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# WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) MANAGEMENT FOR UNIVERSITY SUSTAINABILITY: A CASE STUDY AT THE UNIVERSIDAD AUTÓNOMA DE OCCIDENTE, LOS MOCHIS REGIONAL CAMPUS (UAdeO-URLM)

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**Abstract--** The increased use of digital technologies in higher education institutions has led to a sustained rise in the production of Waste Electrical and Electronic Equipment (WEEE), which poses an environmental problem due to the presence of hazardous substances, but also presents an opportunity for material recovery under circular economy schemes. This study analyzes student perceptions of WEEE management based on a random sample of students from the Universidad Autónoma de Occidente, Los Mochis Regional Unit (UAdeO-URLM), with the aim of identifying the main institutional challenges aligned with the Sustainable Development Goals. A descriptive study was conducted using a Likert-scale questionnaire that assessed dimensions of environmental knowledge, current practices, infrastructure, willingness to change, and academic background. The reliability of the instrument was analyzed using IBM SPSS software via Cronbach's alpha coefficient. The results will help strengthen university environmental management policies and promote strategies aimed at the comprehensive management of WEEE.

Keywords-- Circular economy, Environmental management, Electronic waste, University sustainability
university.

**Abstract--** The increasing use of digital technologies in higher education institutions has led to a sustained rise in the generation of Waste Electrical and Electronic Equipment (WEEE), which represents an environmental challenge due to the presence of hazardous substances, but also an opportunity for material recovery under circular economy schemes. This study analyzes students' perceptions of WEEE management based on a random sample of students at the Universidad Autónoma de Occidente, Los Mochis Regional Unit (UAdeO-URLM), with the aim of identifying key institutional challenges aligned with the Sustainable Development Goals. A descriptive study was conducted using a Likert-scale questionnaire that assessed dimensions of environmental knowledge, current practices, infrastructure, willingness to change, and academic training. The reliability of the instrument was evaluated using IBM SPSS software via Cronbach's alpha coefficient. The results are expected to strengthen university environmental management policies and promote strategies aimed at the integrated management of WEEE.

**Keywords**: Electronic waste, University sustainability, Circular economy, Environmental management

## INTRODUCTION

The rapid expansion of digital technologies in recent decades has substantially transformed educational, administrative, and research processes in higher education institutions. The incorporation of computer equipment, mobile devices, projection systems, servers, and specialized equipment has increased academic efficiency; however, it has also led to a sustained increase in the production of Waste Electrical and Electronic Equipment (WEEE), one of the fastest-growing waste streams globally (Forti et al., 2020; Baldé et al., 2017).

WEEE contains hazardous substances such as mercury, lead, cadmium, and brominated flame retardants, which pose significant risks to human health and ecosystems when not properly managed (European Commission, 2020). At the same time, this waste contains strategic materials such as copper, aluminum, gold, and rare earth elements, the recovery of which is key to reducing pressure on natural resources and advancing toward circular economy models (OECD, 2019). In this context, international organizations have highlighted the need to strengthen comprehensive management systems that prioritize prevention, reuse, recycling, and environmentally sound final disposal of electronic equipment (United Nations Environment Programme [UNEP], 2021).

Universities occupy a strategic position regarding this issue, not only due to their high technological demands but also because of their educational role and their capacity to generate scientific knowledge and proposals for social innovation. Various studies have documented that higher education institutions can serve as living laboratories for the implementation of environmental policies, student participation, and the adoption of sustainable practices (Lozano et al., 2015; Armijo & Ojeda-Benítez, 2021). In Latin America, however, challenges persist related to the lack of systematic inventories, clear institutional protocols, and permanent environmental awareness programs (Zapata et al., 2020).

In the Mexican context, WEEE management is closely linked to international commitments associated with the Sustainable Development Goals, particularly those related to responsible production and consumption, climate action, and the protection of ecosystems. Analyzing the perceptions of the university community, and in particular of the student body, is a

fundamental element for assessing current practices, identifying institutional barriers, and designing intervention strategies based on empirical evidence.

