Bota: A Personalized Persuasive Mobile App for Sustainable Waste Management

Banuchitra Suruliraj¹ Tolulope Olagunju¹ Makuochi Nkwo² Rita Orji¹

¹ Faculty of Computer Science, Dalhousie University, Halifax NS, Canada
² Department of Computer Science, Ebonyi State University, Abakaliki, Nigeria
{Banuchitra.suruliraj; Tolulope.Olagunju; Rita.Orji}@dal.ca, makuonkwo@gmail.com

Abstract. This paper presents a personalized persuasive mobile app for promoting sustainable waste management behavior called Bota. The app design follows an iterative design process beginning with a review of existing apps in the area of waste management, the results of the review is then used to inform a medium-fidelity prototype design. Finally, we used the results from the evaluation of the medium-fidelity prototype to design the high-fidelity prototype. Specifically, first, we evaluated 148 mobile applications for sustainable waste management and deconstructed the strategies employed in their design. Personalization emerged as one of the frequently employed strategies. Based on the findings from the review, we designed the initial medium-fidelity, and subsequently, the high-fidelity prototype of Bota. A preliminary evaluation of the Bota app shows that our participants liked it; would use it if available; and found the app to be highly persuasive and capable of motivating desired behavior change towards sustainable waste management. In addition, 75% of the participants liked the game feature provided in the app.

Keywords: Persuasive Technology, Behavior Change, Waste Management, Sustainability, Persuasive Strategies, Mobile Apps, Sustainable Development Goals (SDG)

1 Introduction

People often think it's only the manufacturing industry that has contributed to climate change; improper disposal waste is one of the leading causes of environmental pollution. In reality, to live in an eco-friendly and sustainable world, everyone has a role to play. When recyclable and non-recyclable items are disposed of together it destroys the earth. Studies have shown that lack of awareness and negative attitudes are some of the hindrances to efficient waste disposal, sorting, and management in most developing communities [11]. Although various stakeholders have developed a number of strategies and approaches to curbing the high incidences of improper waste disposal and motivating and/or compelling people to embrace positive waste management behaviors, however, there have been little or no improvements in the waste management processes of most individuals and communities. Therefore, there is a need for a new approach to motivate sustainable waste management behaviors which can be achieved via the integration of mobile technology and persuasive strategies.

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Persuasive strategies are the building block of persuasive technologies (PTs) that enable us to motivate, influence, and assist users in adapting the desired behaviors [13, 15, 19, 21]. As a result, they are progressively being implemented in a variety of systems or apps to engage users and support them to achieve desired outcomes [12]. Also, smartphones are becoming more popular as people conduct all kinds of activities such as banking, shopping, gaming in their smart phones [16]. This provides the avenue for mobile apps to drive changes that can positively impact our environment.

Therefore, the goal of this research is to design a personalized persuasive mobile app for promoting sustainable waste management behavior called Bota. The app follows an iterative design process beginning with a review of existing apps in the area of waste management, the results of the review is then used to inform a medium-fidelity prototype design. Finally, we used the results from the evaluation of the medium-fidelity prototype to design the high-fidelity prototype. Specifically, we reviewed 148 mobile applications to deconstruct all the persuasive strategies implemented in the apps. The findings from our study uncover that the apps cumulatively employed 837 persuasive strategies spread across the four categories of the PSD framework as follows: Primary Task Support (PTS) (n= 327), Dialogue Support (DS) (n=193), System Credibility Support (SCS) (n=245), and Social Support (SS) (n=72).*Reduction, Personalization, Real-world feel, Surface credibility, Reminder,* and *Self-monitoring,* (listed in decreasing) emerged as the most frequently employed strategies in available apps for sustainable waste management.

Based on the design recommendations from this study, we developed an initial mediumfidelity, and subsequently, a high-fidelity prototype of Bota; a personalized persuasive mobile app for promoting sustainable waste management behaviors. A preliminary evaluation of the Bota app shows that all the participants liked the Bota app; would use it if available; and found the app to be highly persuasive and capable of motivating desired behavior change towards sustainable waste management. In addition, 75% of the participants liked the game feature provided in the app.

