Innovative Practice Research of Visualization of City Garbage Classification Based on Information Design

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Abstract. Objective: To find a suitable visual language for the information content presented in the current city garbage classification in China, to help the public learn and remember the operation of garbage classification. Methods: Through research on the current situation of at home and abroad, the focus of information transmission was analyzed. Through questionnaire surveys, the pain points of current classification information were pointed out. Then, the graphic innovative design of garbage information was explored, and simulation experiments were conducted to demonstrate that the introduction of information visualization design can attract public attention to garbage classification. Innovative strategies for the visualization of garbage classification information were summarized. Conclusion: The feasibility of information visualization design in the operation of city garbage classification was demonstrated. It reduces the difficulty for the public to passively receive classification information, moderately solves problems such as slow cognition, difficult operation, and confusing symbols, and plays a guiding role of "classification as learning, memory promotes classification", promoting the public to voluntarily complete environmental protection actions.

Keywords: Garbage Classification, Visualization, Information Design, Innovation Strategy.

1 Introduction

Garbage classification refers to a general term for a series of activities to classify, store, put and carry garbage according to certain regulations or standards, so as to transform it into public resources. Since 2019 China has begun to comprehensively promote public organizations to do a good job of living garbage classification, and the State Administration for Organ Affairs has published the Reference Standards for Evaluation of Living Garbage Classification Work in Public Organizations. The national focus and implementation of garbage classification is on the agenda, the domestic garbage classification system has been incorporated into the law, and local related regulations in major key cities have been introduced one after another, and garbage classification has entered and changed the people's previous lifestyles.

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Looking at the implementation status of garbage classification in the past five years, we can deeply feel that its promotion is slow and ineffective. One of the obvious pain points is the immaturity of the visualization system of garbage classification, which makes it difficult for the public to get clear and explicit classification tips when discarding garbage, and directly affects the subsequent classification process. Therefore, the visualization of the information design of garbage classification needs to be scientifically implemented, and the guidance and application of its improved design in the operation of classification has practical research value, and it is an indispensable link in the big topic of garbage classification.

2 Current Status of Garbage Classification Visualization

2.1 Analysis of the Current Situation at Home and Abroad

The authors grasp the current status of classification visualization through both the analysis of the current situation of garbage classification and the questionnaire survey. The foreign countries adopt the literature analysis method and choose the classic cases of Sweden, the United States and Japan[1]; Sweden can be used for recycling up to 98% of domestic garbage, and their classification design is user-centered, and the outstanding advantage is to improve the classification efficiency through the constraints on the physical structure of garbage cans; the United States pushes the garbage solution from the upstream of the product life cycle, that is, to solve the problem of garbage classification from the stage of designing and producing, Recycling and regeneration, Japan advocates that garbage classification design is part of city landscape design, and they have been treated as cultural and creative industries and city landscapes from the very beginning of their creation, using color-coded classification to strengthen people's impression of the type of garbage.

The domestic analysis used the survey method, and since the policy was issued, there has been a proliferation of visual designs for classification, but precisely because of the inconsistent program strategies, there is no consistent perception of garbage classification among the masses. Existing implementation methods include upgrading household and outdoor garbage cans to separate garbage, and posting posters and guidelines on garbage classification. However, there is no clear explanation of "what exactly is classified", and the visual function that needs to be fully utilized in classification has been seriously neglected[2], and there is a difference in the power of action between "yes" and "excellent". There is a difference in mobility between "yes" and "better", which is an extremely important motivation in the operation of categorization. The authors searched 34 types of household garbage cans from e-commerce platforms, China is in the early stage of city garbage classification, there is no guidance from designers with professional technical knowledge, and the visual symbols of the products are not clear.