Therefore, this study focuses on examining students' perceptions of WEEE management at the Universidad Autónoma de Occidente, Los Mochis Regional Campus, through the use of a Likert scale questionnaire and statistical analysis of the results. This approach aims to provide scientific insights for strengthening university environmental management policies and consolidating institutional programs focused on the comprehensive management of electronic waste from a perspective of sustainability and circular .

**Background**

Studies specifically focused on WEEE management in higher education institutions highlight the need to integrate operational guidelines, internal collection mechanisms, collection centers, and disposal routes with traceability and regulatory compliance (Abbas et al., 2023; Thao et al., 2024). Furthermore, it has been noted that policy recommendations for WEEE in universities must consider organizational (roles/responsibilities), technical (safe storage, segregation), and educational (training and communication) factors to sustain the adoption of programs in the long term (Ramos et al., 2022; Thao et al., 2024).

The analysis of environmental perceptions in university communities has established itself as a relevant methodological tool for diagnosing attitudes, practices, and levels of knowledge associated with institutional sustainability. Various studies have shown that instruments based on Likert-type scales allow for the collection of quantifiable information on pro-environmental behaviors and the evaluation of the effectiveness of educational programs and institutional policies (Matas, 2018; Tuapanta et al., 2017).

In the regional context of northwestern Mexico, the study conducted by (Amador et al., 2024) serves as a direct precedent for the present research. That study administered a 30-item Likert-scale questionnaire to students in various engineering and administrative programs, assessing dimensions related to environmental knowledge, institutional commitment, and environmental education, as well as the instrument's reliability using Cronbach's alpha coefficient, with average values exceeding 0.90, indicating high internal consistency of the questionnaire.

Likewise, the results reported in that study show high student participation in technological innovation projects and a favorable perception regarding the presence of environmental education in study programs, although areas of opportunity were also identified to strengthen institutional policies and ongoing awareness programs, particularly regarding the efficient use of resources and the reduction of indirect carbon emissions.

Other studies in Latin America have pointed to similar patterns: there is a positive attitude among students toward sustainability, but this does not always translate into systematic practices without the support of infrastructure, clear regulations, and permanent training programs (Gädicke et al., 2017; Martínez & Juárez, 2019; Tovar et al., 2022).

Within this framework, the present study adopts the methodological approach used at the Technological Institute of Los Mochis—reliability analysis using Cronbach's alpha and statistical software—to specifically address the issue of WEEE at the Autonomous University of the West, Los Mochis Regional Campus. This adaptation allows for broadening the scope of analysis from general sustainability to a specific waste stream, considered a global priority, and for generating local empirical evidence to inform the formulation of university environmental management policies.

## DEVELOPMENT

The study adopts a mixed-methods approach, of a descriptive-analytical nature, combining a literature review, regulatory analysis, and the application of an institutional perception instrument based on a Likert scale, with the aim of assessing the level of knowledge, current practices, and attitudes of the university community regarding the management of Waste Electrical and Electronic Equipment (WEEE).

The methodology is structured into four main phases:

1. Institutional diagnosis via survey,
2. Technical-administrative analysis of WEEE flows
3. Design of the management model,
4. Academic feedback and continuous improvement

### Survey Instrument Design

The survey instrument was designed and administered electronically via the Microsoft Teams platform. Each item was structured using a five-point Likert scale widely

used as a psychometric tool to assess perceptions, attitudes, and levels of agreement in social and educational studies:

1 = Strongly disagree

2 = Disagree

3 = Neither agree nor disagree

4 = Agree

5 = Strongly agree

This type of scale facilitates the construction and administration of questionnaires, as well as the coding and statistical analysis of the collected data (Li, 2013). Additionally, to analyze students' attitudes regarding knowledge and practices related to the proper management of institutional resources and Waste Electrical and Electronic Equipment (WEEE), the questionnaire consists of 15 items distributed across five main dimensions:

1. **Environmental knowledge:** level of understanding regarding WEEE, risks, and recycling.
2. **Current practices:** disposal of obsolete equipment, reuse, and institutional reporting.
3. **Infrastructure and regulations:** perception of the existence of collection centers and protocols.
4. **Attitude and openness to change:** interest in participating in environmental programs.
5. **Academic training:** inclusion of the topic in courses, workshops, or projects.

