Intention to Recycle E-Waste Among TVET Institution Practitioners: Analysing Factors Using Partial Least Squares Structural Equation Modelling

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Abstract

The widespread adoption of electronic devices has enhanced modern lifestyles but also accelerated the generation of electronic waste (e-waste) due to shorter product lifespans. To address this challenge, an e-waste collection centre was established at Polytechnic Sultan Haji Ahmad Shah (POLISAS). However, limited utilisation of the collection box has resulted in low e-waste recovery compared to the institution's high gadget usage. This study investigates the behavioural factors influencing e-waste recycling intentions among POLISAS staff, focusing on environmental knowledge, attitudes, and subjective norms. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), data from 85 staff members were analysed. Results indicate a strong intention to recycle e-waste (mean = 4.109), with attitudes and subjective norms showing significant positive correlations with recycling intentions. However, environmental knowledge and awareness were not significant predictors. From an engineering standpoint, these findings suggest that effective e-waste management systems must prioritise social and behavioural drivers. Engineering solutions could include optimising collection infrastructure, integrating user-friendly systems, and leveraging social influence through strategic campaigns. These approaches are critical for enhancing recycling rates in educational institutions and addressing the broader issue of e-waste. This research highlights the importance of engineering systems designed to support and promote sustainable behaviours, contributing to improved e-waste management and fostering environmentally responsible practices within institutional settings.

Keywords: Attitude, Environmental Awareness and Knowledge, E-Waste, Subjective Norm and Intention, Sustainability

1.0 Introduction

Electronic devices such as smartphones, tablets, and laptops have become integral to modern living, facilitating communication, boosting productivity, and enabling entertainment. However, these devices' rapid technological advancements and shorter lifecycles contribute to a surge in electronic waste (e-waste) generation. This issue is particularly significant in Malaysia, where

the increasing population and consumer demand for electronics amplify the challenge.

E-waste encompasses discarded or obsolete electronic equipment, including computers, smartphones, printers, chargers, televisions, and home appliances such as washing machines and refrigerators. According to the Malaysian Department of Environment (DOE), e-waste is classified as "wastes from electrical and electronic assemblies containing components like accumulators, mercury switches, and other materials contaminated with hazardous substances such as cadmium, lead, and mercury" [1].

Improper disposal of e-waste introduces severe environmental and health risks. Toxic substances in e-waste can leach into soil and groundwater, polluting ecosystems and exposing humans and wildlife to harmful chemicals. Research by Dhir et al. [2] highlights how the accumulation of heavy metals like lead and mercury from e-waste contributes to environmental degradation, impacting air quality, vegetation, and overall public health. In Malaysia, the urgency to address these challenges is underscored by the rising volume of e-waste and its improper disposal in landfills, rivers, and illegal dumpsites. Proper recycling prevents hazardous substances like lead, mercury, and cadmium from contaminating soil and water, protecting ecosystems and public health. Establishing accessible collection centres, raising public awareness, and enforcing strict regulations are essential to promoting effective e-waste recycling practices. Figure 1 shows a general overview of processes in e-waste recycling [3].