The domestic research team chose to conduct offline research in the new first-tier city of Zhengzhou, which has the garbage problem commonly found in first- and second-tier cities. The team visited 30 households, 10 residential communities, 10 public places and 10 colleges and universities, mainly investigating the configuration of the

equipment at the garbage drop-off points and the situation of residents' garbage disposal. Taking residential communities as an example, the most common configuration of garbage cans is to have four types of garbage cans side by side, but this solution does not consider the rationality of the placement, the amount of daily garbage placement of harmful waste is small, and the amount of input of kitchen waste and other waste is large, so it is necessary to adjust the ratio of garbage cans. In addition, the new electronic "recyclables" machine has problems such as unhygienic touch buttons and unclear icons, and is cumbersome to operate, making it unsuitable for the elderly and children. Therefore, the design of waste equipment needs to be optimized.

2.2 Questionnaires

The team sampled 200 people of all ages to conduct an online questionnaire survey on garbage classification. The survey focused on the public's specific views on garbage classification in the city, figuring out where the blind spots, confusions, and barriers to implementation lie in the process of classification, as well as the specific needs for visualization of information in the process of classification.

Comprehensively analyzing the data from 200 valid questionnaires, the authors summarized them into a data survey summary table(see Figure. 1). 72% of the population in the figure indicated that they were willing to actively cooperate with garbage classification; for the two points of the most troublesome classification and the most difficult to place, the percentage of kitchen waste, harmful waste, and recyclable waste was significantly higher than that of other wastes; and in terms of the difficulty in identifying the other wastes, 58% of the people believed that they were the most difficult to identify. The above research data can be analyzed to find out what problems people have with the implementation of garbage classification, followed by their views on the visualization of information. On the point of "seeing instructions on the garbage cans", 96.5% of the questionnaires indicated that they would like to see them; on the form of the sorting instructions on the garbage cans 90% of the people chose a combination of graphics and text rather than separate text or icons, which is an extremely important reference for the information visualization design carried out by the researchers later on; and, the most crucial point, 150 people chose the "easy to recognize" option, which is the most difficult to recognize. The most crucial point is that 150 people chose "the correlation between the implementation of garbage classification at and the display of classification information is more than 30% at ", which is as high as 75% of the total number of people, indicating that more than two-thirds of the people in the research think that the visual display of garbage information can effectively help the people to implement classification.

From the results of the online survey, the majority of the public is supportive of the garbage classification policy, and their willingness to classify garbage is relatively positive, but their knowledge of classification is lacking, and there is no place to find correct and comprehensive information on classification, which makes it difficult to implement the policy, and the policy is not effective. The results of the research show that the degree of visualization of information on garbage is still immature at this stage, and

clear design ideas and directions are given based on the results of the data to ensure that the subsequent implementation of the science and rationality.

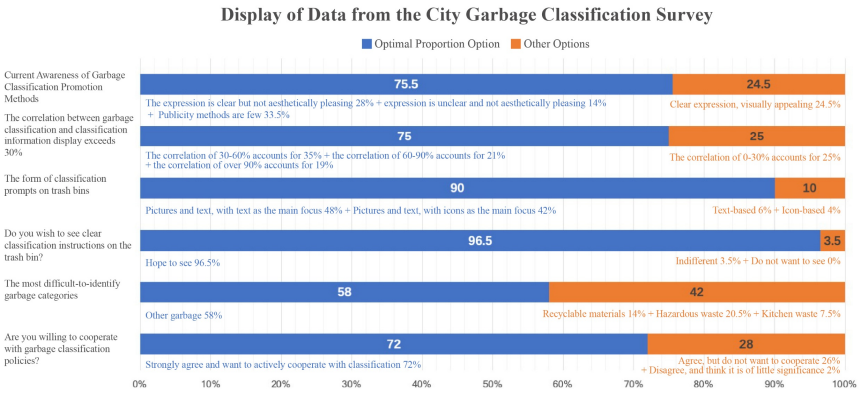


Fig. 1. Display of data from questionnaire survey on garbage classification in the city.

3 Design of Garbage Classification Information Visualization Scheme

After the research, the team summarized five design tasks for information visualization, which were to solve the content description of garbage types, the specific list and icon design of each type of garbage, the design strategy of confusing garbage, the solution to the drawbacks of household and public garbage cans, and the information visualization scheme of garbage cans. After three months of repeated polishing by the team, the design solution completed a total of 86 icon designs for the four types of garbage, identified two forms of confusing garbage presentation, and the overall planning of the information design from the four aspects of text icon, color, information integration, and the design of the garbage can shape. Regarding the trash can shape, four types were designed according to regional differences: household, community, outdoor and indoor public areas. The design of garbage bags also refers to foreign countries to advocate that the color of the bag is the same as the color of the garbage category, to capture the correspondence in terms of color and to help the public form the subconscious of dropping off the garbage according to the color[3].