Table 1 shows the conceptual structure of the measurement instrument used in this study, which was designed to systematically capture students' perceptions of institutional WEEE management. The items, grouped into five theoretical dimensions, allow for a differentiated analysis of the level of knowledge, current practices on campus, the availability of infrastructure and institutional guidelines, willingness to participate in environmental programs, and the integration of the topic into academic training. This organization facilitates subsequent statistical analysis by dimension, as well as the estimation of the instrument's internal reliability and the identification of priority areas for institutional intervention.

**Table 1.** *Likert-scale questionnaire items for student perceptions of WEEE management.*

| Dimension | Item |
|---|---|

| | |
|---|---|
| **Environmental Awareness** | **1.-** I know the meaning of the term Waste Electrical and Electronic Equipment (WEEE).<br>**2.-** I recognize the environmental risks associated with the improper handling of electronic waste.<br>**3.-** I recognize that WEEE contains materials that can be recycled. |
| **Current Practices** | **4.-** In my department or academic area, electronic equipment that is no longer in use is formally reported.<br>**5.-** Before disposing of electronic equipment, its reuse or repair is considered.<br>**6.-** I know who to contact within the university to drop off WEEE. |
| **Institutional infrastructure** | **7.** The university has clear guidelines for the management of WEEE.<br>**8.-** There are visible and accessible collection points for electronic waste.<br>**9.-** I consider the conditions for the temporary storage of WEEE to be adequate. |
| **Attitude and willingness** | **10.-** I am willing to participate in WEEE collection campaigns within the university.<br>**11.-** I am interested in receiving training on responsible electronic waste management.<br>**12.-** I consider it a priority for the university to implement an institutional WEEE program. |
| **Academic background** | **13.-** I have received information about WEEE in a course or academic activity.<br>**14.-** I would like to participate in research projects related to recycling or the circular economy.<br>**15.-** WEEE management should be incorporated into the curriculum. |

**Source:** *Prepared by the author*.

## RESULTS

The internal consistency of the questionnaire was assessed using Cronbach's alpha coefficient with IBM SPSS software version 31.0.2.0 (126), where the overall value obtained was $\alpha = 0.842$, indicating

a high level of reliability of the instrument for measuring student perceptions regarding WEEE management. This result indicates high reliability, confirming that the 15 items possess adequate homogeneity to measure student perceptions regarding WEEE management. The overall mean of the scale was 49.48 points, with a standard deviation of 8.075, indicating a moderate dispersion of responses.

Table 2 shows the "alpha if item is removed" analysis, indicating that no item significantly increases the instrument's reliability when removed; therefore, all items remain in the questionnaire with an overall mean of 3.299, placing student perception at a moderate level.

**Table 2.** *Reliability statistics of the instrument by item.*

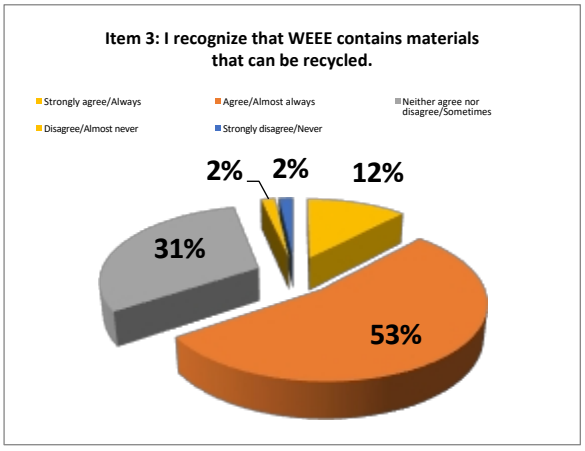
| Items | Scale mean if the item is removed | Scale variance if the item has been deleted | Total correlation of corrected elements | Multiple correlation squared | Cronbach's alpha if the item has been deleted |
|---|---|---|---|---|---|
| 1.- I know the meaning of the term Waste Electrical and Electronic Equipment (WEEE). | 46.97 | 55.402 | .527 | ,582 | .829 |
| 2.- I identify the environmental risks associated with the of electronic waste. | 45,93 | 56,592 | ,533 | .532 | .828 |
| 3.- I acknowledge that WEEE contains materials that can be recycled. | 45,76 | 58,853 | .489 | .475 | .832 |
| 4.- In my department or academic area, formally reports electronic equipment that is out of service. | 46,29 | 58,913 | .277 | .316 | .846 |
| 5.- Before disposing of electronic equipment , consider reusing or repairing it. | 45,74 | 58,125 | .407 | .507 | .836 |
| 6. I know who to contact at the university for the disposal of WEEE. | 47,24 | 54,397 | .443 | .432 | .837 |
| 7.- The university has clear guidelines for the management of WEEE | 46.09 | 59,799 | .376 | .799 | .837 |
| 8.- There are visible and accessible collection centers for electronic waste. | 46,31 | 60,218 | .298 | .694 | .841 |
| 9.- I consider the temporary storage conditions for WEEE. | 45.97 | 55,858 | ,666 | .679 | .822 |

