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Enhancing Sustainable Behavior Through Design: A Case Study of Trash Disposal Area in Learning Environment

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Abstract. Littering in public areas presents a significant health and environmental challenge. This case study explores the use of design interventions to reduce such behavior and encourage social change. We focused on the trash disposal area in our school department, which has long been in state of disarray. Our goal was to modify user behavior through design, thereby maintaining cleanliness in the environment over the long term. Following the redesign and reconstruction of this space, we conducted a two-week experiment, utilizing camera footage to observe user behavior and surveys. Upon conclusion, a total of 72 responses were collected through an online questionnaire. Participants were asked to provide feedback on their experiences and perceptions regarding the redesigned trash disposal area. Further statistical analysis, including the McNemar Test, backward elimination logic regression, and independent samples t-test, was employed to assess the effectiveness of the overall trash disposal space planning and various design elements. From the results, we found a significant improvement in satisfaction and identified a design factor, posters featuring divine patterns and slogans, which significantly influenced user behavior. This study not only observed whether design could alter behavior and optimise the environment but also incorporated some clever ideas into the design to resonate with both teachers and students. We hope that even the simple act of disposing of trash can be enjoyable and that such designs will encourage the faculty and students of the design gallery to collectively maintain a clean and comfortable learning environment.

Keywords. Transdisciplinary engineering, Sustainable Behavior, Product Design, Social Change, Trash Disposal

Introduction

In contemporary society, the persistent issue of littering in public spaces has become a widespread concern, posing significant challenges to both individual health and environmental sanitation. This issue is particularly critical in educational settings, as it directly impacts students' learning efficiency and the overall image of educational institutions. The act of littering not only compromises environmental cleanliness but also diminishes the overall image of schools, affecting the health and learning environment

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of both students and faculty. Therefore, redesigning waste disposal areas to foster better waste management and environmental responsibility is of paramount importance. Through this study, we aim to explore how redesigning the waste disposal environment, such as through color coding and the posting of anti-littering posters, can influence user behavior [1], thereby maintaining cleanliness over the long term and enhancing societal awareness and commitment to environmental responsibility.

The primary objective of this research is to identify and evaluate design modifications that can effectively encourage proper waste disposal behaviors within educational settings. By redesigning waste disposal areas, we aim to establish an environment that guides users towards correct waste management practices, thereby reducing instances of littering. Concurrently, this initiative seeks to enhance community members' awareness and appreciation of environmental responsibility, fostering a collective commitment towards environmental preservation.

The principal focus of this research is concentrated on the waste disposal areas within our institution. Through the redesign and empirical observation of this specific area, we intend to assess the impact of design changes on user behavior. However, the outcomes of this study may be subject to certain limitations, such as the constrained duration of the research, which may not fully represent the long-term effects. Moreover, as the scope of the study is restricted to a specific location and demographic, the generalizability of the results may be somewhat limited.

1. Literature Review

1.1. Social Norms, Personal Norms, and Nudges

Ito differentiates norms [2] into "social norms" and "personal norms." Social norms, which are pressures and sanctions imposed by society, contrast with personal norms, which are pressures and sanctions individuals impose upon themselves. Social norms represent the collective cognition shared by a group. According to Cialdini et al. [3], people's behaviors change based on the norms they focus on when multiple social norms exist. Social norms are further divided into "injunctive norms," which are perceptions of what behaviors are approved or disapproved by others, like acting in accordance with a sign that says, "Please compress trash." When expected behaviors are exhibited, they can be said to be influenced by injunctive norms. "Descriptive norms," on the other hand, are perceptions of how most people *behave, such* as deciding to sort trash because peers do so, reflecting the influence of descriptive norms.

Moreover, Manning notes that descriptive norms have a more significant impact on behavior under the influence of social norms [4], although Kitaore and Yoshida argue that injunctive norms have a more pronounced effect in unfamiliar situations or when there is a conflict between an individual's initial behavioral intention and descriptive norms [5].

Fujii suggests that in considering the behavioral change process of cooperative actions [6], apart from the psychological factors in the theory of planned behavior, knowledge, trust, and moral consciousness, especially the significance of moral consciousness on behavioral intention, should be considered. Ito mentioned that injunctive norms affect behavior through personal norms [2]. Kawamura et al. defined social norms as external factors influencing behavior, whereas moral consciousness

belongs to personal norms, internal factors influencing behavior, both converging into "normative consciousness" [7].

