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Pathways to Sustainability: Empowering Indigenous Communities through Recycling Education

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Abstract: Recycling is a critical component of sustainable waste management, helping to conserve resources, reduce pollution, and mitigate climate change. Despite its importance, awareness, and participation in recycling activities remain low, particularly among indigenous populations who often have limited exposure to modern environmental practices. This study investigates the impact of a recycling awareness program conducted within an indigenous community in Cameron Highlands, Pahang, Malaysia. The program included a pre-program survey to assess participants' awareness, understanding, and participation in recycling activities, followed by an educational session on general recycling practices and e-waste management. A post-program survey was conducted to measure the effectiveness of the program. Using paired sample t-tests reveals significant improvements in participants' knowledge and attitudes toward recycling. The findings provide compelling evidence that targeted educational programs can significantly enhance recycling awareness and participation within Indigenous communities, contributing to broader environmental sustainability goals. The study underscores the need for implementing similar programs in other less exposed communities and continuous engagement and collaboration with local authorities to sustain and expand recycling initiatives.

Keywords: *Indigenous community, recycling awareness, e-waste management, environmental education, sustainability*

1. Introduction

Recycling plays a pivotal role in sustainable waste management, offering substantial environmental, social, and economic benefits. It not only conserves natural resources but also mitigates pollution and reduces greenhouse gas emissions, contributing significantly to environmental protection and climate change mitigation (Liu, 2009). As global environmental issues such as climate change become more pressing, increasing recycling participation across all communities has become paramount. However, the adoption of recycling practices remains uneven across various regions, particularly among marginalized communities (Sanchez, 2023).

Urban areas benefit from well-developed recycling infrastructure and awareness programs, which promote higher rates of participation. In contrast, rural and indigenous communities often lack access to recycling facilities and educational resources, resulting in significantly lower recycling participation (Elmosaad et al., 2023; Mulindwa, 2024). This disparity is concerning, as these underserved communities represent a key segment of the population that can contribute to a circular economy, where waste is minimized, and materials are reused and recycled effectively. Bridging this gap is essential to achieving broader environmental sustainability goals.

Indigenous communities, in particular, face unique challenges. Many indigenous populations rely on traditional ecological knowledge that has sustained them for generations, emphasizing conservation and sustainable resource use (Senekane et al., 2022; Madonsela, 2024). However, the rapid pace of modernization and environmental degradation necessitates the integration of these traditional practices with modern sustainability efforts to address complex waste management challenges. The intersection of indigenous wisdom and modern environmental practices presents an opportunity to develop culturally sensitive and effective solutions to enhance recycling behaviors in these communities.

Given the critical role that rural and indigenous communities play in global sustainability efforts, it is imperative to design recycling programs that address their specific needs and contexts. Hence, this study aims to evaluate the impact of a recycling awareness program on an indigenous community in Malaysia. By focusing on this community, the research provides valuable insights into how tailored environmental education programs can foster sustainable practices in populations that have traditionally been less exposed to modern recycling initiatives. The findings from this study will contribute to the broader body of knowledge on community-based environmental interventions and offer practical recommendations for increasing recycling participation among marginalized groups.

2. Literature Review

Recycling is a sustainable effort that significantly aids in reducing human impacts on the environment and plays a critical role in waste management (Wan et al., 2017). Recycling activities promote environmental sustainability as they contribute to resource conservation, waste reduction, and minimizing environmental impacts across various sectors. By turning waste materials into reusable resources, recycling reduces the need for raw material extraction, decreases energy consumption, and lowers greenhouse gas emissions, thereby mitigating climate change.

Communities are at the heart of successful recycling initiatives, and their active involvement can drive significant improvements in recycling rates, waste segregation, and environmental stewardship. Zhuo et al. (2023) emphasize that community engagement is essential for effective waste management and fostering a culture of environmental responsibility. Moreover, community engagement is essential in managing household waste effectively and fostering organized waste disposal practices (Brotosusilo & Nabila, 2020). Hence, engaging communities in recycling activities empowers individuals to make environmentally conscious decisions, creating a ripple effect that can lead to broader societal changes.

The social dimension of recycling is particularly noteworthy. Lounsbury et al. (2003) demonstrate how recycling can unify communities, strengthening social bonds and collective action. This social aspect is further reinforced by Tong et al. (2018), who found that social norms play a significant role in initiating recycling behaviors. These findings align with Schwartz's altruism model, as discussed by Hopper and Nielsen (1991), which posits that recycling behavior is shaped by social and personal norms, as well as an awareness of environmental consequences. Studies by Kawai & Tasaki (2015) and Vicente & Reis (2008) further underscore the importance of community participation, noting that successful recycling initiatives depend on active and sustained citizen involvement.

