and evenly distributed by gender (50.5% male; 49.5% female). A larger portion (62.6%) were in their early semesters (1–3),

reflecting students at the formative stage of technical education. Overall, the demographic distribution reflects a diverse yet balanced representation of polytechnic engineering students, predominantly from the civil engineering field. Although demographic factors were not statistically analysed, patterns appeared consistent across gender and semester levels.

4.2 KNOWLEDGE ON E-WASTE MANAGEMENT

The assessment of students' knowledge was measured using ten questions related to their understanding of the definition, classification, chemical composition, impacts, and appropriate management of e-waste and the score is shown in Figure 2.

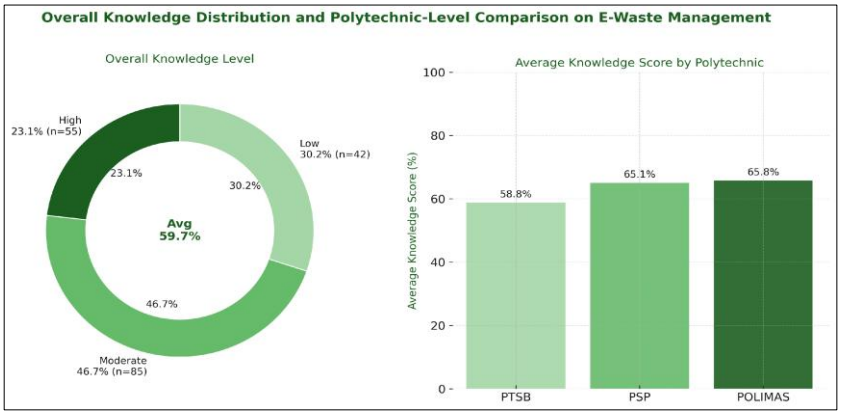

Figure 2: Engineering Students' Knowledge Level

As presented in Figure 2, the overall level of e-waste knowledge among diploma-level engineering students was moderate, with an average score of 59.7%. Out of 182 respondents, 46.7% demonstrated a moderate level, 30.2% a low level, and only 23.1% a high level of knowledge. This distribution suggests that while most students are familiar with e-waste as a general concept, their understanding remains uneven across specific knowledge domains. At the institutional level, a small variation was observed where POLIMAS (65.8%) and PSP (65.1%) recorded slightly higher average scores compared to PTSB (58.8%). These differences may be attributed to variations in exposure to sustainability-related activities, course emphasis, or campus-level environmental initiatives. Nonetheless, all three institutions reflected a similar pattern of basic conceptual awareness rather than detailed technical understanding. Item-level responses showed that students were able to identify small electronic devices such as mobile phones and laptops as e-waste, yet many were less aware that larger household appliances (e.g., washing machines, refrigerators) are also classified as e-waste under Malaysia's Department of Environment (DOE) guidelines. Uncertainty was also noted regarding the toxic elements found in discarded electronics—such as lead, mercury, and cadmium—and their long-term environmental and health risks. These gaps indicate that students' knowledge is primarily surface-level, focusing more on what e-waste is rather than how it affects ecosystems or human well-being.

The findings are consistent with previous studies showing moderate awareness and limited depth of understanding among Malaysian students (Rahman and Hassan, 2023; Shafie et al., 2022; Mohamed Nazree et al., 2022) and similar global patterns (Tuncay and Williams, 2021; Garg et al., 2023). The moderate knowledge level could be linked to the limited inclusion of e-waste topics within the polytechnic curriculum and the lack of continuous institutional awareness campaigns. As Forti et al. (2020) emphasised, education and awareness are critical for bridging the gap between knowing and acting. Therefore, strengthening sustainability education, incorporating practical recycling modules, and establishing visible on-campus e-waste collection systems could significantly enhance students' understanding and support Malaysia's broader vision of achieving Carbon Neutral

2050.

