

Design Mobile Application for Teaching Children Food-Related Waste Sorting

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Abstract: The increasing food-related waste leads to serious social and the environmental problem. While teaching children waste sorting could effectively reduce the waste. This research aims to explore the design strategies of intelligent interactive application for teaching children food-related waste sorting. This research generally followed a 'research through design' process: several design principles are generalized by case studies and literature review as well as Delphi method, then a diet diary was designed as a culture probe to identify the children's daily behavior related to waste. Based on the feedback, we prototyped the application and tested the validity of the design principles.

Keywords: Food-related Waste, Children, Mobile Application Design

1. Introduction: Food-Related Waste and Mobile Application Design

Food-related waste, which including food package, food waste and disposable tableware, is a large contributor to the global environmental footprint, up to 10% of the emissions^[1]. These wastes need to be collected, sorted and recycled scientifically both at home and in schools^[2]. Child as a member of society also has the responsibility for food-related wastes separation. As food waste increases with age^[3], it is necessary to teach elementary students Food Related Waste Sorting (FRWS).

Design of mobile application could contribute to food-related waste reduction^[4,5] by increasing eaters knowledge, facilitating food sharing or even enhancing the food literacy. FRWS is in connection with daily life behavior, scenes and social environment which could be difficult to learn, especially for elementary students. Considering children could produce food waste as much as adults and design of intelligent interactive application have the potential to waste reduction^[4, 6], for example Wharton designed an application named EatChaFood to slice food waste production^[5], we designed Foodoor which is an educational application for teaching children FRWS.

2. Method and Materials

2.1. Research Design

This research generally follows the Research through Design(RtD) steps^[7] which is a practice-based research method focusing on 'making the right things' while researchers building insight through designerly ways of knowing^[8].

This research involves four iterative phases (see in Figure 1):

1) We collected data through case studies, literature review and expert interview. Based on these multiple data, we identified some themes of mobile application design for FRWS. Thematic analysis was also adopted to analyze the literature and interview notes.

2) Based on the themes, first-hand experience and field observation, some design principles were identified.

3) Prototyping from lo-fi to hi-fi according to the design principles.

4) A SUS test was used to test the validity of design principles.

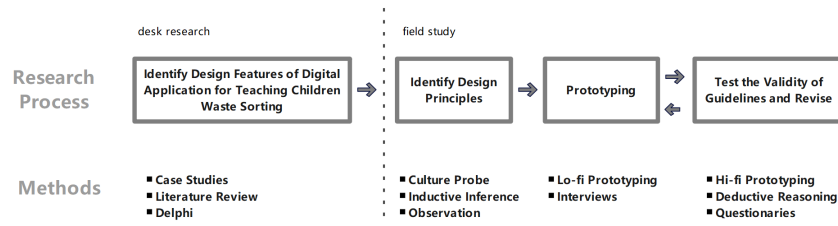


Figure 1: Research process and methods

2.2. Case Studies

Table 1: List of mobile applications designed for teaching children food-related waste sorting

Product Types	Application Apps	Product Positioning & Developers	Key Features	Disadvantages
APPs		A popular science app that combines garbage classification knowledge with practical operation. Developer: Happy Box.	Detailed text content of knowledge points; the interactive scenes are diversified. Contains knowledge of recycled items.	Highly repetitive game process. Educational content is insufficient.
		A professional experiential educational software, including voice interaction. Individual developers.	Comprehensive educational context, including garbage truck structure, sanitation clothing, etc; provide a sense of role experience.	A lot of time-consuming tasks
		Introducing wastes sorting in different scenarios. Individual developers.	The picture is concise and the guiding text is clear.	Too much text, leads to cognitive overhead
		Meet the published garbage classification specifications in 64 cities across the country Developer: Shanghai Nijing Technology.	Well-designed graphical information interface and graphical story telling.	Few operation tips, like voice prompt or help information.
Website		Focusing on rising environmental awareness. Developer: Guangzhou 4399 Information Technology.	Highly educational, with multiple scenes, allowing players to learn garbage sorting in different type of environments.	limited sound effects
		This app provides several small games about classification of municipal domestic waste. Developer: Beijing Chenxing Mutual Entertainment.	Allow people to answer questions online and share their ideas, players can play real-time battles with other players. Users claimed it is fun.	Poor audio experience.
		An interactive game in the exhibition hall providing somatosensory interactive experience. Developer: Maverick Treasure Hunt Environmental Technology	Simple operational system, which could improve children's hand-eye coordination.	Too much entertainment but less educational.
		Mini games with obvious reward mechanisms. Developers are individuals.	Motivate players to participate in garbage sorting through a point system.	Difficult for children.
		Provide educational games for children with storytelling and role playing. Developer: Xinyue Technology.	Provide cartoon images to attract children's attention, with sensitive storytelling and educational enlightenment.	Poor audio experience.
		Provide different type of games to help users classify domestic garbage. Developer: Shenzhen Dingshen Electronic Technology	App involves a lot of knowledge competition, providing a sense of role playing.	Only have single player mode.
Applet of Wechat		App only serve the children in Ningbo. Developer: Ningbo Game Center.	Random questionnaire system.	There is ambiguity in the direction of waste classification.
		Theme-based knowledge popularization. Developer: Duoduo Early Education.	Cartoonish UI and the topics are clear and easy to learn with clear path of operation.	Too much repeated operations.

