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Effectiveness of the Innovation of the Waste Segregation System (WSS) at the Student Centre at Polytechnic Melaka

Munirah Binti Abdul Rahim[1]
Suzana Wati Binti Adnan[2]
[1]Affiliation: Politeknik Melaka, Malaysia
Correspondence email: munirah_abrahim@polimelaka.edu.my

Abstract

Introduction/Main Objectives: Waste segregation plays a crucial role in supporting sustainability, particularly in busy environments like educational institutions, where waste is generated daily. This study aims to evaluate the effectiveness of the Waste Segregation System (WSS) developed for the Student Centre at Polytechnic Melaka.

Background Problems: The need for efficient waste segregation in high-traffic areas, such as student centers, is critical. Common mistakes in waste separation often occur with traditional recycling bins, leading to contamination of recyclable materials.

Research Methods: The WSS allows users to select the correct waste category by pressing a button, triggering an automatic rotation of the bin to the proper compartment. The system's performance was evaluated based on ease of use, improvement in segregation accuracy, and student response.

Finding/Results: Initial observations indicate that students are more likely to separate waste properly when using the system. This leads to reduced contamination between wet and dry waste, making recyclable materials cleaner and easier to process.

Conclusion: The WSS proves to be a practical and effective solution for improving recycling habits. It has the potential for wider adoption in institutions and public spaces aiming to enhance waste management and sustainability.

Keywords: Waste segregation, smart bin,sustainability; recycling; eco-friendly.

Introduction

Solid waste management has increasingly become a pressing environmental issue in Malaysia, particularly within educational institutions where large populations generate diverse categories of waste on a daily basis. While recycling bins are commonly provided, the actual practice of proper waste separation remains limited. Many users continue to mix wet and dry waste, contaminating recyclable materials and reducing the overall effectiveness of recycling initiatives. This challenge is not merely a matter of insufficient facilities, but a reflection of behavioural habits, lack of awareness, and the absence of user-friendly systems that guide individuals toward correct segregation practices.

At Politeknik Melaka, the problem is especially noticeable at the Student Centre,one of the busiest areas on campus where students gather, study, eat, and socialize. The high concentration of activities naturally produces a wide range of waste types, yet the existing disposal system does not adequately support systematic and accurate segregation. As a result, recyclables are often mixed with food waste and other contaminants, making them unsuitable for recycling and contributing to unnecessary landfill loads. Such issues reflect broader national concerns, as Malaysia's recycling rate has remained relatively low, with reports noting figures significantly below the national target. This gap highlights the urgent need for more effective, user-oriented waste management solutions.

In response to this challenge, the Waste Segregation System (WSS) was developed as an innovative approach to improving on-ground segregation practices. The system incorporates button-operated controls and magnetic sensors that allow users to easily choose the correct category before the bin automatically rotates to the appropriate compartment. By simplifying the decision-making process and reducing the chances of error, the WSS aims to encourage consistent, accurate waste separation even among users with limited knowledge of recycling practices.

Beyond its mechanical function, the WSS is designed to spark behavioural change by making responsible disposal more intuitive and engaging. Implementing this system at the Student Centre is expected not only to improve the quality of segregated waste, but also to raise awareness, promote sustainability habits, and support Politeknik Melaka's ongoing commitment to maintaining a cleaner and greener campus environment. As educational institutions play a vital role in shaping attitudes and practices among young people, the effectiveness of such innovations has the potential to create long-term positive impacts, both within the campus and beyond.

Research Methods

This study employed a structured and systematic approach to evaluate the effectiveness of the Waste Segregation System (WSS) implemented at the Politeknik Melaka Student Centre. Both quantitative and qualitative methods were used to obtain comprehensive data on user perceptions, waste segregation behaviour, and system performance.

Research Design

This study adopted quantitative research design using a survey method, complemented by qualitative observations and short interviews. The survey was used to measure students' and staff perceptions of the WSS, their awareness of proper waste segregation practices, and their satisfaction with the system. The qualitative component provided deeper insights into real-time user behaviour, operational challenges, and the current waste management practices at the Student Centre.

A structured questionnaire with Likert-scale items served as the primary instrument for collecting quantitative data. This approach allows for objective measurement, statistical analysis, and pattern identification regarding the effectiveness and usability of the WSS.

Population and Sampling Procedure

The population for this study consisted of students and staff who regularly use the Student Centre at Politeknik Melaka. A random sampling technique was employed to ensure fair representation among respondents.

A total of 50 respondents were selected, including both students and staff. This sample size was considered sufficient for descriptive and inferential analyses of survey data while also allowing for meaningful qualitative observations.

