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Design for Optimizing Waste Classification and Recycling Practices

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Abstract. This study investigates the challenges and opportunities in the domain of garbage classification and recycling, with a specific focus on the campus of Macao University of Science and Technology (M.U.S.T.). Through a multi-faceted approach comprising case analysis, fieldwork, interviews, and a structured questionnaire, the research aims to comprehensively understand the public's perceptions, behaviors, and expectations towards garbage classification software. The findings reveal critical issues in waste management, including location-based inconveniences, operational deficiencies, and user dissatisfaction with existing recycling stations. Moreover, the study highlights the importance of user-centric interaction design in fostering effective waste classification behavior. The research provides valuable insights for the development of tailored waste management solutions for M.U.S.T. and similar educational institutions.

Keywords. Garbage Classification, Recycling Stations, User-Centric Design, Waste Management

1. Introduction

This article addresses the imperative of designing public-centric services to foster a sense of utility, ease of use, and value while surpassing expectations. The primary focus is on resolving pertinent practical challenges, including low public awareness of environmental preservation, apathy towards garbage sorting, and instances of illegal dumping. The aim is to expedite the resolution of the "garbage wall" predicament. This necessitates augmenting user engagement and active participation in garbage classification, while concurrently minimizing costs, thus cultivating a sustainable habit. Ultimately, the paper will proffer targeted design strategies to advance waste classification efforts in our country. By directing and encouraging public involvement in waste classification endeavors, we aspire to augment societal values, instill a robust consciousness of resource conservation, and foster sustainable habits. Effective waste classification holds promise for mitigating environmental pollution, curtailing the need for landfills, and diminishing environmental degradation. Notably, segregating

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recyclable materials from non-degradable waste has been demonstrated to reduce waste volume by over 60%, opening avenues for resource repurposing.

The project's waste classification and recycling service for smart communities hinge on state-of-the-art Internet technology, promising an enhanced user experience. Leveraging online garbage classification applications and offline intelligent recycling infrastructure, the initiative seeks to furnish users with comprehensive education on waste disposal procedures, ensuring accurate classification. Furthermore, the service offers avenues for users to derive economic benefits and provides feedback mechanisms. This addresses the issue of inadvertent non-compliance with garbage sorting practices. A favorable service experience is pivotal in instilling the perception that waste sorting can be a gratifying endeavor, thereby motivating sustained participation. The integration of online and offline waste classification and recycling services serves as a catalyst for transforming user behavior towards active engagement in garbage classification efforts.

In this study, particular emphasis is placed on Macao's waste classification and recycling landscape, with M.U.S.T. serving as the focal point. Drawing inspiration from the mainland's waste classification and recycling system, we aim to adapt and enhance the model to suit the specific contextual intricacies of Macao. By synthesizing elements from the mainland's successful system and customizing it to suit the unique attributes of Macao, we anticipate fostering a seamless waste classification and recycling framework at M.U.S.T., which can serve as a template for broader implementation across the region.

2. Literature Review

Papers should be organized with a clear content-oriented structure. Every paper must have a title and several headings. References follow at the end of the document. Graphics and tables should be embedded into the text. Please only use one space after the period at the end of a sentence. Adhering to the styles outlined in this guide will enable more streamlined conversion to the InDesign templates for publication.

2.1. Waste Treatment and Classification Status

The escalation in domestic waste production has resulted in a growing complexity of classification projects. Adequate processing technology, data resources, and skilled professionals dedicated to waste classification remain insufficient. Concurrently, the development of supporting equipment for garbage classification is an ongoing endeavor [5]. Notably, the coverage of domestic waste classification in residential areas across 46 key cities, encompassing central municipalities, provincial capitals, and cities under separate national planning, approximates 86.6% (People's Daily, 2020).

2.2. Attitudes Towards Garbage Classification

Residents' inclination towards garbage classification is influenced by both external and internal factors. External factors encompass governmental promotional campaigns, incentive structures, and the availability of infrastructure. Internal factors pertain to residents' demographic attributes such as age, educational attainment, household income, environmental awareness, and personal perspectives on supervision[3]. A

significant portion of residents, constrained by limited resources and energy, engage in sporadic garbage sorting. A majority of residents exhibit insufficient familiarity with the standards and associated knowledge of garbage classification, underscoring the pivotal role of residents' acquaintance with pertinent classification principles and national standards [1].

2.3. Interaction Mode Impact on User Empathy and Cognition

The effectiveness of information retention is contingent upon the simplicity and clarity of the interaction design. A straightforward and comprehensible design promotes user comprehension and acceptance, subsequently influencing behavioral intentions. Generally, heightened interactivity heightens users' willingness to engage with garbage classification software. It is imperative to recognize that users' attention resources are finite. Interaction functionalities that are excessively intricate or beyond users' grasp may diminish the likelihood of behavioral intention. Consequently, it is essential, in the development of mini program functions, to possess a comprehensive understanding of users' cognitive capacity, proficiency in interactive function operation, and aptitude for information assimilation [4].

2.4. Interaction Design Method Anchored in User Cognition and Behavior

Attending to users' distinct roles is paramount in design considerations. Users' cognitive abilities are inherently shaped by their emotions, habits, experiences, and objective environments. Given that cognitive and behavioral activities are inherently user-centric, design decisions must accord primacy to the user, centering on their cognition and behavior. Analyzing and comprehending user cognition and interaction behavior is rooted in the principle of user-oriented software. It necessitates an exploration of users' thought processes and behavioral logic, as well as an understanding of their motivations for using the software and the information they seek to acquire. Clear articulation of needs and refinement of product objectives are critical. User requirements span the fundamental material needs, such as inquiries about garbage categories and the dissemination of garbage classification knowledge, to the more abstract emotional needs, encompassing elements of humor, entertainment, and social interaction. Addressing cognitive load and behavioral biases entails the establishment of a scalable information architecture to furnish users with diverse problem-solving approaches, thereby harmonizing product architecture with users' cognitive and behavioral patterns. This facilitates users' capacity to think critically and surmount challenges while engaging with the product [2].