The concept of "nudge" is closely related to the influence of social and personal norms on behaviour. Nudging refers to the use of positive reinforcement and indirect suggestions to influence people's behaviour in a desired direction, without eliminating their freedom of choice [8]. Nudges can take the form of subtle environmental cues or changes that leverage social norms and personal norms to guide individuals toward making better decisions or adopting specific behaviours. The key nudging techniques include prompting, sizing, proximity, presentation, labelling and functional design [9].

1.2. Designing for Behavioral Change through Community Observation

In 2000, California experienced massive, planned blackouts due to severe summer heat, leading Wesley Schultz et al. to conduct a social experiment on 287 households to encourage energy saving [10]. They randomly placed message boards with various energy-saving messages on each household's door, assessing the impact of each message. Only the message "Your neighbors are already doing this—turn off the AC and use a fan" significantly influenced behavior, demonstrating that people are more likely to change their actions when informed about others' actions in similar situations. This effect underscores the power of social norms and suggests that providing normative feedback about energy consumption can motivate individuals to adopt more sustainable behaviors, regardless of their initial stance on energy conservation.

1.3. Waste Disposal Behavior: The Influence of Trash Bin Design and Messaging on Collection Rates and Sorting Efficiency

Strategic trash bin design and placement can enhance categorized waste collection efficiency. The design and placement of trash bins, including their color schemes, have a significant impact on waste collection rates and the efficiency of sorting [11]. When designing waste bins, considerations should include color preferences and prominence, as well as their influence on individuals' waste disposal behaviors. Properly designed waste bins can not only make the sorting process more intuitive but also encourage more responsible waste disposal practices among users, thereby improving overall waste management effectiveness. Moreover, Brinton et al. tested signage messaging at outdoor university receptacles, finding negative and concrete messaging was most effective for increasing recycling diversion and reducing contamination compared to positive/abstract messaging [12].

2. Method

2.1. Experimental Architecture

For this experiment, we designated one floor of our department building as the experimental site. By renovating the existing trash disposal areas and introducing new signage and deity posters, we aimed to influence user behaviors to reduce littering [13]. The modifications were specifically designed to engage users more effectively and encourage responsible waste disposal [14]. We also understand and assess user behavior

through surveillance footage. Additionally, we conducted surveys to gather feedback and assess the impact of these changes on user behavior [15]. This comprehensive approach allowed us to evaluate both the immediate and long-term effects of our interventions on promoting a cleaner and more organized waste management system.

2.2. Identification of Problems

During the initial observation of the trash bin area, several issues were revealed: the absence of waste sorting, unclear instructional signage, and bins often overflowing due to inadequate capacity. These problems became the focus of our improvement efforts.

2.3. Ideation and Positioning

To enhance waste management, we implemented several nudging strategies. We assigned distinct representative colors to each waste category to guide users in proper disposal. Labels for each category were provided in both Chinese and English, accompanied by illustrative icons to indicate the types of waste designated for each bin. Simple, clear instructions for recycling steps and signs encouraging waste compression were prominently displayed on the bins. Additionally, we displayed engaging and authoritative illustrations and slogans to resonate with users and encourage adherence to disposal guidelines, as shown in Figure 1.



Figure 1. Design of the poster and messaging signage.

The posters utilize images of deities and teachers to curb users' littering behavior. The background of the posters features various tools commonly used in model-making, such as files, rulers, putty, and spray paint, aiming to evoke empathy and a sense of connection among design school students, making the posters more engaging and interesting. Additionally, the posters include humorous slogans such as "The gods are watching you," "Cleanliness is happiness," and "Clean spaces, smooth critiques." These slogans are designed to instill a sense of fear about potential evaluation difficulties, thereby encouraging users to adhere to proper waste disposal practices.

In addition, the duck was chosen as the mascot for this educational campaign due to the pun in Chinese where "pressure" (壓) and "duck" (鴨) are homophones. The illustrations also reference the recycling steps outlined by the Taiwan Environmental Protection Administration.

2.4. User Testing

Observing the original waste disposal area revealed that many items of trash, such as paper food containers and packaging bottles, could be further compressed. Therefore, we designed dividers of different shapes for the three waste categories, hoping to encourage users to compress their waste before disposal using specific shapes and openings.