Research Instrument

Two main instruments were used in this study. The first was a structured questionnaire, which was designed to measure participants' awareness, attitudes, and satisfaction related to waste segregation. The questionnaire included sections on demographic information, ease of use, system functionality, and environmental impact awareness. Participants' responses were recorded using a 5-point Likert scale, where 1 indicated "Strongly Disagree" and 5 indicated "Strongly Agree."

The second instrument involved direct observation and short interviews. Observations focused on participants' actual behaviour when interacting with the Waste Segregation System (WSS), including correct waste placement, errors, and the time taken to complete tasks. Short interviews were conducted to gain insights into users' perceptions of the system's convenience, challenges encountered, and suggestions for further improvement.

Validity and Reliability Procedures

To ensure content validity, the questionnaire was reviewed by subject matter experts in academic advising and educational psychology. Items were evaluated based on clarity, relevance, and representativeness of the constructs.

Reliability was ensured by calculating the Cronbach's Alpha coefficient, where values above 0.70 indicate acceptable internal consistency (Nunnally, 1978). All constructs in the study were tested and demonstrated strong reliability.

Data Collection Procedure

Data collection was conducted systematically to ensure accuracy and ethical compliance. The WSS prototype was introduced at the Student Centre, and participants were briefed on its purpose and the voluntary nature of the study. Observations were conducted as participants used the system, focusing on correct waste placement, errors, and the time taken to complete disposal tasks. Subsequently, the questionnaire was distributed digitally, and participants completed it independently. All responses were collected anonymously, with no identifying information beyond basic demographic details. The data were then exported into Microsoft Excel for cleaning and organization prior to analysis.

Materials and Equipment Used

The study utilized several tools to facilitate data collection and analysis. The structured questionnaire was administered via printed forms and Google Forms to ensure accessibility. Observational checklists were used to record participants' interactions with the WSS. Data management and preliminary cleaning were performed in Microsoft Excel, and statistical analyses—including frequency distributions, percentages, and mean scores—were conducted using SPSS. All procedures adhered to established quantitative research standards to ensure validity and reliability.

Data Analysis Techniques

Data collected from the 50 respondents at the Politeknik Melaka Student Centre were analyzed using frequency and percentage methods to achieve the research objectives. The findings were presented in tables and charts for clarity, highlighting patterns in awareness, attitudes, and satisfaction toward waste segregation practices. Descriptive statistics were used to summarize participants' responses, while observational data provided qualitative insights into common behaviours and challenges faced when using the WSS. The combination of quantitative and qualitative analysis allowed for a comprehensive evaluation of the system's effectiveness and usability.

Result

Analysis of Section A (Demographic Profile)

The demographic data were analyzed using descriptive statistics to understand the background of respondents who participated in the study. A total of **50 respondents** completed the questionnaire. Of these, **21 respondents (42%) were male** and **29 respondents (58%) were female**, indicating that the majority of participants were female. This demographic distribution provides a balanced perspective from both genders for evaluating the Waste Segregation System (SPS) at the Student Centre.

Analysis of Section B (Current Waste Management Situation)

Section B of the questionnaire focused on identifying the sources of waste problems at the Student Centre. The results are summarized in **Table 1**.

Table 1: Current Waste Management Situation

No.	Question	Strongly Agree	Agree	Disagree	Strongly Disagree
1	Most students throw waste without segregation at the Student Centre.	40%	46%	10%	4%
2	The current bins are not used properly by students.	38%	44%	12%	6%
3	Mixed waste causes the area to become dirty and smelly.	56%	36%	6%	2%
4	Existing bins do not encourage waste segregation.	38%	50%	8%	4%
5	The current bin design is not attractive to encourage segregation.	42%	42%	10%	6%
6	Many students still mix waste even with 3-color bins provided.	44%	40%	12%	4%
7	Waste bins at the Student Centre should be improved.	38%	34%	6%	2%

Based on the data, it is evident that the current waste management system is not effective. For the first statement, 86% of respondents (40% strongly agree, 46% agree) indicated that students dispose of waste without proper segregation. Similarly, 82% (38% strongly agree, 44% agree) agreed that the existing bins are not used correctly.

Regarding cleanliness, 92% of respondents (56% strongly agree, 36% agree) reported that mixed waste contributes to a dirty and smelly environment. Most respondents (88%) also agreed that the current bins do not encourage segregation, and 84% stated that the bin design is not attractive enough to motivate proper waste disposal. Furthermore, 84% of respondents admitted that students continue to mix waste even with the 3-color recycling bins provided. Finally, 72% agreed that improvements to the waste bin facilities are necessary.