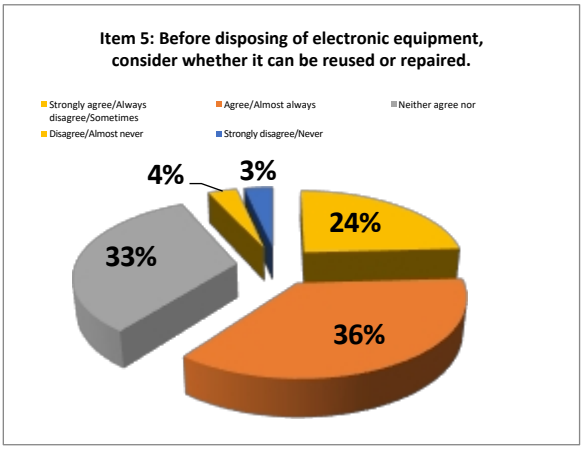
| | | | | | |
|---|---|---|---|---|---|
| 10. I am willing to participate in WEEE collection campaigns within the University. | 45.71 | 55,404 | .624 | .666 | .823 |
| 11. I am interested in receiving training on responsible management of electronic waste . | 45.81 | 57,420 | ,507 | .775 | .830 |
| 12. I consider it a priority that the university implement an institutional WEEE program. | 45,62 | 59,678 | ,476 | ,665 | .833 |
| 13.- I have received information about WEEE in some course or academic activity. | 47,22 | 57,089 | .481 | .579 | .831 |
| 14. I would like to participate in research projects related to recycling or the circular economy. | 46,19 | 55,455 | .594 | .788 | .825 |
| 15.- WEEE management should be incorporated into school curricula. | 45,91 | 58,396 | .475 | .748 | .832 |

**Source: Author***'s own analysis using data from IBM SPSS.*

On the other hand, Figure 1 presents the items with the highest ratings, which correspond to the following questions:

a) Item 3: *"Recognition of the recycling potential of* WEEE" with a mean of 3.72.
b) Item 5: *"Reuse or repair of electronic equipment"* with a mean of 3.74.
c) Item 10: *"Willingness to participate in collection* campaigns" with a mean of 3.78.
d) Item 12: *"I consider it a priority for the university to implement an institutional WEEE program,"* with a score of 3.78.



