Persuade Oscar, the Grouch: A Design Approach for a Persuasive Gamified Smart Waste App

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Abstract

Littering, for instance caused by awareness lacks on appropriate waste disposal, is one of the pollution causes in cities and can damage water, air, and soil. In the smart city context, smart waste apps (SWAs) can be used to address the change of citizens' littering behavior by implementing persuasion. This research aims to provide a first step toward a design theory for SWAs that enhances the internal motivation to engage in correct litter disposal. Our research follows a six-step design science approach to identify design requirements, derive design principles, and develop design features based on a literature review on SWAs and a series of expert workshops. We investigate which design principles should guide SWAs' design to select an adequate set of persuasive elements and, thus, better target littering behavior change. The proposed prototypical SWA is expected to motivate citizens' littering behavior change, thereby, improving urban cleanliness.

Keywords: Smart waste app, persuasive systems, gamification, design science.

1. Introduction

One main environmental pollution cause in cities is improper and illegal waste disposal (Neumann & Brudermann, 2023). Citizens often dispose of waste in public places, rather than in garbage bins or recycling containers, which is referred to as littering (Chaudhary et al., 2021) and can lead to water, air, and soil pollution (Breitbarth, 2014; Briones et al., 2018). For example, due to the political Corona measures, littering of face masks and other personal protective equipment significantly increased, leading to a uprise microplastic pollution in the environment (OECD, 2022). There is a common understanding among politicians, practitioners, and researchers to overcome littering: citizens' behavior needs to change (Hansmann & Steimer, 2017), particularly, since littering significantly thwarts sustainable development in cities (OECD, 2022; UN, 2022).

Littering is caused by awareness lacks on appropriate waste disposal or an individual's inherent disposition towards engaging in such behavior (Breitbarth, 2014; Hansmann & Steimer, 2017). According to Helmefalk and Rosenlund (2020), the awareness lack is prompted by a knowledge deficit if one's littering behavior has a significant impact on the environment. The individual's disposition may result from the fact that proper waste behavior provides no personnel benefit. We consider these two causes to be the most important to significantly motivate citizens' behavior change.

The use of information systems (IS) offers vast opportunities and a sound base to improve sustainability (van der Aalst et al., 2023) and has the capability to engage user in behavior change (Oinas-Kukkonen & Harjumaa, 2009). However, research on the impact of ISs on changing users' littering behavior remains inconsistent (Hasan & Hasan, 2020; Helmefalk & Rosenlund, 2020). The inconsistency can be attributed to the fact that IS implemented into the waste management processes are mainly concerned with optimizing scenarios, such as waste collection, where the waste is already disposed in a sensor equipped smart bin, (Castro Lundin et al., 2017; Kamm et al., 2020). Thereby, the pollution causes in cities stay unaddressed, as a network of smart bins and collection route optimization is insufficient to foster citizens' participation and behavioral change (Tadili & Fasly, 2019). Nonetheless, smart bins can be used as a basis to engage citizens in more sustainable waste behavior. Extending a smart bin network with a smartphone-based smart waste app (SWA) provides an opportunity to actively involve citizens in the municipal waste management. Thus, citizens can be provided with persuasive elements in the SWA which address the main causes for littering and motivate behavioral change (Hasan & Hasan, 2020; Oinas-Kukkonen & Harjumaa, 2009; Suruliraj et al., 2020). Persuasive elements are parts of persuasive information systems focusing users behavior change (Oinas-Kukkonen & Harjumaa, 2009). However, SWAs are usually considered as supplementary elements in waste management used for e.g., mere

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data monitoring of smart bin fill-levels without addressing the littering behavior (Delnevo et al., 2021).

Previous work in the waste management context suggests that gamification is an appropriate way to support citizens' behaviors change (e.g., Antonache et al., 2020; Briones et al., 2018) and persuasion (Orji et al., 2018). In the context of SWAs, some authors have also unintentionally employed persuasive elements in their gamification design (Hasan & Hasan, 2020; Suruliraj et al., 2020). However, insufficient implementation of game-design elements without regarding the users' littering behavior misses persuasion potentials (Krath & von Kortzfleisch, 2021) to change the littering behavior. Addressing the outlined problem, we pursue the following research question: *Which design principles should guide SWAs' design to select an adequate set of persuasive elements in a structured way and, thus, more targeted encourage littering behavior change?*

Our research aims to provide a first step toward a design theory for SWAs that enhances the motivation to engage in litter disposal. To that end, based on a literature analysis and a series of expert workshops, we propose five design requirements (DRs) and four design principles (DPs) that we demonstrate as part of a prototypical SWA motivating citizens' littering behavior change. Thereby, we rely on extrinsic and intrinsic motivation theory (Ryan & Deci, 2000) to select suitable DPs. To attain our objective and answer our research question, we established design science guidelines (e.g., Gregor et al., 2020; Peffers et al., 2007). We focus on DPs that can potentially combine gamification and persuasion, thereby better enhancing citizens' motivation to reduce littering.