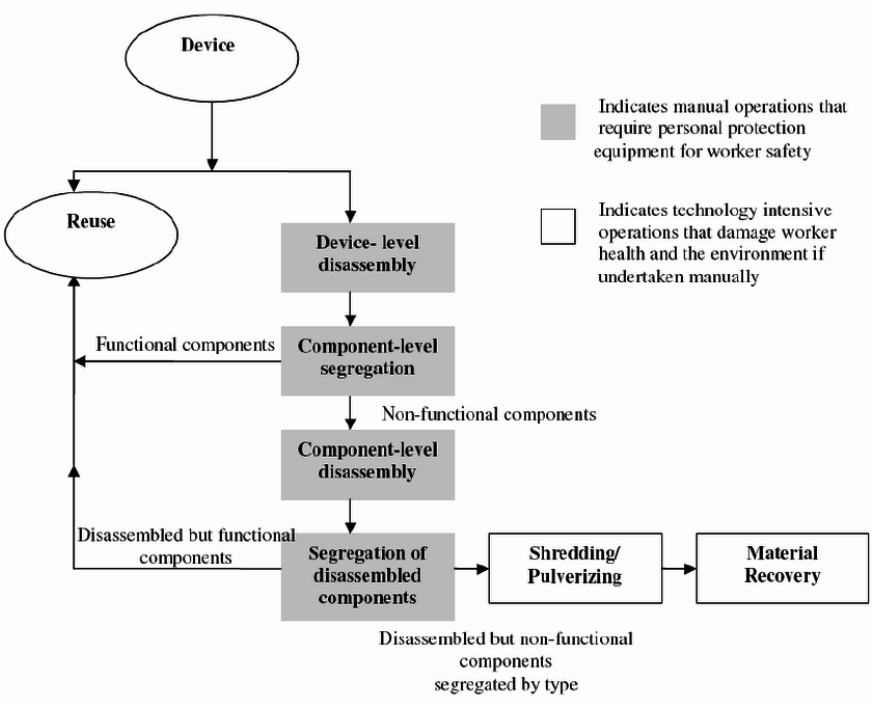

Figure 1: Processes in E-waste recycling

Malaysia's Environmental Quality Act 1974 (Code SW110) mandates the segregation of e-waste from general waste to promote environmental

sustainability and protect public health. Yet, studies reveal gaps in the country's e-waste management systems. Mahat et al. [4] observed that insufficient collection facilities and limited public knowledge often lead to improper disposal practices, such as mixing e-waste with household garbage or discarding it in rivers. While over half of Malaysian youth recognize the hazards of e-waste, a significant proportion still hoard these items due to inadequate recycling infrastructure and awareness.

To address these issues, the DOE has introduced incentives and campaigns to encourage proper e-waste disposal. Malaysian citizens are encouraged to dispose of e-waste through licensed collectors or facilities. Figure 2, illustrates recommended steps for proper e-waste management [1]. One notable effort is the Smartgreen POLISAS initiative, launched by Polytechnic Sultan Haji Ahmad Shah (POLISAS) in collaboration with the DOE and Senheng Electric Sdn Bhd. This program establishes e-waste collection centres and raises public awareness about responsible disposal.

Despite these initiatives, Malaysia's household e-waste recycling rate remains under 25%, far below the national average recycling rate of 36.67% [1]. With projections estimating over 24.5 million units of e-waste generated annually by 2025, the gap in effective recycling infrastructure and public participation must be urgently addressed.

POLISAS has taken a proactive stance by placing e-waste collection boxes within its facilities (Figure 3, located in the lobby of the administration building at POLISAS). However, their effectiveness is hindered by low participation. Observations reveal that the collection box, situated in the administration building's lobby, often remains underutilized. This raises questions about whether the lack of awareness or motivation prevents individuals from recycling e-waste.

Figure 2: E-waste management

Figure 3: E-waste box collection

The current study aims to explore the behavioral factors influencing e-waste recycling intentions among POLISAS staff. By examining the roles of environmental knowledge, awareness, attitudes, and subjective norms, the study seeks to identify barriers and opportunities for improving e-waste recycling practices within the institution.

The mounting e-waste crisis in Malaysia underscores the importance of integrating robust management strategies, public awareness, and technological interventions. By addressing behavioural and infrastructural gaps, initiatives like Smartgreen POLISAS can drive higher recycling rates and mitigate environmental and health risks associated with e-waste. Collaboration between government agencies, academic institutions, and the private sector remains critical in fostering sustainable e-waste management practices nationwide.

Building on the Theory of Planned Behavior (TPB), which has demonstrated efficacy in predicting recycling behaviours [5], this study integrates engineering and behavioural perspectives to enhance e-waste management practices. TPB extends the Theory of Reasoned Action (TRA) [5], offering a robust framework for understanding the psychological factors influencing intentions and behaviours across diverse domains. By combining technological solutions with insights into environmental knowledge, attitudes, and subjective norms, this research aims to advance sustainable e-waste management in Malaysia, with a focus on the POLISAS community.

This study seeks to evaluate how environmental knowledge and awareness about e-waste hazards influence recycling behaviour among POLISAS citizens. Awareness often serves as a precursor to more profound knowledge. Research on Selangor's community showed that raising awareness positively correlates with understanding proper disposal methods and encouraging recycling behaviour [6]. Similarly, Nduneseokwu, Ying, and Appolloni

demonstrated that environmental knowledge enhances participation in formal e-waste collection systems [7]. However, a study among UiTM students found limited knowledge about e-waste management, despite some awareness of its dangers [8].

The study also explores how positive or negative attitudes toward e-waste recycling shape behavioural intentions. Attitude significantly affects recycling practices, as favourable attitudes are more likely to result in action. Razali et al. reported that favourable attitudes among Malaysian households promoted waste separation, improving recycling rates and reducing landfill dependence [9].