The garbage icons in the program are divided into four categories: recyclable waste, other waste, food waste, and harmful waste, and representative items are selected from each category, and the image of the items is refined using a recognizable line structure design style, with rounded corners and a single line plus a color block filled in to make the icon a simple, unified, and easily recognizable visualization graphic design as the basis for the graphic design on the garbage cans(see Figure. 2). The design strategy for the confusing garbage is to give priority to being recognized among similar types of garbage through text or icon enlargement, and to remind the public of the exact category

of an item through warning graphics. The design strategy for confusing garbage is either to enlarge the garbage through text or icons to prioritize it for recognition among similar garbage, or to remind the public of the exact category of an item through a warning graphic. Both methods can be used individually or in combination. For example, plastic bags can be given a negative warning in the graphic design of "recyclable waste", and the text or graphic can be enlarged in the correct "other waste", and the two methods can be used together to deepen the message. In terms of layout design after information integration, the team chose the idea of color correspondence and illustration according to the data of the preliminary research (see Figure. 3) as an example of kitchen waste, we zoomed in the common garbage, filled in the uncommon ones with smaller text or icons, and included the confusing garbage in them, and juxtaposed the information in a prioritized and focused manner by using the methods of textual graphicization, mixed arrangement of text and graphics, and creative illustration. It also utilizes strokes to replace the corresponding English language in the large characters of other waste types, giving full consideration to the delivery needs of other language groups[4].

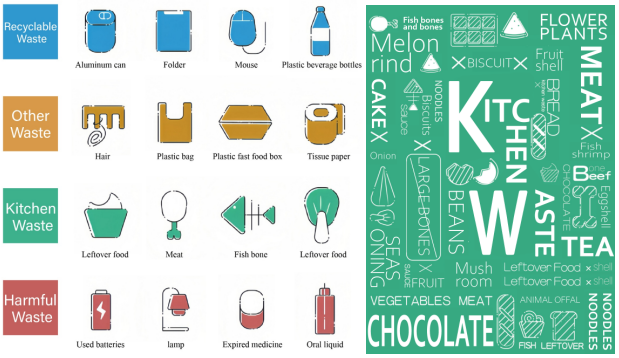


Fig. 2. Basic icon scheme for garbage classification section (left).

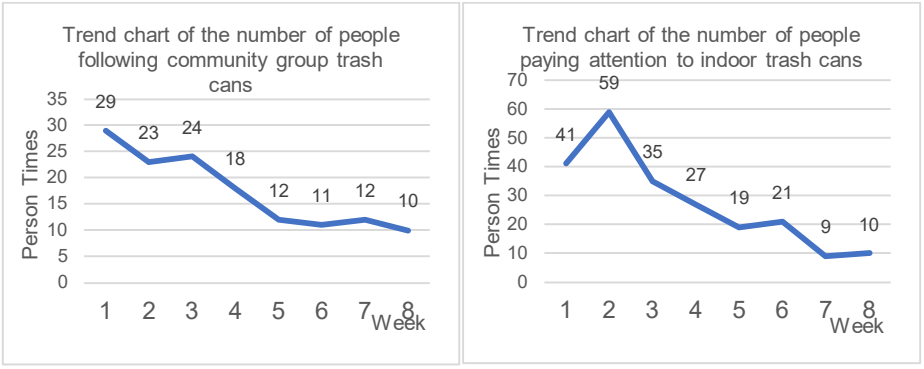
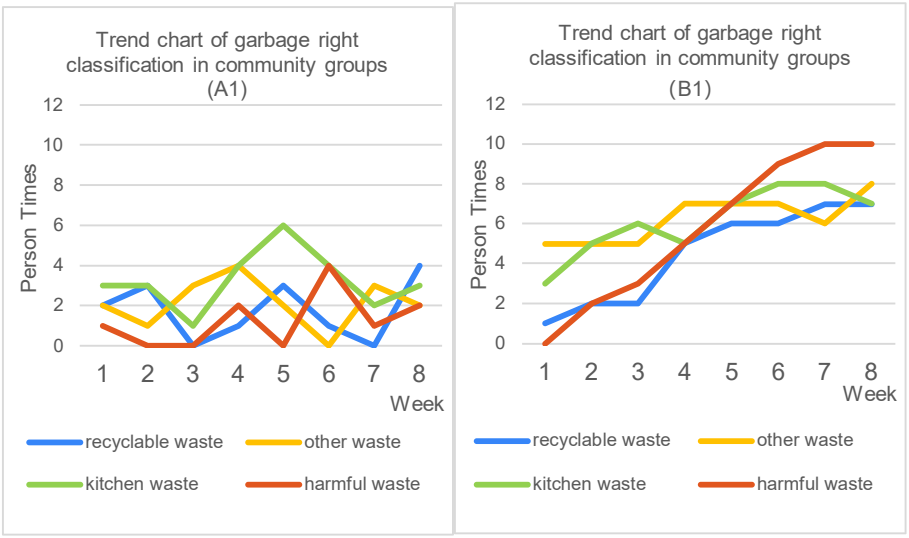