Educational interventions have also been shown to be powerful drivers of recycling behavior. Sun et al. (2018) highlight that increased recycling knowledge is positively associated with recycling practices. Therefore, integrating recycling education programs, community engagement initiatives, and effective communication strategies is essential for fostering a recycling culture and promoting environmental sustainability (Lee & Krieger, 2020).

However, despite the critical role of recycling, research on these practices within indigenous communities remains limited. Indigenous communities often face unique challenges in adopting recycling practices, including limited awareness, infrastructure, and access to recycling facilities and educational programs, particularly in remote areas. These barriers highlight a significant gap in the literature and underscore the need for tailored approaches to recycling in Indigenous contexts.

This study seeks to address this gap by implementing a tailored recycling awareness program within an indigenous community in Cameron Highlands, Pahang, Malaysia. By assessing the impact of this program, the study aims to contribute to the limited body of knowledge on recycling practices in Indigenous communities and provide actionable recommendations for future initiatives.

3. Methodology

This study employed a quantitative methodology to evaluate the impact of a recycling awareness program on an Indigenous community. The focus was on assessing changes in participants' recycling knowledge, attitudes, and behaviors through structured surveys and statistical analysis. It included informational sessions, practical activities, and interactive discussions aimed at enhancing participants' understanding of recycling, its benefits, and its practical application in their daily lives.

The study involved 30 participants from the indigenous community in Cameron Highlands, Pahang, Malaysia, Data were collected using pre- and post-program surveys that assessed participants' knowledge, attitudes, and behaviors related to recycling. These surveys utilized a 5-point Likert scale, allowing participants to express their level of agreement or disagreement with statements regarding their awareness of recycling campaigns, understanding of recycling benefits, knowledge of recyclable materials, and practices related to recycling.

Following the pre-survey, a knowledge transfer session was conducted. This session covered the importance of recycling, recyclable materials, and e-waste management practices aimed to enhance participants' knowledge and encourage active participation in recycling. Besides the talk on recycling and waste management, various interactive methods, such as the distribution of infographic flyers, question, and answer (Q&A) sessions, and quizzes were employed to ensure active participation and retention of information.

After the knowledge transfer session, a follow-up survey was administered to evaluate changes in participants' knowledge, attitudes, and intentions regarding recycling. The post-survey included questions similar to those in the pre-survey, also using the 5-point Likert scale, to facilitate direct comparison and measure the program's effectiveness.

Quantitative data analysis was conducted using descriptive statistics to summarize participants' responses before and after the program. Inferential statistics, specifically, paired sample t-test was employed to determine statistically significant differences between the pre-and post-program survey results.

The null hypothesis of the paired sample t-test indicates that there is no significant difference in participants' recycling knowledge, attitudes, and behaviors before and after the program. In other words, the mean scores of the pre-program and post-program surveys are equal. This analysis provided insights into the effectiveness of the program in improving participants' recycling-related knowledge and behaviors. This study adhered to ethical standards, ensuring informed consent from all participants and maintaining their privacy.