Numerous mobile applications available on the market target FRWS in various settings. Most provide features to assist users with instructions or daily food management. To explore the mobile application design strategies for FRWS, a qualitative multiple case studies^[9] (n=12) has been adopted(see in Table

1). Here a case is defined as an already operated mobile application that focuses on teaching children FRWS. As this research represents the first synthesis of various applications designed for FRWS, the cases were selected following criteria below:

- 1) Apps that aimed to teach children FRWS skills and knowledge;
- 2) Apps has been going on for more than one year and received feedback from users;
- 3) Users could interact with apps and get feedback according to their own circumstances.

In order to identify the common advantages and disadvantages of these applications, we kept on use of each application over one week period. We also collected data through user and expert interview. The use of diverse methods by different researchers converged into triangulated data to enhance research reliability and validity^[10]. In the end, we found that these apps share some certain problems as below:

- 1) Most apps only provide unidirectional-information flow without multiple interaction.
- 2) Scenario is unfamiliar for children.
- 3) Homogenization is serious.
- 4) The context is not strongly related to everyday scenes.

On the other hand, theses apps have some common advantages which help us gain some insights:

- 1) Many apps gamify their educational task which could enhance the continuance intention to use app.
- 2) Scenario-based storytelling could provide a sense of identification.

2.3. Literature Review: Design and Food-Related Waste

Since 2012^[11], designers and researchers have been examined the relationship between design and food-related waste from different angles^[12] and found that the design of food packages^[13], interactive games^[14] and space could reduce food waste^[15]. Specifically, Song^[16] and Hebrok^[17] explored the design intervention path on household food waste through case studies and user-centered design. You, Bhamra and Clark^[18] identified the role of design in facilitating behavior change for airline food waste reduction, based on feedback from participatory design. Both Michalec^[19] and Veranika^[20] designed the food sharing service with social-tech perspective.

Recent researches confirmed that service design and social innovation could positively affect food waste reduction while co-design and user-centered design could be applied on the design process. Furthermore, researchers also find that Internet of Things (IoT), like mobile application, could be used to manage the food waste^[21]. Considering few research focus on online educational service for FRWS, this paper aims to explore the design principles of apps for teaching children FRWS.

2.4. Design Diet Diary as Culture Probe

Cultural probes have been used for qualitative data collection and analysis in many design researches. In order to understand how children address FRWS in their daily life, including which waste they produce, where and how they produce waste, we design a diet diary as a culture probe to collect, screen and analyze information about their daily FRWS (see in Figure.2). Diet diary could facilitate daily information analysis and help children to reflect on their own eating activities. Furthermore, self-reported diary could facilitate daily information analysis and provide data visualizations to support abductive reasoning^[22].

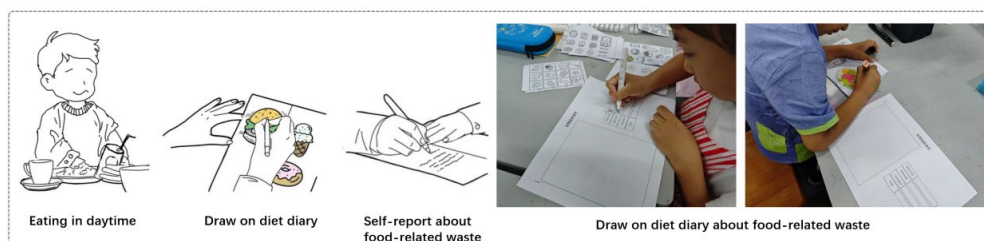


Figure 2: Children use diet diary to report the food-related they produced in daytime

Based on the self-report from children, we got some insights as below:

- 1) Children wasting food strongly related to their family lifestyle.
- 2) Children mainly learn FRWS from family member or teachers without self-study.
- 3) Most children have not kept on self-report about their daily life. Therefore, they are in lack of reflection on their food wasting.