2 Background and Related Work

Wastes are real and waste management is a big business and sustainability challenge! But the bigger problem is the peoples' negative attitude and behaviors towards waste disposal and management across the communities [9, 11]. Behavior-change technologies also known as persuasive technologies are interactive systems (mobile, desktops and games) that are developed to inspire attitudinal and behavioral change from potential users without coercion or deception [4][5]. They are integrated with persuasive strategies, which are implemented on those technologies to inspire and support users to perform target behaviors [8][14]. In the past, many researchers developed various design steps [4], and strategies [17]which could be employed to design and evaluate persuasive systems. Specifically, Oinas-kukkunen and Harjumaa (2009) came up with twenty-eight persuasive strategies (persuasive system design (PSD) framework) which are categorized into four groups based on the type of support that they provide to users of a system: the primary task, dialogue, system credibility, and social support [15][17].

The results from recent studies show that the PSD framework has been used to design and deconstruct the persuasive strategies implemented in various kind of systems in different domains of human endeavors [11][5,13][14][18]. Fewer works have been done in developing persuasive technologies (PTs) to support sustainable waste management behaviors [2, 3, 10, 11][22]. However, we advance research in this domain by reviewing 148 mobile applications to

highlight relevant persuasive strategies that are effective at promoting sustainable waste behaviors. The findings from this review informed the iterative development and subsequent evaluation of the different phases of our mobile app, which could be employed to encourage behavioral and attitudinal changes of individuals to waste management.

3 The Study

This research seeks to uncover the finest persuasive strategies which have been successfully used to promote sustainable waste management behaviors. In addition, we want to use these strategies to design and evaluate a prototype mobile app for this purpose. To achieve these objectives, we addressed the following research questions: 1) What persuasive strategies were implemented in typical mobile apps for waste management online? 2) How can we adapt and implement these strategies in a new mobile app to promote sustainable waste management and sorting behaviors to improve its effectiveness?

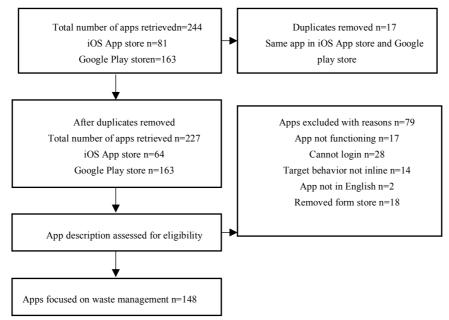


Fig. 1. Mobile applications filtering criteria

3.1 Evaluation of Mobile Apps for Sustainable Waste Management

To answer research question one, we searched for apps on the App Store and Google Play that is related to the subject matter, using various search terms including "waste management", "waste disposal", "sustainable waste", "waste tracker" and "waste recycling". In addition, we searched using various combinations of search terms using 'OR' and 'AND'. We applied a number of criteria to extract the apps that align with our study objectives; we accepted only those apps that are designed to support waste management activities and are in English (according to the app's description, demo and checking language options in app settings). In contrast, we left out those apps that failed to satisfy the aforementioned criteria. We ensured that apps that appeared in both the App Store and Google Play were counted as one.

In addition, we downloaded and coded the mobile apps for sustainable waste management to uncover the persuasive strategies implemented on them and how they were implemented, based on the Persuasive System Design (PSD) framework described by research [15]. We chose this framework because it is a widely used model for deconstructing persuasive systems to identify strategies that are effective at abetting users to accomplish desired tasks and target behaviors. We agreed on initial codes and ensured a mutual understanding of the coding decisions at every point. We organized and analyzed our data as follows:

- 1. Categorized apps based on their purpose and target behaviors.
- 2. Carried out a descriptive analysis of the collected data to get the persuasive strategies employed in the apps.