On Day 1, our redesigned waste disposal area was officially completed. To assess the effectiveness of these dividers, we observed user reactions under two different scenarios through surveillance footage on two days, and used the findings for subsequent improvements:

Day 1 (without shape dividers):

- 1) Users carefully read the sorting signage before disposing of their waste.
- 2) Users began sorting their waste individually, influenced by the behavior of those around them, regardless of acquaintance.
- 3) The informational material attracted attention and discussion.
- 4) There was no overflow of trash.

Day 2 (with shape dividers):

- 1) Disposing of waste using dustpans became inconvenient.
- 2) Many users lifted the dividers to compress previously disposed waste.
- 3) Janitorial staff often forgot to replace the dividers after collecting the trash.

Based on observations over these two days, we concluded that the dividers were ineffective and decided to remove them. Furthermore, we noticed that trash no longer overflowed as before. Lastly, we observed that many students disposed of large items such as models or cardboard boxes, which inconvenienced other users and contributed to disorder. As a result, we decided to add a disposal basket for large waste items. To encourage users to sort and compress their trash, we also provided trash tongs.

The following elements were finalized to study user behavior: Sorting signage (clearly visible to users approaching the bins), Sorting signboards (visible from a distance), Color for different waste categories, Trash tongs, Large garbage bins, Deity posters, Three-step recycling process signage, Waste compression signage.

Lastly, our team launched the "WasteWorld" initiative. In Chinese, "WasteWorld" carries a dual meaning. It echoes the Buddhist concept of a serene and pure world and, through a play on words, refers to a zone dedicated to waste collection.

3. Evaluation and Data Analysis

This project aimed to redesign the waste disposal area to guide users towards proper trash handling, thereby reducing littering. To determine whether redesigning the trash disposal environment can effectively change users' littering behavior, we observed and collected user behavior data over about one month. Our goal was to identify design elements that significantly influence people's waste disposal behaviors and their impact on environmental enhancement. Specifically, we intended to understand user responses regarding:

1. Environmental improvements before and after the design intervention.

2. Specific design elements that contributed to environmental enhancements.

3. Variances in achieving three major objectives across different departments: increasing the willingness to dispose of trash correctly, encouraging trash compression to save space, and promoting waste sorting.

3.1. Subjects and Data Collection Method

3.1.1 Subjects and Data Collection

Targeted participants were students and faculty from the College of Design of the National Taipei University of Technology, using their feedback to gauge user satisfaction. A questionnaire survey method was employed to collect feedback. The survey was conducted in January 2024, with a distribution of 100 questionnaires and a collection of 72, resulting in a 72% response rate.

3.1.2 Operational Definitions

In this study, scores from the Likert scale were treated as binary variables, with scores above (including) 5 considered satisfactory ("Yes"), and all others deemed unsatisfactory ("No"), as shown in Table 1.

1	
Variable Name	Operational Definition
Participant Type	Student or Teacher
Department	Architecture or Industrial Design
Gender	Male or Female
Cleanliness of the Environment Before Improvement	Scale of 1-7
Cleanliness of the Environment After Improvement	Scale of 1-7
Increase in Willingness to Dispose of Trash Correctly	Scale of 1-7
Increase in Willingness to Compress Trash, Saving	Scale of 1-7
Space	
Increase in Willingness to Sort Waste	Scale of 1-7
Clarity Sorting Signage and Icons	Scale of 1-7
Clarity Sorting Signboard	Scale of 1-7
Clarity of Waste Sorting Colors	Scale of 1-7
Convenience of Trash Compression with "Trash	Scale of 1-7
Tongs"	
Convenience of "Large Garbage Bins"	Scale of 1-7

Table 1. Operational definitions.

Increase in Willingness to Dispose of Trash Correctly	Scale of 1-7
Due to " Deity Poster "	
Increase in Willingness to Dispose of Trash Correctly	Scale of 1-7
Due to "Three-step Recycling Process Signage"	
Increase in Willingness to Dispose of Trash Correctly	Scale of 1-7
Due to " Trash Compression Signage "	

3.1.3 Statistical Methods

Analysis was performed using SAS 9.4, with a significance level set at 0.05. Key analyses included the McNemar Test to assess significant environmental changes pre and post-intervention and Logistic Regression to examine the impact of "WasteWorld" design elements on environmental improvements. The design elements were selected using a backward selection method. Additionally, a two-sample T-test was conducted to explore differences in meeting the three main objectives between students from different departments, treating the Likert scale objectives as continuous variables.