Finally, the study analyzes how perceived social pressures influence recycling behaviours. Subjective norms, reflecting societal expectations, have been found to significantly impact recycling behaviour in other regions [10]. However, findings in Malaysia remain inconclusive; Afroz et al. observed that subjective norms had limited influence on household e-waste recycling behaviours [6].

By integrating behavioural insights with engineering solutions, this study underscores the importance of optimizing collection box placement, improving infrastructure, and running targeted awareness campaigns to increase e-waste recycling rates. The findings contribute to a comprehensive model for sustainable e-waste management, with implications for policymakers, institutions, and private sector stakeholders working collaboratively to address Malaysia's e-waste crisis.

2.0 Methodology

This study employed a quantitative approach, targeting both academic and non-academic staff at Polytechnic Sultan Haji Ahmad Shah (POLISAS) in Pahang. Data collection was conducted online from April to June 2024, with a total of 85 respondents completing the survey. The questionnaire was available in both Bahasa Malaysia and English and was divided into two sections. The first section gathered information on the socio-economic conditions of respondents, while the second section focused on evaluating the constructs of the independent variables.

The dependent variable in this study is the intention of respondents to recycle e-waste. All items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire was distributed online via a link and a QR code for easy access. Items were adopted and adapted from Afroz et al. [6].

3.0 Data Analysis

Structural Equation Modelling (SEM) using SmartPLS 4.1.0.4 was employed in this study. SEM was chosen due to the relatively small sample size (less than 100), non-normal data distribution, and the study's focus on predicting relationships between independent and dependent variables [11], [12].

Although the sample size was only 85 (representing a 49% response rate), it was deemed sufficient for this analysis, as Saunders, Lewis, and Thornhill recommend a minimum level of 30 to 50% [13]. Thus, SmartPLS-SEM was considered appropriate and well-suited to the study's objectives.

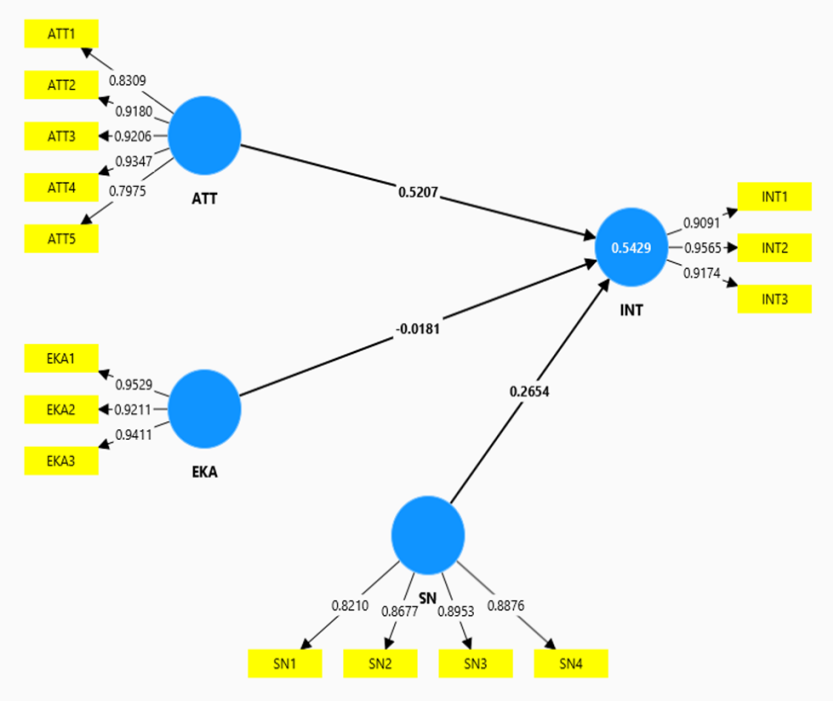

Figure 3: Research model

3.1 Respondent Demographics

Table 1 shows that the majority of respondents were female (62%). Most respondents (59%) were between 35 and 44 years old, followed by those aged 45 to 54 (27%) and those over 55 (11%). Only 2% of respondents were under 34. The sample largely comprised individuals pursuing higher education. Additionally, 93% of respondents were married (79 individuals), while 7% (6 individuals) were unmarried.