2. Theoretical framework

Our theoretical framework incorporates insights from three research fields. First, we turn to SWA literature and present the current research state and different application fields of SWA. Second, we expound on the fundamentals of persuasion (Oinas-Kukkonen & Harjumaa, 2009) and outline the use of gamification (Deterding et al., 2011; Schöbel et al., 2020) in current SWAs. Third, we turn to extrinsic and intrinsic motivation literature (Ryan & Deci, 2000) to better understand psychological processes that occur at behavior change and how persuasion supports it.

SWAs are a part of smart waste management and can exchange data with other elements within a network of smart waste management systems such as smart bins (Pardini et al., 2020). We understand SWAs as intelligent, proactive, and sustainable systems for managing urban waste using citizen participation with the aim of improving the cities' waste management sustainability (Castro Lundin et al., 2017; Pardini et al., 2020). Smart waste management includes required activities for the collection, transport, and treatment of waste, from its generation to its final disposal or recycling (Anagnostopoulos et al., 2017; Nema & Modak, 1998). Table 1 presents three frequently discussed concepts for the use of SWAs, as derived from the literature.

Turning to persuasion theory next, Fogg (2002) originally defined persuasive systems as interactive IS that aim to change user behavior or attitudes without coercing the user. Focusing the socio-technical perspective, we regard persuasive systems, based on the work of Oinas-Kukkonen and Harjumaa (2008), as socio-technical IS designed to reinforce, change, or shape both attitudes and behaviors, without force, coercion, or deception of the user. Looking at existing research, we found that several authors have unintentionally employed persuasion through the implementation of (game) design elements but left the persuasive characteristics unaddressed. For instance, Delnevo et al. (2021) implemented the reward principle by awarding the user with points and badges for correct waste disposal. Hoffmann and Pfeiffer (2021) divide the learning process of proper recycling behavior into challenges a user should fulfil, thereby the authors use the reduction principle. More examples of design elements employed in SWA design we found within our review are presented in Table 2.

Table 1. Application concepts of smart waste management systems

Concept	Description	Exemplary references
Data collection and user support	A smart waste management system collects data and informs user with an SWA. SWAs integrated into the processes support user tasks (e.g., by sending messages about fill levels or waste collection schedules).	Dasari et al., 2021; Makhseed et al., 2021; More et al., 2018; Pardini et al., 2020
Organizational process optimization	Smart bins collect and transmit data to dynamically optimize navigation routes for the waste collection vehicles displayed in SWAs (e.g., by artificial neural networks). Resource consumption (e.g., fuel and time) can be reduced, resulting in cost savings and less pollution.	Kamm et al., 2020; Likotiko et al., 2021; Mishra et al., 2019
Motivation to use the systems or to change waste behavior	SWAs motivate sustainable use of waste systems, separation of waste into different types of recyclable materials or to recycle waste in an orderly way. The objective is a change or improvement in waste behavior.	Aguiar-Castillo et al., 2019; Briones et al., 2018; Delnevo et al., 2021; Helmefalk & Rosenlund, 2020; Hoffmann & Pfeiffer, 2021; Orji et al., 2018; Santti et al., 2020

Table 2. Exemplary design elements and related DPs of SWAs (Krath & von Kortzfleisch, 2021; Oinas-Kukkonen & Harjumaa, 2009; Schöbel et al., 2020)

Design element	Related DP	Exemplary references
Tasks and Challenges	Reduction: Complex tasks are decomposed into simpler, smaller tasks to encourage users to perform a desired behavior.	Delnevo et al., 2021; Hoffmann & Pfeiffer, 2021.
Virtual environment	Visualization: Data is visualized abstractly to encourage the user to reflect about their behavior and show them how those behaviors relate to the goal of using the system.	Briones et al., 2018; Helmefalk & Rosenlund, 2020; Hoffmann & Pfeiffer, 2021
Positive feedback messages	Praise: The system praises user for positive behavior as reinforcement.	Aguiar-Castillo et al., 2019; Delnevo et al., 2021; Santti et al., 2020
Points, Badges	Rewards: The system rewards the user with virtual elements when the user shows the desired behavior.	Aguiar-Castillo et al., 2019; Delnevo et al., 2021; Helmefalk & Rosenlund, 2020; Santti et al., 2020