3. Research Approach and Methodology

3.1. Case Analysis

To comprehensively assess the public's understanding, willingness, behavior, and expectations concerning garbage classification software, a structured questionnaire was administered. The survey addressed critical issues, including:

1) Challenges Pertaining to Community Garbage Classification and Recycling Stations:

Some communities exhibit limitations in proximity to recycling stations, leading to inconvenience for residents residing on distant floors. Consequently, a proportion of residents' resort to direct disposal in traditional bins, compromising classification efforts. Environmental factors further influence residents' sorting behavior.

2) Management Deficiencies in Garbage Classification and Recycling Stations:

A dearth of manpower responsible for garbage removal often results in neglected bins, causing residents to encounter difficulties in using the recycling stations as intended.

3) Imperfections in Design and Interactive Systems:

Some community recycling stations feature intricate and suboptimal design, leaving residents uncertain about potential benefits. This initial curiosity often devolves into dissatisfaction after a single use, discouraging further engagement. Adverse experiences significantly impact residents' recycling behavior.

3.2. Fieldwork

A comprehensive field investigation was conducted at M.U.S.T.'s campus to evaluate waste types, analyze trash receptacles in teaching buildings, and assess the strengths and weaknesses of existing systems. Key observations and findings include:

1) Trash Cans Adjacent to Teaching Building Elevators:

Advantages: Compact, space-efficient design, harmonious with teaching building aesthetics.

Disadvantages: Utilizes a conventional manual flip-top mechanism, limiting sorting capabilities and necessitating unified waste collection.

2) Staff-Operated Cleaning Trolleys in Teaching Buildings:

Advantages: Equipped with various cleaning tools and storage space for waste, streamlining staff operations.

Disadvantages: Exhibits a conventional, aesthetically unremarkable design, incongruent with teaching building architecture.

3) Campus Roadside Trash Receptacles:

Advantages: Offers higher capacity for waste storage.

Disadvantages: Features a basic, aesthetically unimpressive design. Open lids may compromise hygiene and facilitate odors and bacterial growth.

4) First-Floor Trash Receptacle in Teaching Building B:

Advantages: Compact, space-saving design, unobtrusive within the teaching building context.

Disadvantages: Adheres to a conventional form, precluding garbage classification and offering limited capacity.

3.3. Interviews

In-depth interviews were conducted with three postgraduate students (aged 21-30) majoring in design and fine arts at M.U.S.T. These interviews provided valuable insights into students' comprehension of garbage classification, their daily sorting practices, and their expectations for the campus recycling system. Key takeaways include: Students exhibit a positive inclination towards garbage classification, emphasizing its environmental benefits.Despite their favorable attitudes, students

encounter challenges in distinguishing between different types of waste, underscoring the need for enhanced educational efforts. Commonly perceived problems with garbage classification in China include inadequate public awareness, technological constraints hindering effective recycling, lack of standardized regulations, and deficient facilities. All three interviewees expressed a willingness to download a garbage classification applet, indicating a demand for features such as classification education, waste identification, and doorstep recycling.

3.4. Questionnaire

A structured questionnaire was administered to 103 respondents, comprising 41.75% males and 58.25% females. The sample spanned various age groups, with 85.44% of respondents affirming the significance of garbage classification and recycling. Notably, 76.7% possessed a vague understanding of the subject, while 69.9% relied on informal sources for relevant information. A resounding 89.32% expressed a willingness to utilize a garbage classification applet, with a strong preference for features encompassing classification education, waste identification, doorstep recycling, and mini-games.

4. Design for Garbage Classification

Intelligent garbage classification bin - functions, including garbage crushing and compression; intelligent garbage weighing; overflow and fault alarm; user face/scan code login. Intelligent classification trash can: It is mainly composed of four separate boxes, which are used to collect hazardous waste, kitchen waste, recyclable waste and other waste. According to the different characteristics of each type of garbage, each box will be designed to compress or break according to the characteristics of the garbage, thereby saving storage space. Product specifications: 550mm x 360mm x 250mm. The material is ABS stainless steel. Functions: facial/QR code login, smart weighing, sealing and sterilization, food waste shredding process: the user logs in with face recognition in front of the garbage bin camera - the wave sensor lid automatically opens - throws in the food waste - —The blades in the trash bin automatically sense and rotate to break up the trash—the trash is broken and falls from the compartment into the trash storage bin—it is automatically weighed and the data is entered into the user account.

5. Conclusion

The study underscores the significance of user-centric design principles in optimizing waste classification and recycling efforts, particularly within the context of M.U.S.T. The identified challenges related to recycling station location, operational management, and user experience necessitate targeted interventions. Insights gleaned from interviews and questionnaire responses emphasize the need for robust educational initiatives to enhance public awareness and understanding of garbage classification. The willingness of respondents to engage with a dedicated garbage classification applet signifies a promising avenue for technological interventions. By addressing these critical issues,

tailored solutions can be implemented to foster sustainable waste management practices within educational institutions.

Figure 1. Intelligent garbage classification bin.

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