Table 1: Respondent profile

Items	Description	Frequency	Percentage (%)
Gender	Male	23	23
	Female	62	62
Age	<24	0	0
	25-34	2	2
	35-44	50	59
	45-54	24	27
	>55	9	11
Education	Higher	82	96
	High School	3	4
	Primary School	0	0
	No Formal	0	0
Status	Single	6	7
	Married	79	93

3.2 Research Objective 1: The Level of Intention to Recycle E-Waste

Descriptive analysis indicates a mean score of 4.10 with a standard deviation of 0.86, as shown in Table 2. Following [14], this score reflects a high level of awareness regarding the intention to recycle e-waste among POLISAS citizens.

Table 2: Mean for level of intention

Variable	Mean	Standard Deviation
Intention	4.10	0.86

3.3 Research Objective 2: Relationship Between Environmental Knowledge and Awareness, Attitude, and Subjective Norms Toward the Intention to Recycle E-Waste

The hypothesis was tested using PLS-SEM, with three assessment criteria applied before hypothesis testing: internal consistency reliability, convergent validity, and discriminant validity.

3.3.1 Measurement Model

The measurement model is a prerequisite for testing the hypotheses. According to Hair et al. [15], the accepted thresholds for factor loadings, composite reliability (CR), and average variance extracted (AVE) are >0.5, >0.7, and >0.5, respectively, to measure convergent validity. Table 3 presents the assessment of construct reliability and convergent validity for the variables in this study.

The CR values are as follows: 0.9307 for Attitude, 0.9002 for Subjective Norm, and 0.9364 for Environmental Knowledge and Awareness, indicating high internal consistency among these constructs. Furthermore, all constructs achieved the minimum threshold of 0.5 for AVE, demonstrating that the items account for more than 50% of the variance in each construct [12]. Therefore, the instrument is reliable, appropriate, and suitable for use in this study.

Table 3: Convergent validity

Construct	Item	Loadings (>0.5)	CR (>0.7)	AVE (>0.5)
Attitude	ATT1 ATT2 ATT3 ATT4 ATT5	0.8309 0.9180 0.9206 0.9347 0.7975	0.9307	0.7781
Subjective Norm	SN1 SN2 SN3 SN4	0.8210 0.8677 0.8953 0.8876	0.9002	0.7541
Environmental-related knowledge and awareness	EKA1 EKA2 EKA3	0.9529 0.9211 0.9411	0.9364	0.8807
Intention	INT1 INT2 INT3	0.9091 0.9565 0.9174	0.9247	0.8610

Table 4 presents the assessment of discriminant validity using the Heterotrait-Monotrait (HTMT) Ratio of Correlations, as proposed by Henseler, Ringle, and Sarstedt [16]. Discriminant validity measures the distinctiveness of constructs from one another. The results show that all values are below the recommended thresholds of HTMT 0.85 [17] and HTMT 0.90 [18], indicating established discriminant validity among the constructs. Furthermore, none of the HTMT values reached 1, which further confirms the discriminant validity [16].

Table 4: Discriminant validity (HTMT) <0.9 or < 0.85)

	Attitude	Subjective Norm	Environmental-related knowledge and awareness	Intention
Attitude				
Subjective Norm	0.8748			
Environmental-related knowledge and awareness	0.8743	0.6954		
Intention	0.7767	0.7281	0.6179	

3.3.2 Structural Model

In the structural model, it is crucial to assess lateral collinearity issues [12]. While vertical collinearity (discriminant validity) has been established, lateral collinearity must be evaluated separately for each subset of the structural model, as noted by Kock and Lynn [19]. Table 5 presents the results of the collinearity test. The VIF values for all constructs are below the threshold of 5 [12], indicating that collinearity is not a concern in this study.

Table 5: Collinearity statistics VIF

Variables	Intention
Attitude	4.9601
Subjective Norm	2.8478
Environmental-related knowledge and awareness	2.9796

Table 6 presents the results of the path coefficient assessment using the bootstrapping procedure for each hypothesized relationship in the model. The support for each hypothesis is based on three conditions: i) the direction and beta value indicate whether the relationship is positive or negative, ii) the T-value must exceed 1.645 for significance at 0.05 or 2.33 for significance at 0.01, and iii) the lower level (LL) and upper level (UL) should not include 0 [12].