Utilizing gamification is seen as an effective way to support persuasion and to motivate behavior change (Orji et al., 2018). However, authors implementing gamification in SWAs neglect the user motivation to change the littering behavior, thereby the SWA loses persuasion potential (Krath & von Kortzfleisch, 2021). We argue that this gap from insufficient user-system interaction design can be bridged by utilizing persuasive elements.

We consider persuasive elements as a means to enhance both extrinsic and intrinsic motivation among users, thereby support a change in their littering behavior (Deci & Ryan, 1985; Krath & von Kortzfleisch, 2021). Extrinsic motivation refers to engagement in an activity to attain some separable outcome such as a reward (Ryan & Deci, 2000). Intrinsic motivation is the drive to perform an activity because of the inherent satisfaction (Ryan & Deci, 2000). For instance, praise and reward (employed by points and badges as game-design elements provide the user with an external stimulus, thereby these DPs can provide an extrinsic motivation to change the littering behavior (Krath & von Kortzfleisch, 2021; Sailer et al., 2017). Showing progress in form of a visualization (such as a virtual environment as a persuasive element) addresses the intrinsic motivation (Bitrián Arcas et al., 2021; Krath & von Kortzfleisch, 2021). The user takes personal responsibility for the visualization's progress, thereby the SWA enables the user to reflect the littering behavior and motivates behavior change (Oinas-Kukkonen & Harjumaa, 2009). SWAs' design must consider both fundamental motivation mechanisms to effectively address the behavior change. We argue that gamification can support persuasion, but gamification is not always persuasive, therefore, the SWA needs to employ persuasive elements in addition to game-design elements. We summarized the relationship between the SWA, the user-system interaction and the littering behavior in our research framework in Figure 1.

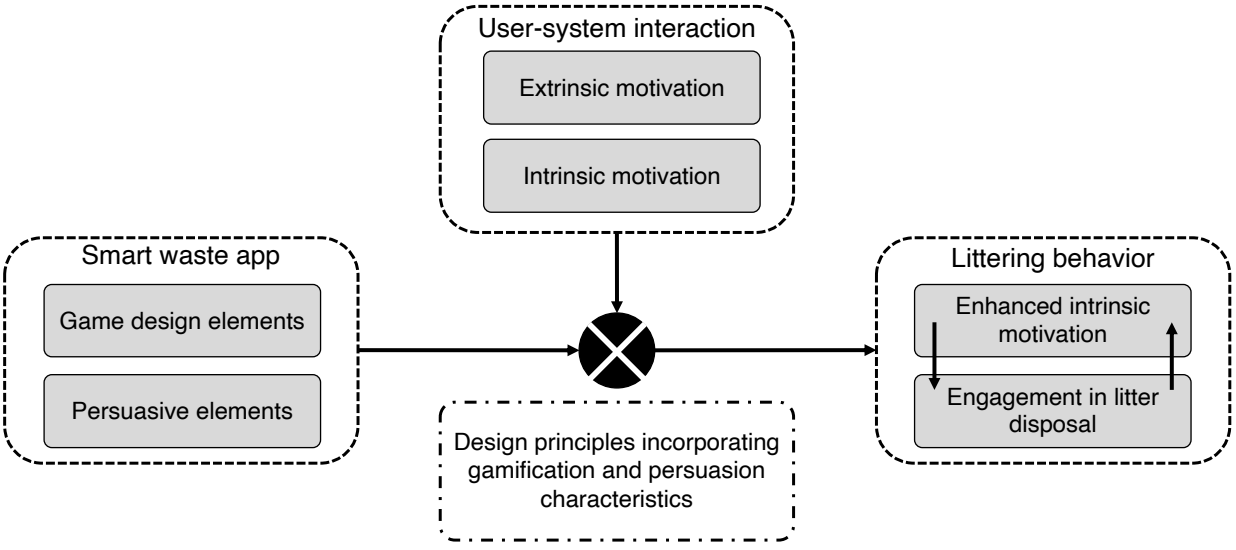

Figure 1. Research framework

3. Research process and methods

Our design encompasses a set of DPs to employ game-design elements and persuasive elements to successfully enhance user motivation and engagement in litter disposal (Gregor & Jones, 2007). To build our artefact, we followed the six-step design science research methodology by Peffers et al. (2007) consisting of (1) problem identification and motivation; (2) define solutions objective; (3) design and development; (4) demonstration; (5) evaluation; and (6) communication.