The evaluation uncovered that the apps cumulatively employed 837 persuasive strategies spread across the four categories of the PSD framework as follows: Primary Task Support (PTS) (n= 327), Dialogue Support (DS) (n=193), System Credibility Support (SCS) (n=245), and Social Support (SS) (n=72). In addition, we identified the persuasive strategies implemented on mobile apps, how they were implemented to promote particular target behaviors and respective behaviors targeted by the apps.

These findings are discussed in detail in a separate research paper [7][21].

3.2 Initial Prototype Design

To answer research question two (2), we proposed a number of design recommendations for developing sustainable waste management apps, which will potentially enhance the apps' effectiveness at encouraging sustainable waste management behaviors. These recommendations for design were based on the most commonly applied persuasive strategies including: Reduction (n=97), Personalization (n=90), Real-world feel (n=83), Surface credibility (n=83), Reminders (n=73), Self-monitoring (n=50), Tailoring (n=45), Social facilitation (n=40), Rewards (n=36), Suggestion (n=33), Verifiability (n=32), Praise (n=29), Liking (n=18) and Rehearsal (n=17)

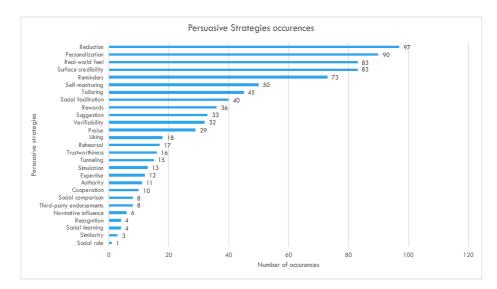


Fig.1.Persuasive strategies and number of occurrences

Some of the recommendations for design include:

- 1. Reduction of efforts expended by users in performing target behaviors using Simple and Easy-to-Use Routines
- 2. Opportunity for Users to Customize Contents and Displays suing personalized support features.
- 3. Provision information about the owners of the app using genuine and responsive design
- 4. The offering of competent and credible interfaces to support various categories of users
- 5. Notification Management by employing Reminder strategy to remind users to perform target behaviors
- 6. Helping users track their performances using self-monitoring strategy
- 7. Adapting information to different user groups using tailored contents and services
- 8. Facilitating interaction and collaboration among potential users by using social media tools and platforms to share information.

The details of the recommendations for design and how they may be implemented in typical persuasive technologies for waste management are discussed on a separate research paper [7].

Subsequently, we used the recommendations to design a medium-fidelity and subsequently, a high-fidelity prototype of Bota; a mobile persuasive app that will potentially motivate people to practice pro waste management behaviors. Figure 2 (a - d) shows the screenshot description of the medium-fidelity prototype of Bota.

Figure 3a is a map view window that shows nearby recycling centers based on the user's current location. It lists the names of nearby recycling centers and distance in kilometers. This screen implements a *reduction strategy* showing a visual picture of nearby centers, reducing the time spent in finding the closest one. *The real-world feel* is implemented by showing names of nearby centers and addresses upon selecting each center. *Surface credibility* is employed by embedding a Google map view to have a competent look and feel. *Tailoring* is employed by showing centers tailored to the user's current location not a generic list. *Verifiability* is em-

ployed as the names of recycling centers and contact information can be provided in more information pages.



Fig. 2.Medium-fidelity prototype implementing 12 persuasive strategies

Figure 3b is a Self-tracking feature. *Personalization* is employed by providing an option to add/modify goals and tracking items to reflect their personal preference. This is one of the common implementations of personalization in persuasive apps [1]. *Rewards* are implemented by providing awards for consistent performance, and *self-monitoring* is employed by showing a graph of statistical data, and calendar view. *Reminders* strategy is employed by push notification and News that frequently reminds the user to use the app and track progress.