3.2. Response Rate Percentage

A total of 73 questionnaires were retrieved, comprising 71 students (97.3%) and 2 teachers (2.7%). By department, 27 respondents (37%) were from the Architecture department, and 46 respondents (63%) were from the Industrial Design department. Gender distribution was 27 males (37%) and 42 females (57.5%), with 4 respondents (5.5%) preferring not to disclose their gender.

3.3. McNemar Test

The McNemar Test was employed to evaluate the effectiveness of the design interventions in improving the environmental cleanliness of the waste disposal areas. This test is particularly useful for matched pair data, where the same participants are observed before and after an intervention. In our study, the analysis focused on changes in satisfaction levels regarding the cleanliness of the environment.

Before the intervention, a considerable portion of the participants (22.22%, n = 16) expressed discontent with the cleanliness of the area. After implementing the design changes, a significant shift was observed, with 48.61% (n = 35) of participants reporting satisfaction, demonstrating a notable improvement in perceptions of cleanliness(P<0.001). This transition from discontent to satisfaction underscores the effectiveness of the environmental design changes in enhancing participant perceptions.

Conversely, the smaller proportion of participants who remained satisfied both before and after the intervention (9.72%, n = 7) indicates that while some individuals were consistently content with the environment, the intervention had a significant positive impact on those previously dissatisfied. This result is crucial as it highlights the potential of design interventions to convert dissatisfaction into satisfaction, thereby improving overall user experience in communal spaces.

3.4. Logistic Regression (Backward)

The analysis investigated the influence of design factors on three main objectives: increasing the intention to correctly dispose of trash, encouraging the compression of trash to save space, and enhancing the willingness to sort waste.

Higher satisfaction with the deity poster is significantly associated with an increased willingness to dispose of trash correctly, with an odds ratio (OR) of 1.789 (95% Confidence Interval [C.I.] [1.004, 3.188]). Similarly, higher satisfaction levels with the recycling trilogy led to a higher intention of correct trash disposal, with an OR of 1.881 (95% C.I. [1.110, 3.187]).

Satisfaction with the deity poster also significantly increases the willingness to compress trash, thus saving space, with an OR of 2.346 (95% C.I. [1.525, 3.609]). Additionally, effective color coding (OR: 1.922, 95% C.I. [1.136, 3.250]) and satisfaction with the deity poster (OR: 3.164, 95% C.I. [1.721, 5.871]) are both significantly associated with an increased willingness to sort waste.

These results demonstrate the significant impact of specific design elements, particularly the deity poster and recycling trilogy signage, on enhancing user engagement with waste management practices. These practices include correct disposal, compression for space-saving, and sorting.

3.5. The Two-sample T-test (comparing the Industrial Design and Architecture Departments)

Comparative analysis between departments using a two-sample T-test revealed no significant differences in most behavioral intentions between the Architecture and Industrial Design departments, except for the willingness to sort waste. Participants from the Industrial Design department reported higher willingness to sort waste with a mean score of 5.64 (SD = 1.55), compared to 4.74 (SD = 1.91) in the Architecture department (P = 0.032). This suggests that the design interventions were particularly effective in promoting waste sorting behaviors among Industrial Design students.

4. Conclusion

This study has conclusively shown that strategic design interventions can effectively transform waste disposal behaviors in communal educational settings. Through the implementation of "WasteWorld," a program that included redesigned waste disposal areas with clearly marked and visually engaging signage and deity posters, we were able to guide users toward more responsible waste management practices.

Our observations and surveys indicated significant improvements in the cleanliness of the disposal areas, with notable increases in user satisfaction and compliance with disposal guidelines. The McNemar Test results supported these observations, revealing statistically significant enhancements in environmental cleanliness after the interventions (p < 0.001). Furthermore, the logistic regression analysis underscored the effectiveness of specific design elements like the deity posters and recycling signage, which significantly increased users' willingness to dispose of trash correctly, compress waste, and engage in sorting activities.

These findings highlight the critical role of thoughtfully designed environmental cues in promoting sustainable behaviors and fostering a culture of environmental stewardship among students and faculty. By marrying design thinking with behavioral science, the "WasteWorld" initiative not only addressed immediate environmental concerns but also contributed to a long-term positive impact on the community's ecological consciousness. This research demonstrates the power of design interventions in educational settings and provides a scalable model for similar environments looking to enhance sustainable practices and reduce littering behaviors. Future studies might expand on this work by exploring the long-term sustainability of such interventions and their applicability across different cultural or demographic settings, ensuring that the improvements in environmental responsibility are both enduring and universal.

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