We identified the problem with a literature analysis on smart waste management systems and SWAs and, to also consider the perspective of practitioners, during four workshops with municipal experts. First, we conducted a comprehensive analysis of literature on SWAs research (vom Brocke et al., 2009; Webster & Watson, 2002). We searched ACM Digital Library, AIS eLibrary, EBSCOHost, and IEEE Explorer/ Digital Library. We started our literature review by searching article abstracts, titles, and keywords for the string "Smart Waste Management" AND "App OR information system" AND "persuasion OR gamification OR sustainable*" (vom Brocke et al., 2009). In total, 102 articles related to our search were collated. In a next step, we excluded studies purely focusing on the technical realization or implementation of SWA or systems in the waste management context (57 Studies) or systems only addressing pollution symptoms without considering the causes (29 studies). Included studies aim to change user behavior based on persuasion or gamification and a SWA (14 Studies). We examined all studies in which persuasive elements and game-design elements were implemented, even if they were not explicitly stated. In addition, we used both backward and forward search to gather the further relevant articles (Webster & Watson, 2002). Upon reviewing the literature, we identified three fundamental limitations that encompassed a wide range of studies in the field of SWAs: (1.) In smart waste management research SWAs are mainly considered as supplementary elements (e.g., to monitor data); (2.) environmental impact of littering behavior is unaddressed by most SWAs; and (3.) SWAs addressing behavior change are insufficiently designed particularly the user-system interaction and the impact on littering behavior. As a result, the full potential of SWAs to promote waste disposal and sustainable development has not yet been realized.

Second, we conducted workshops with municipal representatives from a metropolitan region in Germany to extend the motivation with practical experience. We recorded the workshops and transcribed them verbatim to code and analyze the workshop results (Mayring, 2014; Schulze et al., 2023). The municipal experts are highly experienced in the fields of public utilities and municipal waste management through executive positions in the city administration. These perspectives from the field are an important part in the development process of our SWA. The experts were able to give us insights into the challenges of littering from a practical point of view. The six experts and their particular areas of expertise are presented in Table 3. Sex and age were included in the table to illustrate the diversity of participants.

Table 3. Characteristics of workshop participants

ID	Sex	Age	Position	Experience
1	W	20	Employee in environmental office	Conducted a littering survey in the city of (blinded) and is working on a project to improve city cleanliness.
2	W	37	Consulting scientist in the field of smart city	Experienced in the persuasive system development and the deployment of smart city solutions.
3	W	55	Head of Department for City Cleanliness	Leads the project to improve urban cleanliness in the city and develops measures for it by political order.
4	M	49	Alderman for Environment	The alderman provides the political perspective on citizen persuasion.
5	M	37	Consulting scientist in the field of smart city	Member of the German Smart City Forum. Experienced in the development and deployment of smart city solutions.
6	M	57	Head of the environmental office	Accompanied projects to raise citizens' awareness of environmental protection and littering (Advertising and education campaigns).

In addition to the results from our literature analysis, the findings from the expert workshops ground our DRs. As a next step, we defined our aim (2) is to design an SWA to motivate users to perform correct littering behavior and support them to change their behavior if needed. The major challenge was to sufficiently combine the DPs with persuasive elements and game-design elements to address the DRs. Further, in step (3), we designed a prototypical SWA which will be discussed in detail in the following section, hence the demonstration (4) is within the scope of this paper. We focus our argument on demonstrating how we encourage users to change their behavior and see the positive environmental impact of their actions (intrinsic motivation) and how a SWA may provide personal benefits through external rewards (extrinsic motivation) (Hansmann & Steimer, 2017; Helmefalk & Rosenlund, 2020). We validated our prototype (5) with the municipal experts and will briefly outline how we did so. We consider the last step of the design science research methodology fulfilled with the (6) communication of our work in this paper.