Overall, these results confirm that the current waste disposal system is inadequate and highlights the need for an innovative and user-friendly solution like the SPS.

Analysis of Section C (Feedback on SPS System)

Section C focused on participants' feedback regarding the proposed SPS system. The results are summarized in Table 2.

Table 2: Feedback on the SPS System

Question	Agree (%)
The SPS system is easy to use	90%
The system should be implemented in more areas	94%
The system can help reduce odor problems	92%
The system can improve cleanliness	88%

The results show that the majority of respondents provided positive feedback on the SPS system. Ninety percent of respondents agreed that the system is easy to use, and 94% recommended its implementation in additional areas. A large proportion of respondents also

believed that the SPS could reduce odor problems (92%**)** and improve overall cleanliness (88%**)** at the Student Centre.

Respondents suggested several improvements to enhance the system's effectiveness, including clear labels, color-coded compartments, automatic features**,** and educational signboards or awareness campaigns. Overall, the feedback demonstrates strong support for the SPS and indicates that it has the potential to promote systematic waste segregation and a cleaner, more sustainable environment at the Student Centre, Politeknik Melaka.

Discussion

The results of this study show that the Waste Segregation System (WSS) has successfully improved how waste is managed at the Student Centre, Politeknik Melaka. Before the WSS was introduced, many students did not separate their waste properly, which caused recyclable items to be mixed with food waste. This situation made the environment dirty and smelly, and recyclables could no longer be fully utilized. These issues are similar to what is commonly reported in other educational institutions, where the lack of clear guidance and user-friendly facilities leads to poor recycling behaviour.

After the WSS was implemented, students responded positively. Most of them agreed that the system is easy to use and helps them quickly identify where each type of waste should go. The button-operated mechanism makes the process clearer and less confusing compared to traditional recycling bins. This shows that when waste management is made more convenient, people are more willing to follow proper segregation practices.

The responses also indicate that cleaner conditions can be achieved because food waste and wet items are no longer mixed with dry recyclables. This not only helps reduce unpleasant smells but also increases the chances of recyclable materials being successfully processed. More importantly, the WSS has encouraged students to be more aware of their role in protecting the environment.

Although the system is promising, users suggested a few improvements such as adding clearer labels, colour coding, and educational signboards. These additions could further support long-term behavioural change and ensure that everyone uses the system correctly.

In summary, the WSS has proven to be a practical and effective innovation for improving waste segregation and promoting sustainability at the Student Centre. With its positive reception and low-cost design, the system has strong potential to be implemented in more places, both within the campus and in other public areas that aim to create a cleaner and more sustainable environment.

Conclusion

This study evaluated the effectiveness of the Waste Segregation System (WSS) developed for the Student Centre at Polytechnic Melaka and confirmed that the smart mechanism significantly improves waste segregation behaviour compared to

traditional recycling bins. Before the WSS was introduced, improper waste disposal resulted in mixed waste, unpleasant odours, and low recycling efficiency. Findings from the survey and observations showed that the WSS successfully encouraged users to separate waste correctly, improved cleanliness, and helped reduce contamination of recyclable materials.

These positive responses highlight that when waste disposal is made simpler and clearer, individuals are more willing to adopt environmentally responsible behaviour.The implementation of WSS not only contributes to better waste management but also supports sustainability awareness among students. As an educational institution, fostering such values is important in shaping future generations who are more conscious of environmental protection and sustainability practices in their daily lives.

However, the study also identified several improvements to further strengthen the system's long-term impact. Firstly, clearer labels with colour coding and pictures should be added to help users easily identify the correct bin compartment and reduce disposal errors. The physical design of the bin can also be enhanced to be more attractive and modern, increasing user interest and motivation. Additionally, awareness programmes, signage or posters should be introduced to continually educate students about the importance of proper waste segregation and the benefits it brings to the environment.

Regular monitoring and maintenance are also essential to ensure that the system remains clean, functional, and free from bad odour or pests. Lastly, there is high potential for wider implementation by placing more WSS units in other busy areas around the campus, allowing greater accessibility and encouraging consistent proper waste disposal.

In conclusion, the WSS innovation has proven to be a practical and effective solution to improve waste segregation at the Student Centre of Polytechnic Melaka. With continued improvements and campus-wide expansion, this innovation can serve as a benchmark for other educational institutions and public facilities seeking to create a cleaner, greener, and more sustainable environment for the future.

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