4. Findings and Discussion

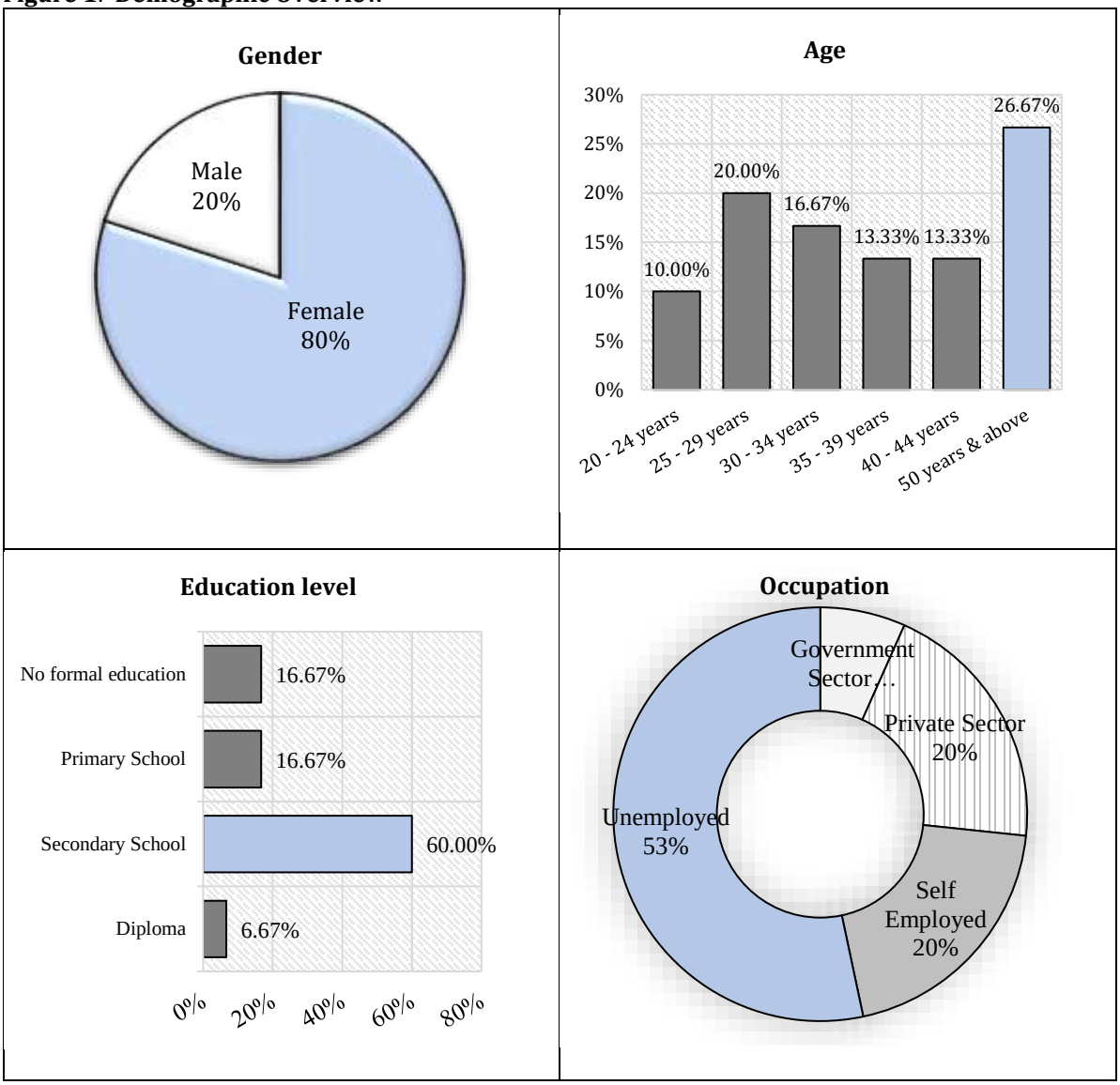
This section presents and discusses the results of the study, beginning with an overview of the participant's demographic characteristics and their initial recycling behaviors. Understanding these factors is crucial for evaluating the effectiveness of the recycling awareness program and its impact on different population segments. The subsequent analysis explores the feedback received from participants regarding the program and assesses the program's overall success in enhancing recycling knowledge and practices within the community.

Demographic Overview

This section presents an overview of the demographic characteristics of the participants involved in the recycling awareness program, alongside their reported recycling behaviors. Understanding the demographic profile of the participants is crucial in contextualizing the findings of the study and in evaluating the program's reach and effectiveness across different population segments.

As reported in Figure 1, the majority of participants were female, comprising 80 percent of the total sample, while males represented 20 percent. The age distribution of the participants was diverse, with the largest group being those aged 50 years and above, accounting for 26.67 percent. Participants in the 25-29 year age group made up 20 percent, followed by those aged 30-34 years at 16.67 percent, 35-39 years at 13.33 percent, and 40-44 years at 13.33 percent. The youngest group, aged 20-24 years, constituted 10 percent of the participants.