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Table 4. Design requirements for SWA development

DR	Description	References
DR1 Extrinsic/ Intrinsic	The SWA should persuade the user of correct littering behavior.	Briones et al., 2018; Delnevo et al., 2021; Helmefalk & Rosenlund, 2020; Hoffmann & Pfeiffer, 2021
DR2 Extrinsic	The SWA should incentivize users for correct littering behavior.	Briones et al., 2018; Delnevo et al., 2021; Schöbel et al., 2020
DR3 Extrinsic	The SWA should give a positive and reinforcing response for correct littering behavior.	Bitrián Arcas et al., 2021; Helmefalk & Rosenlund, 2020; Hoffmann & Pfeiffer, 2021; Santti et al., 2020
DR4 Intrinsic	The SWA should visualize the positive relationship between correct littering behavior and environmental impact in an intuitive form.	Consolvo et al., 2009; Hansmann & Steimer, 2017; Helmefalk & Rosenlund, 2020; Vainio et al., 2014
DR5 Intrinsic	The SWA should enable the user to reflect his waste behavior.	Bitrián Arcas et al., 2021; Hansmann & Steimer, 2017; Helmefalk & Rosenlund, 2020

Table 5. Exemplary quotes from the expert workshops and addressed DRs

Exemplary quotes from the expert workshops	Design requirements				
	1	2	3	4	5
We want the citizens to enjoy the use of the SWA and those who contribute should also receive something in return. We are also willing to offer a financial incentive for positive littering behavior as a reward (ID 2).	•	•	•		
We have a population segment that may not be sensitized enough to dispose trash in garbage bins because they don't know the impact of pollution and the difference correct littering behavior can make (ID 4).			•	•	•
When it comes to rewards, we should not only think materially, but even positive feedback from the system can be a reward. We could also imagine that the most active users of the system could be honored by the local government in the SWA (ID 3).		•	•		

4. Design guidelines for a prototypical smart waste app

The focus of our SWA concept is on persuading citizens of correct littering behavior to effectively contribute to enhance the cleanliness and sustainability in cities. From the practical aspects, brought in by the experts, and from the current state of research in the field of SWA, different DRs arise in the sense of a design-theoretical approach for the development of a SWA for persuading citizens of correct littering behavior, as shown in Table 4 (Gregor & Jones, 2007). We categorized the requirements as to be met by DPs focusing extrinsic motivation or intrinsic motivation as depicted in our research framework. Table 5 shows three exemplary quotes from our experts' workshops and the connection to our derived DRs. Including the experts' perspective makes it possible to critically review the requirements derived from literature. Further, discussing the DRs with the experts ensures the rigor of our research (Hevner et al., 2004). In summary, we derived five synthesized DRs based on the literature and the results from the expert workshops. Next, we present our DPs. We understand a DP as prescriptive knowledge (Gregor, 2021) and describe how the DP fulfils DRs.

4.1. Proposed and employed design principles

To reduce the complex process of littering behavior change, the process is divided into simple sub-steps thereby reducing the effort required for the user to carry out the process (Oinas-Kukkonen & Harjumaa, 2009). Considering the littering context, such sub-steps are for instances establishing the user's littering awareness, provide support for new behavior and elements to maintain new habits. Dividing the complex behavior into simple sub-steps, the user perceives the system more positively and the probability of persuasion increases (DR1) (Oinas-Kukkonen & Harjumaa, 2009). Further, the user has the autonomy to decide which steps he performs to improve his littering behavior which can be augmented through intrinsic support from persuasive elements (DR4) and extrinsic support from game-design elements (DR2, DR3) (Bitrián Arcas et al., 2021; Suh et al., 2016). We derive: **DP1 (Reduction):** *Divide the process of behavior change into simple sub-steps and thereby reduce the effort for the user to correctly dispose waste.*

Some users are unaware of their littering behavior's environmental impact (DR4). Visualization of data about the user's behavior in an abstracted form, helps users to reflect their own behavior and understand the relationship between their behavior and the ensuing outcomes (DR5) (Bitrián Arcas et al., 2021; Consolvo et al., 2009). For targeted user information about the cor-

rect littering behavior (DR3) and to promote self-reflection one one's littering conduct, in the SWA data is visualized in an abstracted form. By prompting self-reflection on one's own littering behavior, the abstract representation of data also possesses to instill a feeling of competence by recognizing the own capabilities which enhances intrinsic motivation (Bitrián Arcas et al., 2021). Further, positive emotions about changes in the system can be related to the system usage and correct littering behavior. Relevant is: the form of representation should show a significant connection between the behavior and the system change in order to promote a constructive learning process based on experience and reflection (Vainio et al., 2014). We derive: **DP2 (Visualization):** *Use abstract visualization of data to present information to the user to encourage them to reflect on their behavior and understand the connection between their correct littering behavior and positive changes in the system.*