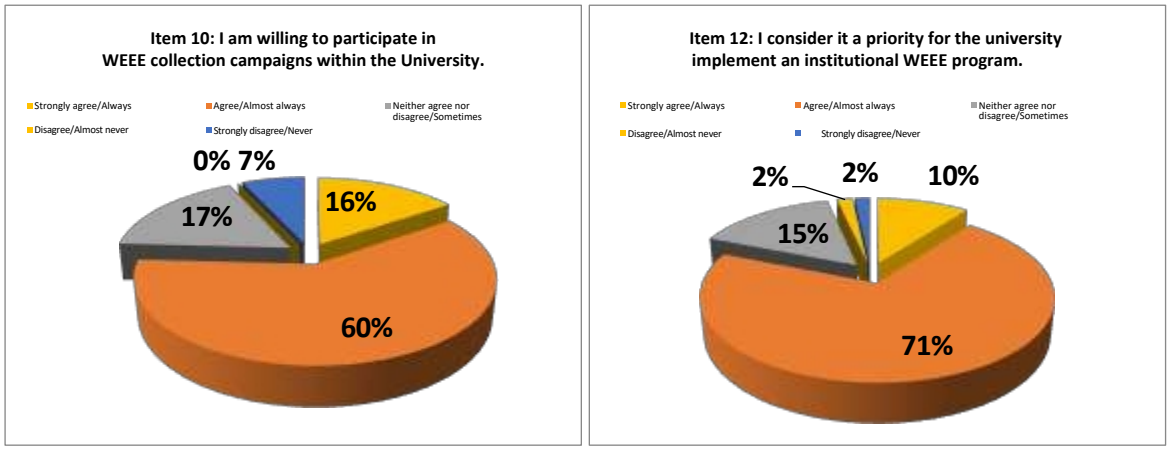



**Figure 1.** *Items with the highest ratings.*

**Source: Author's** *own work.*

These results reflect a positive attitude and willingness among students toward the implementation of institutional WEEE management programs. They also demonstrate a favorable attitude toward WEEE management, particularly in terms of willingness to participate in collection campaigns and recognition of the need to implement an institutional program. It is also observed that a significant proportion of students consider the reuse and repair of electronic equipment to be a common practice, reflecting behaviors associated with the circular economy. However, these actions are still carried out individually rather than as part of a structured institutional system, highlighting the need to strengthen university policies aimed at the comprehensive management of electronic waste. Figure 2 presents the items with the lowest ratings, which correspond to the following questions:

a) Item 1: *"Knowledge of the WEEE* concept" with an average of 2.24.
b) Item 13: *"Information received about WEEE in courses"* with a mean of 2.26.
c) Item 6: *"Knowledge of the WEEE concept"* with a mean of 2.52.