4.3 E-WASTE DISPOSAL PRACTICES

The students' e-waste disposal practices were assessed using 10 items designed to evaluate their real-life behaviour in handling, storing, and disposing of electrical and electronic waste. Table 4 displays the mean and standard deviation (SD) for each item, arranged in descending order to highlight the most to least commonly practiced behaviours among respondents.

Table 4: E-Waste Disposal Practices

No.	E-Waste Disposal Practice Item	Mean	SD
1	I collect broken electrical or electronic items and dispose of them at designated e-waste collection points.	3.54	1.25
2	I send large electronic items such as televisions, refrigerators, and washing machines to second-hand or scrap shops.	3.52	1.21
3	I send e-waste such as computers, printers, mobile phones, chargers, and other broken devices to designated e-waste collection centres.	3.51	1.17
4	I keep damaged electrical and electronic items such as computers, laptops, printers, and mobile phones in the store at home.	3.44	1.20
5	I sell broken electrical or electronic items as scrap materials.	3.43	1.25
6	I send damaged electronic items such as computers, laptops, printers, and mobile phones to scrap shops.	3.43	1.25
7	I dismantle or remove components from electronic devices before throwing them into the dustbin.	3.40	1.30
8	I throw away small e-waste such as batteries, earphones, and phone chargers into the dustbin.	3.30	1.33
9	I only store damaged electrical and electronic items at home.	3.25	1.33
10	I dispose of broken electrical and electronic items into large roadside garbage bins.	2.95	1.44
	Average Mean	3.38 (67.6%) (Moderate)	1.27

The findings indicate that students demonstrated moderate e-waste disposal practices (M = 3.38, SD = 1.27). Respondents were most likely to adopt positive actions such as sending damaged items to authorised collection centres (M = 3.54) or scrap shops (M = 3.52). However, less desirable habits remained, including keeping non-functional devices at home (M = 3.44) and discarding small items like batteries or earphones in regular trash (M = 3.30). This pattern suggests that while students are aware of proper disposal methods, awareness has not yet developed into fully consistent behaviour. These results align with previous Malaysian studies showing that students possess fair knowledge but face barriers to recycling, such as limited access to certified collection points and weak institutional support (Rahman and Hassan, 2023; Shafie et al., 2022; Mohamed Nazree et al., 2022). International evidence shows similar tendencies: in Australia, for instance, structured campus drop-off programmes encouraged regular participation (Tuncay and Williams, 2021), while in India, students recycled more when convenient systems were available (Garg

et al., 2023). Collectively, these findings confirm that practice levels depend not only on knowledge but also on infrastructure and behavioural incentives (Forti et al., 2020).

The moderate practice score observed in this study represents a transitional stage—students generally know what should be done but are hindered by logistical and behavioural constraints. Cultural habits of hoarding old electronics "just in case" also contribute to passive storage rather than active recycling. To strengthen behaviour change, polytechnics could implement on-campus collection drives, reward-based recycling campaigns, and integrate sustainability modules within engineering curricula. In summary, Malaysian polytechnic students show encouraging but still inconsistent participation in responsible e-waste disposal, highlighting the need for both educational engagement and infrastructural support to advance national sustainability goals and Malaysia's Carbon Neutral 2050 agenda.

4.4 RELATIONSHIP BETWEEN KNOWLEDGE AND DISPOSAL PRACTICES

To further understand how awareness influences behaviour, this study examined the relationship between students' knowledge levels and their actual e-waste disposal practices. Figure 3 presents the comparative pattern showing how higher knowledge scores correspond to safer and more responsible disposal behaviours among polytechnic students.