Fig. 3. Visualization scheme for kitchen waste information (right).

4 Experimental Analysis of the Design Program

During the experimental phase, the team divided the experimental subjects into two control groups: the original data group (referred to as Group A) that did not receive visual design intervention, and the data group (referred to as Group B) that received visual design intervention. The total experiment duration was 42 days. Since Group A's data exhibited long-term stability, the monitoring period was set at 14 days. Group B conducted its experiments in the same location after Group A's data collection was completed. To monitor changes in human behavior following the design intervention, the monitoring period for Group B was set at 28 days. The experiment selected a residential community and an art training institution in Jinshui District, Zhengzhou City as the two design sample experimental sites. Group A was divided into eight regular monitoring sessions over the first two weeks, while Group B was divided into eight regular monitoring sessions over the last four weeks. The monitoring periods and durations for both Groups A and B were identical. The experiment collected data on the implementation effects of the visual design of waste sorting in the community group (referred to as groups A1 and B1) and the indoor public place group (referred to as groups A2 and B2), compared the results before and after the design intervention, and analyzed whether the introduction of information visualization design could raise public awareness of waste sorting and improve behavior through Figure 4. Additionally, in the final week, the team conducted surveys and interviews with participants to collect their feedback and suggestions, and summarized areas for improvement in the design. (see Figure. 4).



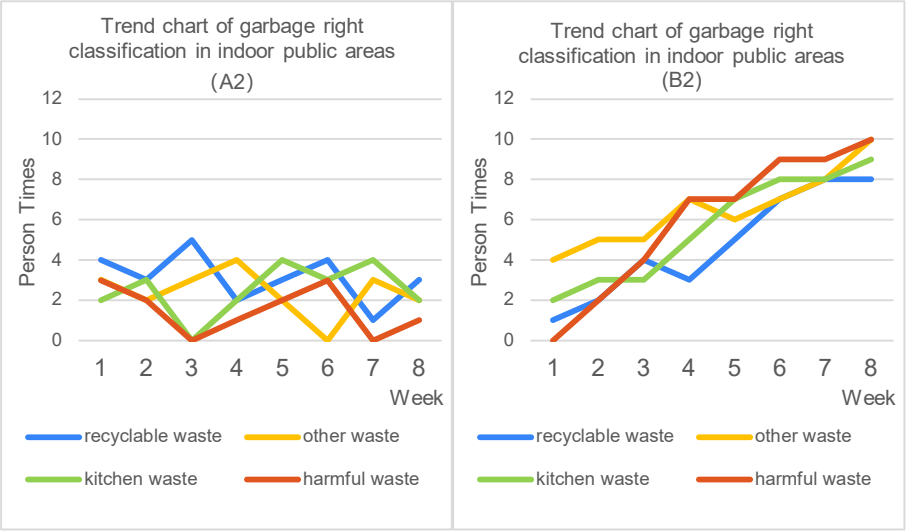


Fig. 4. Plot of simulation experiment data analysis.