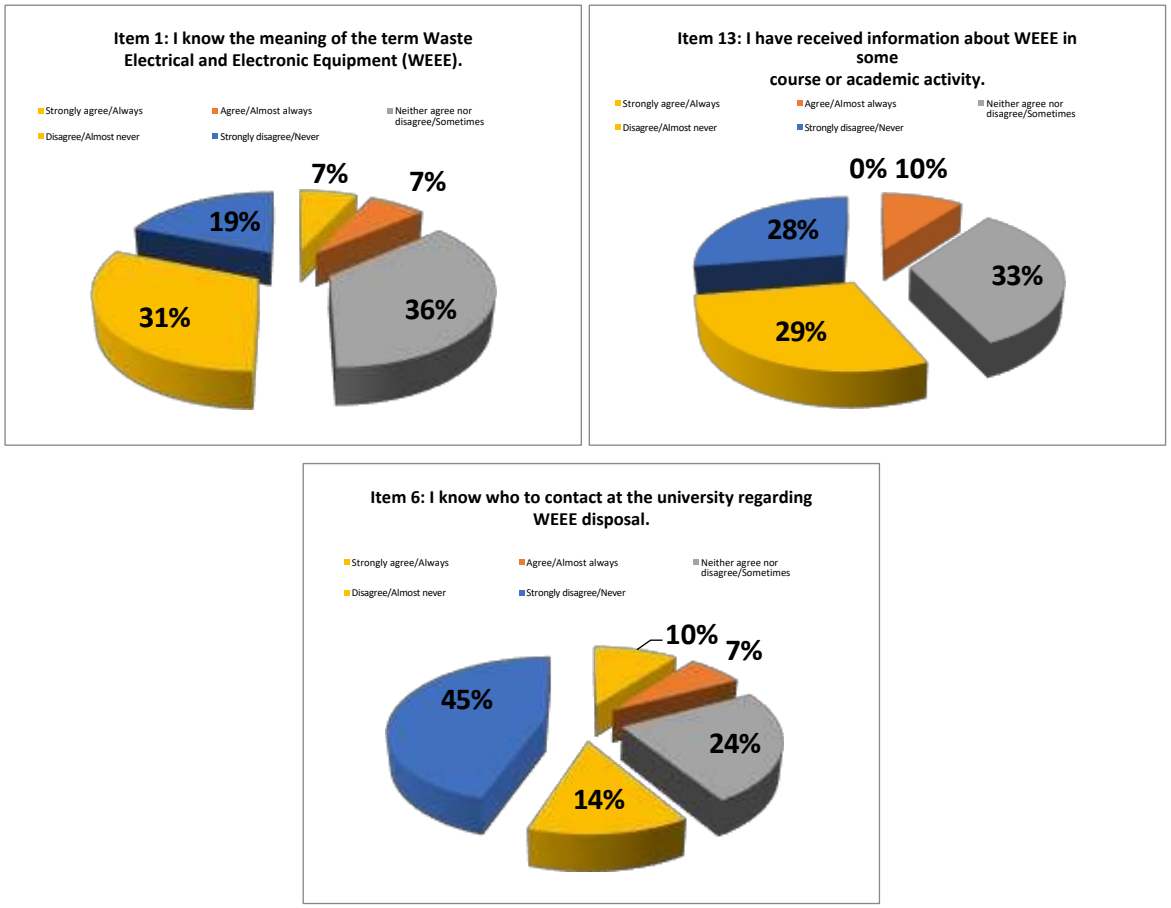



**Figure 2.** *Items with the lowest ratings.*

**Source: Author's** *own work.*

The results obtained for the items with the lowest mean scores help identify the main areas of opportunity in the institutional management of Waste Electrical and Electronic Equipment (WEEE), particularly regarding conceptual knowledge, academic training, and internal management mechanisms. From the perspective of university management, this result highlights the need to strengthen environmental education and institutional communication strategies that incorporate the concept of WEEE into academic activities, awareness campaigns, and cross-disciplinary courses.

This suggests that, even though institutional actions related to electronic waste management exist, they have not been effectively communicated to the university community. In terms of university sustainability, this finding is key, as the literature indicates that organizational communication is a determining factor for the successful implementation of environmental programs.

## CONCLUSIONS

This study analyzed student perceptions of WEEE management at the Universidad Autónoma de Occidente, Los Mochis Regional Campus, identifying strengths and areas for improvement in the design of an institutional program for comprehensive electronic waste management.

The results show that:

- The overall perception of the student body is moderate, with a high willingness to participate in environmental initiatives.
- There is widespread recognition of the importance of implementing an institutional WEEE program.
- The main areas for improvement relate to academic training, raising awareness of the concept of WEEE, and clarifying institutional procedures for its disposal.
- The instrument used demonstrates high reliability, validating its application in environmental perception studies within the university context.

In terms of university sustainability, these findings indicate that the institution possesses favorable social conditions for the implementation of circular economy strategies, but requires strengthening the coordination between operational management, environmental education, and institutional policies.

The reliability values obtained are consistent with previous studies conducted at higher education institutions in the region, such as the one carried out at the Instituto Tecnológico de Los Mochis, where Cronbach's alpha coefficients greater than 0.80 were reported, confirming the relevance of using Likert-type scales to assess environmental perceptions in the university context (Amador-Castro et al., 2024).

## FUTURE WORK

Based on the findings, several lines of research are proposed aimed at strengthening the institutional model for managing Waste Electrical and Electronic Equipment (WEEE) and consolidating a comprehensive approach to university sustainability.

In the methodological realm, we propose the application of multivariate statistical techniques to delve deeper into the structure of the instrument and the relationship between the analyzed variables.

In this regard, we recommend:

- Conducting an exploratory factor analysis (EFA) to identify the empirical grouping of the items and verify their correspondence with the proposed theoretical dimensions;
- Conduct confirmatory factor analysis (CFA) using structural equation modeling (SEM) to validate the measurement model of students' perceptions of WEEE management;
- Evaluate the model fit indices (CFI, TLI, RMSEA, and $\chi^2$/df), which will ensure the construct validity of the instrument.

In addition, we propose the use of multiple linear regression models to identify the predictors of students' willingness to participate in WEEE management programs, as well as the application of cluster analysis to segment student profiles based on their environmental perceptions.

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| Formal Analysis | Lennin Enrique Amador Castro, Román Edén Parra Galaviz, Esther Graciela Lizárraga Mata, Wendy Lizbeth Lizárraga Mata. |
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