From the proposed relationships, both independent variables were found to be statistically significant at a 99% confidence interval: Attitudes → Intention (beta = 0.5207, t = 2.8273, LL = 0.1617, UL = 0.8883) and Subjective Norm → Intention (beta = 0.2654, t = 2.27, LL = 0.0455, UL = 0.5038). In contrast, Environmental-related Knowledge and Awareness → Intention showed no

significance (beta = -0.0181, t = 0.1064, LL = -0.3494, UL = 0.331). Consequently, we conclude that Attitude and Subjective Norms positively influence POLISAS citizens' intentions to recycle e-waste by dropping off mobile phones at the collection box. Environmental-related Knowledge and Awareness negatively affect this intention.

Table 6: Path coefficient assessment

Relationship	Beta	T Value	P Value	LL	UL	Decision
Attitudes -> Intention	0.5207	2.8273	0.0047	0.1617	0.8883	Supported
Subjective Norm -> Intention	0.2654	2.27	0.0233	0.0455	0.5038	Supported
Environmental-related knowledge and awareness → Intention	-0.0181	0.1064	0.9152	-0.3494	0.331	Not Supported

$p < 0.01$ and $p < 0.05$

4.0 Discussion

The findings reveal that POLISAS citizens demonstrate a high level of intention to recycle e-waste by utilising the collection box. This positive trend may be attributed to increased knowledge and awareness regarding effective e-waste management, thanks to campaigns conducted by Smartgreen POLISAS. The results also support two hypotheses: attitudes and subjective norms. Specifically, attitudes positively correlate with intending to recycle e-waste. This finding aligns with previous research, including studies by Kassim et al. [20], Sabbir et al. [21], Dhir et al. [2], and Zhang et al. [22]. Similarly, Razali et al. [9] found that positive attitudes among Malaysian households encouraged participation in waste separation activities, confirming that attitudes are a significant factor influencing recycling intention among POLISAS citizens.

Subjective norms are also positively related to the intention to recycle e-waste, corroborating findings from Pradini et al. [23], Kassim et al. [20], and Vijayan et al. [10]. These results suggest that subjective norms play a crucial role in recycling intention, emphasising the need for POLISAS citizens to recognize the benefits of using the collection box, given the risks associated with improper e-waste disposal. However, the relationship between environmental-related knowledge and awareness was not supported, indicating a negative relationship between these factors and the intention to recycle e-waste. This finding is consistent with Nazree et al. [8], which found that while UiTM students grasp the concept of e-waste, they lack comprehensive knowledge regarding proper e-waste management. In contrast, other studies by Afroz et al. [6], Nduneseokwu et al. [7], and Ang et al. [24] suggest that environmental knowledge directly influences intentions to participate in e-waste collection systems.

5.0 Conclusions and Recommendations

This study examines the factors influencing e-waste recycling intentions among POLISAS citizens. The results indicate that environmental knowledge and awareness alone do not significantly drive recycling behaviour, highlighting a gap between awareness and action. In contrast, attitudes strongly affect recycling intentions, consistent with previous research showing that favourable views toward recycling enhance participation. POLISAS citizens with positive attitudes are more likely to engage in e-waste recycling. Furthermore, subjective norms reflecting social pressures and community influences significantly impact recycling behaviour. When individuals perceive that their peers support and engage in recycling, they are more inclined to participate. To bridge the gap between awareness and action, POLISAS should implement strategies that translate awareness into tangible behaviours. This may involve educational campaigns that not only inform but also actively engage citizens in recycling initiatives. Campaigns should emphasise the benefits of recycling, share success stories, and illustrate the environmental impact of proper e-waste disposal. Fostering a strong community culture through events, challenges, and rewards can further enhance participation, while influential community members can amplify support for recycling. Additionally, addressing barriers such as access to recycling facilities is essential; increasing the number of e-waste collection points, offering pick-up services, and improving communication about recycling options will facilitate greater participation. Continuous monitoring and feedback mechanisms, such as surveys and tracking participation rates, can help refine strategies over time. This study underscores the importance of targeted educational efforts and leveraging social influence to promote e-waste recycling. Positive attitudes and community norms, even in the face of limited knowledge, can significantly drive recycling behaviour. Future research should expand the sample to include students and other demographic groups while exploring additional variables to provide further insights into the factors influencing e-waste recycling intentions.

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Author Contributions

W. Z. W. Yusoff: Conceptualization, Data Collection, Supervision, Writing-Reviewing, Proofreading, and Editing; **N. Ahmad**: Data Analysis, Methodology, Software, Data Validation; **F. Osman**: Writing-Reviewing, Writing-Original, Draft Preparation Technical Content.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest in the manuscript.

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