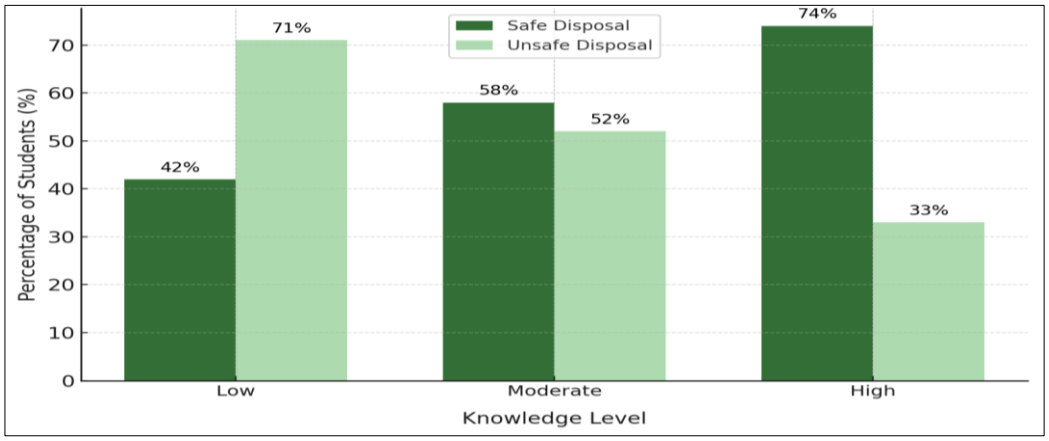

Figure 3: Relationship between knowledge level and e-waste disposal practices among polytechnic engineering students.

The analysis examined how students' knowledge of e-waste relates to their disposal behaviour. As shown in Figure 3, students with higher knowledge levels were more likely to practise responsible disposal, such as sending damaged electronics to authorised collection centres. About 74% of high-knowledge students reported safe disposal, compared to 58% of moderate and 42% of low-knowledge respondents. In contrast, unsafe habits such as discarding small electronic items in general waste declined as knowledge increased, indicating a positive relationship between knowledge and practice. This pattern further validates the Knowledge–Attitude–Practice model underlying this study.

These findings partially support the Knowledge–Attitude–Practice (KAP) framework, which proposes that greater knowledge encourages better behaviour. However, the link was not absolute. Some well-informed students still engaged in unsafe practices, reflecting the common knowledge–behaviour gap noted in earlier studies (Shamim et al., 2022; Singh and Chow, 2024). External barriers such as limited access to collection facilities, convenience, and social habits likely influence behavioural outcomes. This suggests that campus-based learning and awareness activities can promote consistent action. Overall, enhancing knowledge remains necessary but insufficient; effective improvement requires education, infrastructure, and motivation working together to bridge the gap between understanding and practice.

5. CONCLUSIONS

This study examined Malaysian polytechnic engineering students' knowledge of e-waste management and their disposal practices. Overall, respondents demonstrated moderate knowledge (M = 59.7%) and moderate levels of practice (M = 3.38), indicating a persistent gap between awareness and actual behaviour. Although many students recognized the environmental and health risks associated with improper e-waste disposal, a substantial proportion still stored unused devices or discarded smaller items in general waste streams. The results therefore suggest that knowledge, on its own, does not reliably translate into sustainable action.

The findings further indicate that behaviour is strongly shaped by structural and contextual constraints, including limited infrastructure, convenience barriers, and weak institutional mechanisms. Consequently, strengthening student e-waste management requires a systemic and participatory approach rather than stand-alone awareness initiatives. Polytechnics can serve as effective enablers of change by: (1) establishing accessible, well-structured e-waste collection systems in collaboration with certified recyclers; (2) integrating sustainability-focused content and hands-on, experiential projects into engineering curricula; (3) implementing incentive-based recycling schemes to reinforce responsible disposal; and (4) cultivating a campus culture that normalizes proper e-waste practices through peer-led initiatives and digitally supported campaigns.

Overall, the study underscores that narrowing the knowledge–practice gap depends on aligning education, infrastructure, and behavioural motivation. By positioning polytechnics as catalysts for sustainability, Malaysia can develop a technically competent generation that not only understands environmental responsibility but also consistently applies it in everyday practice. This is an essential step toward advancing a circular economy and supporting the national Carbon Neutral 2050 agenda.

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