Figure 3c shows a personalized sorting game. Here, a waste item is shown, and the player has to choose how to dispose of it based on its types like organic, recyclable, paper or hazardous type. *Rehearsal* strategy is employed to help a user to rehearse waste sorting activities which could support them in day to day life waste sorting. *Praise* and *Reward* strategy are employed via congratulations to the user on completing a level and award of badges/trophies for obtaining a high score. *Social facilitation* is employed to allow users to share their high scores on social platforms like Facebook, Twitter or others, thus motivating users to perform target behaviors [20].

Fig 3d shows a get a social window which helps to bring people with similar goals together, by providing information about local initiatives like beach cleanup or virtual events happening across the globe. It also shows friends who are taking part in those events. *Social facilitation* strategy is implemented by showing events and friends taking part in those events. *The tailoring* strategy is employed by showing events relevant to goals or saved filter options. *Reminder* strategy is implemented by sending push notification about interesting events, and new events.

3.3 Evaluation of the Medium-Fidelity Prototype

We assessed the effectiveness of the persuasive strategies implemented on the mobile app prototype at promoting intended waste management behaviors. This will enable us to identify and select the most effective strategies. In all, eight (8) participants took part in this medium-fidelity prototype evaluation. The researchers gave a brief introduction to the study. The questionnaire took about 20 min to complete. The questionnaire consisted of 6 sections namely: **Participant Information**: In the last section, participants are requested to enter information about education and country of origin. The questionnaire is formatted in Google forms¹ and shared with participants; participants answered the questionnaire from their personal laptop. The participants consist of 50% females and 50% males; all were above 20 years of age and had a minimum of an undergraduate degree.

Waste Sorting Quiz: The waste sorting quiz section had four questions examining participants' knowledge of the different types of wastes and how to appropriately dispose of the incorrect bin them in line with the best waste management practices.

Play Rethink Waste Game²: The participants were requested to complete at least one level of Rethink waste game. The game is a waste sorting game that teaches participants how to sort different types to the appropriate waste bin provided by a Canadian municipality.

Share Their Experience of Playing the Game: In the third section of the questionnaire, participants were requested to share their experiences about playing the Rethink Waste game and answer two questions on how playing a waste sorting game can educate people on waste sorting in real life.

Waste Management Practices: This section had five questions about current waste management practices that participants follow in their day-to-day life.

Rating Proposed App Features: Participants were requested to rate and provide feedback on the medium-fidelity prototype of the Bota app we designed.

We evaluated the prototypes using an online survey (created using Google forms1), downloaded in .csv format and analyzed using Microsoft excel for both studies described in this paper. Quantitative analysis was conducted on close-ended question responses and qualitative analysis was conducted on open-ended question responses.

3.4 Findings and Discussion

The results were analyzed in 5 categories: "Quiz on waste sorting knowledge", "feedback on game", "current waste management practices", "app features" and "participant information".

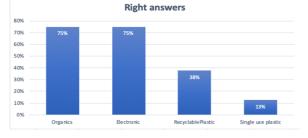


Fig. 3.Participants' knowledge of waste categories

As can be seen from Figure 4, the analysis of the Quiz on waste sorting knowledge shows that 75% of participants showed strong knowledge on organic and electronic waste disposal, but the

¹ https://www.google.ca/forms/about/

² https://www.surrey.ca/city-services/18153.aspx

numbers dropped to 38% on recyclable plastics and only one participant gave the right answer on single-use plastics disposal. This implies that there is a need to improve knowledge of single-use plastics, which can be implemented using effective persuasive strategies.

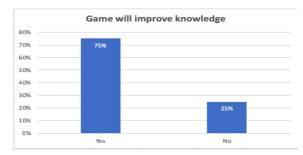


Fig. 4.Sorting game improve knowledge on waste disposal

As can be seen from Figure 5, 75% of the participants agreed that playing a waste sorting game will improve their knowledge of waste management. Out of the negative response, one participant chose "No" because the information in the game was inaccurate which is out of scope for our study as the game is provided by the government of Surrey city, Vancouver, Canada.