Figure 1: **Demographic Overview**



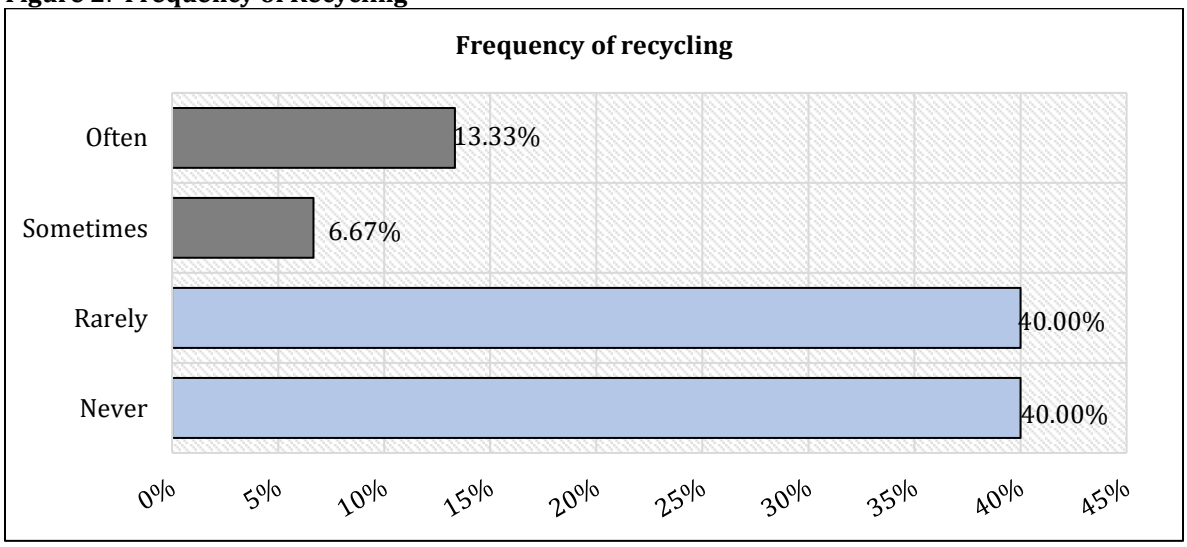
In terms of education, 60 percent of the participants had completed secondary school, making it the most common level of education within the group. This was followed by participants with primary school education and those with no formal education, both representing 16.67 percent each. Only 6.67 percent of the participants had attained a diploma. In terms of occupation, over half of the participants (53.33 %) were unemployed, while 20 percent each were employed in the private sector and self-employed. A smaller proportion, 6.67 percent, worked in the government sector.

Given the diverse demographic background of the participants, the varying levels of education, age, and employment status suggest that participants may have different levels of awareness, motivation, and opportunities to engage in recycling. For instance, those with higher education might have more exposure to environmental information, while older participants or those without formal education might rely on traditional practices. Similarly, employment status could influence the time and resources available for recycling, as well as the perceived importance of such activities.

Looking further at the recycling behavior, the data on recycling frequency, as presented in Figure 2, provides insight into the participants' engagement with recycling behavior before the program. The data reveals that a

significant proportion of the respondents rarely or never engage in recycling activities, with both categories comprising 40% of the total responses. This indicates that 80% of the participants have minimal to no involvement in recycling efforts.

Figure 2: **Frequency of Recycling**



On the other hand, a smaller segment of the population recycles more frequently; 13.33% of participants reported recycling often, while 6.67% indicated that they sometimes participate in recycling activities. This data provides a foundational understanding of the participants' baseline characteristics and their initial engagement with recycling, which is essential for interpreting the subsequent analysis of program outcomes.

Program Evaluation

The evaluation of the recycling awareness program, as reflected in Table 1, indicates a high level of participant satisfaction across multiple key indicators. The program's objectives were rated with a mean value of 4.6, suggesting that the goals of the program were clearly defined and well-aligned with the expectations of the participants. The content of the program received a slightly higher mean value of 4.7, which highlights the relevance and quality of the information provided to the community.

Table 1: Program evaluation

Indicator	Mean value
Objectives of the program	4.6
Content	4.7
Speaker	4.9
Activities conducted	4.7
Overall evaluation	4.8

Besides that, the speaker's effectiveness was particularly notable, achieving the highest mean value of 4.9, implying that the delivery of the material was both engaging and informative, significantly contributing to the overall success of the program. Additionally, the activities conducted during the program were rated at 4.7, indicating that these practical components were well-received and likely enhanced the participants' learning experience.

The overall evaluation of the program, with a mean value of 4.8, underscores the program's success in fulfilling its objectives and delivering a valuable educational experience to the Indigenous community. These results suggest that the program was not only effective in raising awareness about recycling but also well-executed in terms of content delivery and participant engagement.

Effectiveness of the Recycling Awareness Program

To further elucidate the impact of the recycling awareness program, a detailed analysis of participants' knowledge and understanding both before and after the program is conducted. This involves examining the mean values of participants' responses to pre- and post-program assessments to quantify the extent of knowledge enhancement. Additionally, a paired sample t-test was conducted to whether the changes observed in participants' knowledge and understanding of recycling are both meaningful, thereby offering insights into the program's impact on participants' understanding and attitudes toward recycling.