4.1 Experimental Analysis of Community Groups

Community Group A1 conducted data collection twice a week for two weeks on the indicator "proper classification of four types of waste." Community Group B1 conducted data collection twice a week for four weeks on two indicators: "number of people paying attention to trash bins" and "proper classification of four types of waste." Experimental monitoring was conducted on average during the middle of the week and on weekends to balance the proportion of working adults and elderly and young people. Looking at the attention to trash bins in Group B, the trend chart shows that public attention to changes in trash bins was high in the first week, dropped sharply in the third week, and then remained stable. The initial high level of attention was due to the novelty of the visual design, which exceeded previous visual thresholds, and its fun and instructive nature, which encouraged people to stop and watch to learn new sorting knowledge. However, from the third week onwards, attention dropped sharply and remained stable. This is because the novelty had worn off, and the audience began to apply the known classification rules at home rather than sorting before disposal. At this point, those who paid attention to the information graphics were mostly disposing of single items, selecting the correct category before discarding them.

Although attention decreased, a comparison of data before and after the visual design intervention in Groups A1 and B1 shows that within a fixed time period and duration, the correct disposal rate remained relatively stable before the intervention, with no obvious trend of improvement or deterioration. Additionally, the number of people who correctly classified waste was low, resulting in a low overall correct disposal rate. In contrast, Group B1 showed a significant improvement in waste classification. The most noticeable change was in hazardous waste. Initially, hazardous waste bins were often filled with various types of waste, but during the final inspection, only used batteries

and medicines were found, indicating that residents did not dispose of the other three types of waste in the hazardous waste bins, which are clearly designated for different types of waste. The second most improved category was recyclables, as recyclables include a wide variety of items, some of which are easily confused with other types of waste. This time, the recycling bin instructions included four categories: paper, plastic, waste textiles, and glass/metal/electronic products, helping people clearly understand the types of recyclable waste. In the last week, there was almost no other waste in the recycling bins, which is a positive trend. Improvements in food waste and other waste were slower. First, the starting point was high, as people had a good understanding of food waste, but they mistakenly classified all other waste as "other waste" if it did not belong to the other three categories. To save time, people put kitchen waste in the kitchen waste bin and put everything else in the other trash bin. In this experiment, we found that the biggest change after the visual design intervention was in the disposal of hazardous waste and recyclables. For other waste and kitchen waste, we need to trace back to the source, which is household trash bins. Only when households sort their trash correctly can the accuracy of community waste sorting be improved.

4.2 Experimental Analysis of the Indoor Common Area Group

The data on the number of people paying attention to trash cans in indoor public areas was similar to that of the community group, with high numbers in the early stages and a gradual decline in the later stages. However, the difference was that 70% of the people visiting the 300 m^2 site each week were the same, so the visual design was no longer new information from the second week onwards. We can see that the second monitoring (on the weekend) of the first week was the peak of attention, followed by a sharp decline and a steady decline in the following two weeks, with people no longer paying particular attention to the information on the trash cans.

The comparison of "proper sorting of the four types of waste" before and after the intervention shows that the overall effect is better than the community group, with significant improvements in all four categories in Group B2. The primary reasons lie in the nature of the site and the method of individual waste disposal. As seen in Group A2, the foundation for correctly disposing of recyclables is relatively strong, while the correct disposal rates for the other three categories are lower. This is because the community group primarily disposes of household waste in sealed bags, with individual disposal as a secondary method, whereas indoor public areas exclusively use individual disposal, which is similar to household disposal methods, making improvements more noticeable. Furthermore, considering the time span, the experimental subjects in this site were fixed. The visual design intervention was applied to the same group of people for four weeks, with 1-2 sessions per week. This sustained intervention naturally leads to better sorting outcomes.