The persuasion of the system use (DR1) refers to the emotional experience and success of the SWA usage. When the system proactively responds and praises correct littering behavior (DR3), this principle has the potential to contribute to the fulfillment of the user's need for positive recognition and identification with the system (extrinsic motivation) (Sailer et al., 2017). As a result, it fosters behavior change (Oinas-Kukkonen & Harjumaa, 2009). The positive feedback of using the SWA effects the intrinsic motivation and encourages the user to change their behavior (Bitrián Arcas et al., 2021): **DP3 (Praise):** *Use text as responses to correct littering behavior to provide positive feedback to users and encourage behavior change.*

The main difference between a reward and praise is that praise occurs without the transfer of any digital or physical element beyond mere textual feedback. However, in the case of rewards, the user receives an element for his behavior beyond mere textual appreciation. Rewards are intended to extrinsically motivate the correct littering behavior (DR1) and encourage users in behavior change (DR2). The principle represents a direct feedback for users in relation to their actions and the behavior can thus be reinforced in a desired direction (Sailer et al., 2013): **DP4 (Reward):** *Use virtual elements to reward the user for correct littering behavior.*

4.3. Prototype demonstration

In the following section, we exemplary present four implemented design features (DFs) in our prototypical and self-developed SWA. We focus on DFs allowing the user to reflect their own littering behavior. Further, we build a connection between the real world and the virtual world through our rewarding-system. Figure 2 shows our SWA and the implemented DFs. To employ the visualization principle, we depict the positive effect of the user's behavior to persuade behavior change with a persuasive element regarding the user's intrinsic motivation (Krath & von Kortzfleisch, 2021). When the users adopt positive littering behavior, the personal park (DF1) is cleared of litter, the trees grow, and they receive reinforcing feedback (DF2). As a result, the user accepts personal responsibility for the virtual environment whereby intrinsic motivation is addressed and fosters a willingness to change behavior thereby clean the virtual environment (Oinas-Kukkonen & Harjumaa, 2009). Further, this form of abstract visualization illustrates progress to the user without resorting to a one-dimensional game-design elements , such as a filling progress bar (Bitrián Arcas et al., 2021). A one-dimensional form of progress visualization makes it difficult for the user to reflect the correlation between littering behavior and the change in the system (Bitrián Arcas et al., 2021; Consolvo et al., 2009; Vainio et al., 2014). In addition, linking the behavior to the visualization strengthens recognizing the own capabilities which further enhances intrinsic motivation (Bitrián Arcas et al., 2021). Hence, one of the main causes for littering (lack of awareness) is sufficiently addressed. The visualization is the main persuasive element in our SWA and is combined with other DFs such as the challenge (DF3) and badges (DF4) to employ persuasion potential to the game-design elements.

According to the reduction (DP1), SWAs should break down complex processes into simpler steps (Oinas-Kukkonen & Harjumaa, 2009). Challenges include specific tasks a user must complete and provide a meaningful way to implement extrinsic stimuli such as rewards (Sailer et al., 2017). Using challenges, the targeted influencing of the user and the change of behavior are divided into steps, thereby the capabilities in the correct waste disposal can be increased. Further, challenges address the users' intrinsic motivation by providing the ability to behave effectively when carrying out an activity and autonomously build up competences (Bitrián Arcas et al., 2021). The challenges' difficulty level should fit the users' competencies to keep him motivated (Gallego-Durán et al. 2019). The first challenge shown in Figure 2 addresses the user's intrinsic motivation and his personal reasonability to clean up the virtual environment. The user is challenged to dispose his waste at a specific place to clean up the plastic bottles from his virtual environment. Through this challenge, the user knows exactly what actions are expected of him. At the same time, the message that waste is to be disposed of in a waste bin in the Central Park is conveyed to the user. The successful completion of the clean-up challenge is supported with praise (DF2) as a supporting extrinsic stimulus.