Fig. 5. Cumulative ratings on app features

When participants were asked to rate the four app features, we found that "providing information about nearby recycling depots" and "waste sorting game" scored highest; both scored 32 out of 40 each, among the participants. Based on the responses to open questions, we found that 50% of participants believe that sustainable waste management is about waste sorting and disposal, and only one (1) participant said it is about changing daily habits. All the participants agreed that earth is getting polluted by humans and changes in daily habits will bring a change to the environment. We received responses of participants with Pakistan, Saudi Arabia and Nigeria as their country of origin and all of them had a minimum of bachelor's level degree.

3.5 High-Fidelity Prototype Design

Based on the results from the evaluation of the high-fidelity prototype, we iteratively developed the high-fidelity prototype of the app to target users in the pre-contemplation, contemplation and action stages of the trans-theoretical behavioral model. Also, we took into consideration, a few of the state-of-art features existing in sustainable mobile apps for waste management on the online marketplace in designing the high-fidelity prototype of the app. Specifically, we wanted to include those interactive and motivational features that will potentially promote a change in attitude and behavior of users from disposing of waste in one trash/bin to sorting waste into major 4 categories – Organic, Recycle, Garbage and others. The target audience for this app were adults as they are in the best position to dictate what goes on in a household and pass down knowledge to their kids (if any). The prototype was designed using the Proto.io³ website. The figures7(a- g) is a pictorial description of what we have been able to come up with so far.



Fig. 6. High-fidelity Prototype Designs

Figure 7ais the Login screen that is personalized to allow users to login using their individual Facebook account or email addresses or phone number. In addition, new users can sign up using email, phone number or Facebook accounts.

Figure 7b is the home screen of the application and it contains four primary features: Activity, Recycling depots, Game and News and Events. A user can view the demo to understand how the app works. Users are expected to turn on Location Services for the app to know the current location of the user.

³ https://proto.io/

Figure 7c displays the map that shows nearby recycling depots where the users can drop-off wastes. The locations are color-coded into the red for organic or food waste, yellow for paper or glass waste, blue for plastic waste and black for multiple types. This helps the user to know the nearby centers and drop off recyclable wastes.

Figure 7d is the Daily tracker feature of the app. Users can track their daily behavior in three categories food waste, plastics and glass or paper. The user can choose what type of action they followed such as reduce, reuse or recycle on the three waste types provided. Also, the user will earn a golden star for not using a single-use plastic-like bag in a day. Upon consistently logging these actions, users will gain badges and cups. The golden stars can be compared with friends.

Figure 7e is the newsletter feature that allows users to send push information on tips, events, communities and campaigns related to waste management. This helps the user to stay up to date when it comes to waste management.

Figure 7f displays golden stars earned. This is a social comparison strategy that uses a graph to compare the activities of friends who use plastic-like bad daily and those who don't. It also shows the achievement of their friends. This allows users to stay motivated and compete with friends.

Figure 7g is a waste sorting game. The game is similar to commonly found waste sorting games that use features like rewards and praise inform of words and virtual trophies to motivate gamers to perform target behaviors.

3.6 Preliminary Evaluation of Bota App

We conducted a preliminary evaluation to understand the usability of the high-fidelity prototype design in the context of effectiveness in achieving sustainable waste management and gather feedback on usability issues and potential improvements. Four (4) participants from the same set of people who evaluated the first study were chosen to evaluate the prototype.

Study design: The study was conducted using a combination of open-ended and closeended questions. The study consisted of 2 parts: Prototype testing and answering questionnaire. The prototype is designed using the Proto.io3 website and a link to the high-fidelity prototype is shared with the participants. After browsing through the prototype screens, the participants were requested to answer a questionnaire to rate the app on the Likert scale. Feedback is requested in four categories according to feedback capture grid⁴: Liking, Criticism, Questions and Suggestion. Finally, participants asked to provide general comments. The questions were designed using a Google survey1.Before beginning the study, the researchers demoed the prototype; participants were requested to use the app on their mobile phone. After which they responded to the questionnaire. The task took an average of 15 minutes to complete.