4.3 Summary of Experimental Subject Visit Information

To obtain more in-depth experimental results, the research team conducted on-site visits during the final week of the study, targeting participants from the community group

and the indoor public area group when they disposed of garbage. The visits covered five aspects: attention to the improved garbage bins, understanding of the text and images, objective factors contributing to classification difficulties, subjective factors contributing to classification difficulties, and evaluations of how confusing garbage information was handled. Each group consisted of 10 participants, with the following composition: 4 adult women, 2 adult men, 2 elderly women, and 2 elementary school students. During the visits, 13 participants indicated that they had actively noticed the improved text and images on the trash bins, viewing this as a positive step forward. In terms of understanding the text and images, children and adult women demonstrated higher levels of recognition. stating that they were easier to recognize and understand than small, single icons. However, 3 elderly participants suggested that the clarity of the images needed improvement. Objective factors contributing to classification difficulties included 9 participants noting the absence of mandatory household waste sorting products, 5 participants citing the lack of social supervision or penalties for non-sorting, and 4 participants mentioning inconvenient waste bin designs in various public spaces. Subjective factors included 7 participants believing mandatory sorting was unnecessary, 6 participants stating they would not sort waste, while another 5 said it was too troublesome. Regarding the graphical representation of easily confused waste, 11 respondents approved of the approach, 4 did not notice it, and 3 suggested that displaying information only on the bin body was insufficient, and that easily confused waste should be addressed through dedicated social campaigns. From the survey, over half of the respondents believe this experiment provides guidance for waste sorting operations, with icons and handling of easily confused waste requiring further visual improvements. However, it also highlighted reasons for limited improvements in other waste and kitchen waste in the community group, primarily due to difficulties in household waste sorting and insufficient subjective enforcement.

4.4 Experimental Conclusions

Through comparative analysis of two sets of experimental data and participant surveys at the end of the experiment, we concluded that, compared with traditional trash can icons, the introduction of information visualization design in waste sorting can raise public awareness of waste sorting, help implement sorting actions, and improve sorting behavior, especially in the areas of hazardous waste and recyclables. Group B data shows that the audience's attention to visualization design is inversely proportional to the trend of correct waste sorting. This reflects that the initial stage after the introduction of information visualization is a learning stage, followed by a reminder and maintenance process. In the future, it is necessary to persist in the application of visual classification design and use simple and easy-to-understand images to increase the audience's awareness of waste sorting.

5 Garbage Classification Information Visualization Innovation Strategy

The implementation strategy of information visualization design in city garbage classification is an integrated, scientific and comprehensive thinking mode, which is extracted from program design and experimental data. The guiding strategy of this paper summarizes the innovation strategy of garbage classification design through the integrated design of visual system, the support of guiding principles and the guidance of positive value, which is divided into three parts:

5.1 Visualization of Priority Families information

Households are directly linked to human daily life and are the primary source of waste generation. As evidenced by the experimental visits, bypassing household trash bin renovations and directly implementing visual information upgrades on community trash bins in the second phase resulted in significantly limited effectiveness. Public confusion regarding the separation of food waste and other types of trash remained largely unchanged. Drawing on data from indoor public spaces, the repeated use of dual visual cues—color and graphics—can embed waste icons into the brain, enhancing implicit memory. Through reasonable redesign of waste bins, standardization of waste bags with corresponding colors, and the introduction of visual information, the accuracy of kitchen waste and other waste sorting in households can be improved, leading to subsequent improvements in community-wide sorting. Waste sorting is a chain of interconnected actions, and taking the first step correctly is crucial to the success of the entire waste recycling system.

5.2 Visualization Information for Layered Designs

The question breaks down garbage classification into four types of places: household, community, indoor and outdoor public places. The design solution section of the paper has given the corresponding bucket design solution for each of the four types of places with the introduction of the visualization section.

5.2.1 Household Waste Information Visualization Design.

Family waste sorting emphasizes rationality and flexibility. Rationality in the bin design should be achieved by minimizing “kitchen waste”, maximizing “other waste”, sealing “hazardous waste”, and ensuring ample space for “recyclables”. The visual design should offer sufficient flexibility, featuring four types of illustrated stickers that can be applied to the bin according to household needs. These stickers can be easily removed and replaced once memorized, ensuring flexibility and ease of use. At the same time, garbage bags should match the classification colors, ensuring a consistent visual signal throughout the disposal process, further enhancing disposal accuracy. (see Figure 5).