Table 2 presents the mean values for participants' knowledge levels before and after the program, alongside the results of a paired sample t-test. The findings demonstrate a significant positive impact of the recycling awareness program on the Indigenous community's knowledge, attitudes, and behaviors related to recycling. The paired sample t-test results reveal substantial improvements across all measured indicators from the pre-survey to the post-survey, with highly significant p-values ($p = 0.000$) for each indicator.

In particular, awareness of recycling campaigns increased notably, with the mean value rising from 2.4 before the program to 4.5 after, as evidenced by a t-statistic of -9.479. Similarly, participants' understanding of the benefits and importance of recycling showed a substantial increase, with the mean value moving from 2.4 to 4.6, supported by a t-statistic of -9.289. Knowledge of recyclable materials also saw a significant boost, with the mean value increasing from 2.2 to 4.3, and a t-statistic of -11.217, emphasizing the program's effectiveness in enhancing participants' knowledge in this area.

One of the most significant improvements was observed in participants' knowledge of e-waste recycling, where the mean value rose from 1.3 to 3.8, as reflected by a t-statistic of -13.403. This result highlights the program's success in raising awareness about e-waste management. The ability of participants to share recycling information also improved markedly, with the mean value increasing from 1.6 to 4.0, supported by a t-statistic of -12.815, indicating a significant enhancement in their confidence and ability to communicate recycling practices to others.

Table 2: Comparison of Mean Values and Paired Sample t-test

Indicator	Mean value (Pre)	Mean value (Post)	t-statistic	p-value
Awareness of recycling campaigns	2.4	4.5	-9.479	0.000
Understanding of recycling benefits & importance	2.4	4.6	-9.289	0.000
Knowledge of recyclable materials	2.2	4.3	-11.217	0.000
Knowledge of e-waste recycling	1.3	3.8	-13.403	0.000
Ability to share recycling information	1.6	4	-12.815	0.000
Willingness to segregate waste	1.6	4.1	-12.970	0.000
Awareness of income opportunities through recycling	1.3	4	-15.059	0.000
Interest in recycling activities	3	4.8	-8.762	0.000

Furthermore, the willingness to segregate waste saw a substantial positive shift, with the mean value increasing from 1.6 to 4.1, and a t-statistic of -12.970. This change reflects the participants' greater intention to engage in proper waste segregation practices following the program. Additionally, awareness of potential income opportunities through recycling showed the largest increase, with the mean value rising from 1.3 to 4.0, supported by a t-statistic of -15.059. This result demonstrates the program's success in highlighting the economic benefits of recycling to the community.

Lastly, participants' interest in recycling activities increased from a mean value of 3.0 to 4.8, with a t-statistic of -8.762, reflecting the program's effectiveness in fostering genuine interest in recycling within the community. Overall, these statistical results indicate that the recycling awareness program was highly effective in improving the participants' knowledge, attitudes, and behaviors related to recycling, with significant positive

changes observed across all indicators. Hence, it can be concluded that the program conducted has successfully motivated participants to adopt and promote recycling behaviors, demonstrating the effectiveness of culturally tailored environmental education initiatives.

5. Conclusion

The recycling awareness program demonstrated a significant positive impact on the Indigenous community's knowledge, attitudes, and behaviors related to recycling. The findings reveal that the program was successful in enhancing awareness and understanding across a range of indicators, including awareness of recycling campaigns, understanding the benefits of recycling, knowledge of recyclable materials, and the importance of e-waste recycling.

The significant increases in mean values before and after the program, as shown by the paired sample t-test results, underscore the effectiveness of the program in fostering meaningful behavioral changes. Notably, the most substantial improvements were seen in participants' knowledge of e-waste recycling and their awareness of income opportunities through recycling, indicating that these areas were particularly resonant with the community's needs.

The effectiveness of the program underscores the importance of culturally relevant environmental education in promoting sustainable practices among less exposed communities. Therefore, future initiatives should consider continuous engagement and collaboration with local authorities, as well as tailored approaches to maintain and build on these positive outcomes.

The study has several limitations that should be considered. The relatively small sample size restricts the generalizability of the findings. Additionally, the study primarily evaluates the short-term impact of the program, without assessing long-term behavior changes. Addressing these limitations in future research will enhance the robustness and applicability of the findings, offering more comprehensive insights into the effectiveness of recycling awareness programs.

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