Study participants: For this preliminary evaluation four participants from the same set of participants who evaluated the medium-fidelity prototype were randomly chosen to participate in the high-fidelity prototype evaluation. Participants consist of two females and two males, age ranging from 20 to 40 years old, and possess a minimum of bachelor's degree.

⁴ https://www.interaction-design.org/literature/article/test-your-prototypes-how-to-gather-feedback-and-maximize-learning

3.7 Results

The results show that all the participants (100%) liked the Bota app; would use it if available; and agreed that the app is highly persuasive and capable of motivating desired behavior change towards sustainable waste management. Again 75% of the participants liked the game feature provided in the app. However, participants also requested for some features and more improvements on the app's usability. Specifically, participants highlighted the need to separate the daily tracker from the calendar view. One participant requested a demo or tutorial feature that works users through how to use the app. One participant commented "*I suggest you make the dates on the calendar clickable so that the user would have a larger screen for the particular date he is interacting with. An example of what each waste is would be necessary.*"

To address the comments or issues highlighted by participants in the evaluation, we added three new pages to the app design. These include: to separate daily trackers from a calendar, we added a new page for self-tracking daily waste management activity, see Figure 8a. Again, we created a demo page that shows how to use the app, see Figure 8b. To improve the overall app usability and usefulness we implemented picker for selecting options, added recycling guide from a local municipality and a sorting guide using camera and object recognition library, see Figure 8c. The feature is added to the navigation bar as it helps the user to sort waste in day to day life.



Fig. 7. Additional features based on participant feedback

4 Future Work

Currently, the high-fidelity prototype of the app is at the final stages of development. As soon as we complete the iterative design, we plan to conduct another evaluation study to understand the usability of the prototype in the context of its effectiveness in achieving sustainable waste management and gather feedback on usability issues and potential improvements. Specifically, we will request feedback from a number of participants; a select number of people from the group of participants who evaluated the first version of the high-fidelity app and a new set of participants, to assess this new version. This mixture will afford us the opportunity to measure and compare performance from both the participants who are already conversant with what we are doing and those who are new to this study. After the evaluation of the new version of the high-fidelity prototype, we hope to measure the expected changes and compare them with the results we had after the evaluation of the high-fidelity prototype. In addition, we hope to understand the level of effectiveness of the persuasive strategies implemented on the high-fidelity prototype and how they could be better operationalized to motivate attitudinal and behavioral changes in the manner people manage their wastes.

5 Conclusion

Persuasive technologies are valuable tools of influence and motivation. They may come in form of mobile apps, desktop systems, games, and hardware which are operationalized with persuasive strategies to motivate, influence, and assist potential users to embrace new and desired behaviors that will benefit them and their society. They have been applied in various domains such as in eCommerce, eLearning, health and wellness, workplace, and environmental sustainability. This paper describes an early, middle, and advanced stages of work on the design of a mobile app for waste management. Through an initial evaluation of 148 mobile applications, we extracted some of the finest persuasive strategies which are currently being used to develop sustainable waste management systems. Based on the design recommendations from this study, we developed an initial medium-fidelity, and subsequently, a high-fidelity prototype of Bota; a mobile persuasive app that will potentially motivate people to practice pro waste management behaviors. Using an online survey, we invited users to evaluate the effectiveness and usefulness of our high-fidelity design in changing/improving people's behaviors to waste management. We iteratively used the feedback from our survey to develop a high-fidelity prototype of the app. A preliminary usability evaluation of the initial design of the high-fidelity prototype shows that 100% of the participants liked the Bota app; would use it if available; and agreed that the app is highly persuasive and capable of motivating desired behavior change towards sustainable waste management. In addition, 75% of the participants liked the game feature provided in the app. We are iteratively using the feedback from our evaluation to refine and improve the app's usability. We plan to evaluate the persuasiveness of the new version of our app in promoting pro-environmental behaviors among a mixed group of users.

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