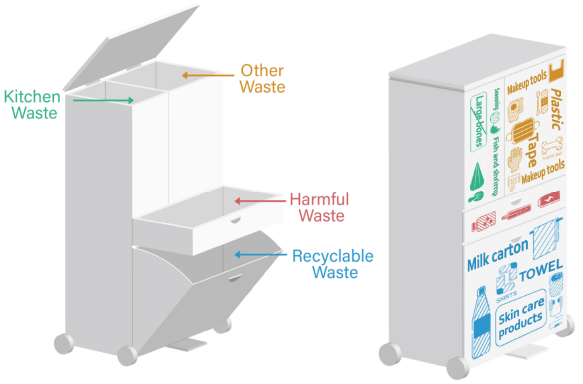


Fig. 5. Information visualization design for household trash cans.

5.2.2 Community Spam Information Visualization Design.

Community garbage cans as far as possible to use no contact flap barrel mouth, coupled with the barrel body garbage information design, you can achieve good guidance. Because of the large amount of community waste, the configuration of the number of garbage cans can be used for the most other waste, kitchen waste second, recyclable materials to be according to the paper, plastic, waste weaving and glass and metal to be more reasonable, (see Figure 6).

Fig. 6. Community spam information visualization design.

5.2.3 Outdoor Public Area Waste Information Visualization Design.

The design of outdoor public trash cans should focus on making their form obvious. The cans are divided into four categories, with physical changes added to the openings to restrict what can be thrown in, emphasizing that each type of trash should be treated differently[5]. The cans should clearly display visual information about the trash, with colors, shapes, and graphics combined to provide effective visual guidance. (see Figure 7).

Fig. 7. Outdoor public area waste information visualization design.

5.2.4 Indoor Public Area Waste Information Visualization Design.

In indoor public spaces, food waste and hazardous waste are extremely rare, so the "recyclable + non-recyclable" dual-bin system is commonly seen in daily life. The dual bin format can be retained, but the information on the bins must be clearly designed. For example, the opening for recyclables can be changed to a round shape, the icons on the bins can be large and clear, and the names of the bins can be changed to "recyclables + other waste." The key colors of the bins should follow the waste sorting regulations to unify the public's impression of the waste sorting names and avoid confusion.

5.3 Harmonization of Visualization Information

An ideal waste sorting system is the result of collaborative efforts among professionals from various fields. It is essential to break down the barriers caused by lack of communication between different urban districts and interference between specialized fields. The current industry model, where managers do not participate in the design and designers do not communicate deeply with the management department, seriously hinders the design and operation of the waste classification system[6]. During the interviews, respondents consistently pointed out that the current visual design for waste sorting lacks a unified standard, leading to difficulties in recognition and operational errors. To establish an interconnected visual system and a coordinated, unified engineering framework, it is essential to ensure that classification information is presented with high visual consistency. Every time a resident disposes of garbage, it should serve as a review of knowledge and a practice of proper behavior, facilitating a more streamlined learning-practice-reinforcement cognitive process. We must not treat residents as long-term subjects of testing and constraints but rather strive to minimize their burden and better serve the public.

6 Conclusion

Garbage classification is part of the development of human civilization, in which the general public should appear as active participants and beneficiaries, and the society is

obliged to explain clearly to them the methods of garbage classification and the results of after the classification and treatment, and to provide people with high-quality classification services. The project team concludes through the practical research on the visualization of classification information that the introduction of visualization design can effectively promote the implementation of garbage classification actions, and has a direct and indirect guiding effect on classification awareness and behavior. The design innovation strategy proposed in this paper is based on the interoperability principle of "learning-operating-memorizing", which improves the visual design of garbage classification in the city from various aspects, and improves the problems of confusion, inconvenience and learning difficulties in classification. It is hoped that this study can provide a directional guide for garbage classification information design, an accurate help for people's daily life, and an effective empirical reference for the general issue of garbage classification.

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