Therefore, we decided to design an application with rich interactive narratives to help children learn FRWS by themselves.

3. Design Digital Application for Teaching Children FRWS

3.1. Design Principles: teach through storytelling

Based on the insights we got from case studies and culture probe, we proposed some design principles for FRWS as below:

- 1) Narrative interface with everyday scenes.
- 2) Structuring educational experience by way of narrating.
- 3) Jog children's memory of their daily life.
- 4) Help children understand the relationship between waste and scenarios.

3.2. Prototype: from lo-fi to hi-fi

Since the design principles and interactive process have been confirmed, we went into low-fidelity prototyping phase (see in Figure 3).

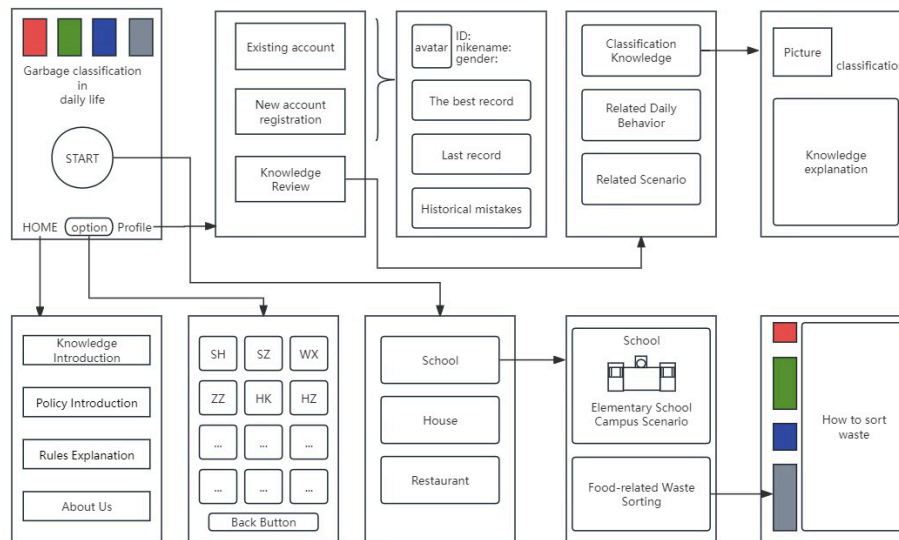


Figure 3: Low-fidelity prototype of Foodoor

Based on the low-fi, we strengthen the visual design according the design principles we summarized and finally made the high-fi of app (see in Figure 4). To ensure a user-friendly interface, readability and legibility as well as the smooth implementation, we designed the information framework and icon iteratively.



Figure 4: High-fidelity prototype of Foodoor

4. Validity and Usability Test

In order to check the usability of Foodoor, we adopt an usability test, modified from SUS (System Usability Scale) [23]. Eight primary school students were invited. Questionnaires are redesigned according to the user characteristics and context of use (see in Table 2). The average user SUS test score is 83.7 which means Foodoor could provide acceptable user experience. According to the questionnaires and our on-field observation, we improved Foodoor in some aspects:

- 1) Adding background music to make the story more effective;
- 2) Highlight the educational performance;
- 3) Enhancing the affordance by adding dynamic effects in images.

Table 2: SUS questionnaire, informed by Brooke[24]

<i>Num</i>	<i>Question</i>	<i>Degree</i> <i>from 1 (strongly disagree)</i> <i>to 5 (strongly agree)</i>
1	I would like to use this system frequently.	
2	I found the app unnecessarily complex	
3	This app is easy to use	
4	I cannot be able to use this app	
5	Various functions in this app are well integrated.	
6		
7	There was too much inconsistency in this app	
8	I think most children would learn to use this app very quickly.	
9	This app is very cumbersome to use	
	I felt very confident using the app	

5. Conclusion

Mobile application could reduce food-related waste by provide food sharing service, food and beverage management. But few researchers explored the role of design in educational area towards food waste reduction, especially for children. Based on case studies and field studies, this paper find that educational apps with narrative interface and daily life scenes could provide sense of identification, which could enhance the effects of education.

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