The second challenge focuses on the reward principle. Virtually rewarding the user with badges (DF4) primarily affirms his competence by an extrinsic stimuli and enhances enjoyment (Bitrián Arcas et al., 2021; Sailer et al., 2013). The obtained badge in form of a fox can then be included as a virtual element in the visualization to show the achievement to the user in a meaningful way, thereby enhance his intrinsic motivation (Bitrián Arcas et al., 2021; Consolvo et al., 2009). In addition, the user collects points (GreenScore). Previous work in the municipal waste management context found that rewarding citizens not only virtually but also in the real world can significantly contribute to behavior change (Briones et al., 2018). Therefore, we have implemented a rewarding-system in which users can redeem their earned points for rewards such as a free coffee at the local bakery or free use of public transportation services. Doing so, the SWA offers users added value and personal benefit for correct waste behavior through various rewards.

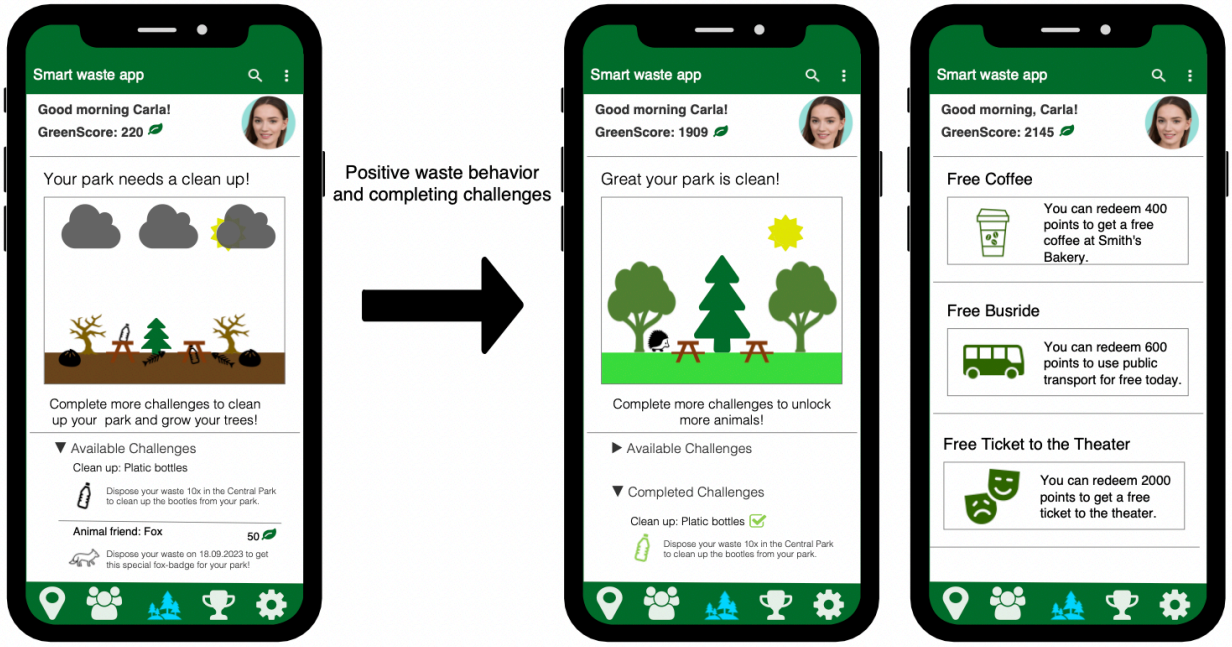

Figure 2. Prototypical SWA

4.3. Prototype expert validation

Prototypes validation is a crucial step in the design science research methodology (Peffers et al., 2012; Peffers et al., 2007). We consider the previous prototype demonstration as an appropriate way to emphasize the prototype's efficacy for the intended purpose to pursue citizens to change their waste behavior (Peffers et al., 2012). Additionally, we conducted an experts evaluation together with the municipal experts to ensure the rigor of our prototype design and its potential to meet the DR and achieve the expected performance (Peffers et al., 2012). To that end, we presented the prototype to the municipal experts and discussed its usefulness against the littering context. Due to space limitations and a planned case study, we present three insights and core feedback from our validation workshop considering the previous outlined littering problems.

First, we turned to the citizens' awareness lack if one's littering behavior has a significant impact on the environment. One expert stated that "the virtual environment reminds of handheld games where I am responsible for the progress (such as Tamagotchi). I think it is an appropriate way to show users that enhanced littering behavior can have a positive impact on the environment in the long-term" (ID 3). Therefore, the virtual environment addresses the intrinsic motivation as users takes personal responsibility for the virtual environment and raises awareness for the behavior effects.

Second, we discussed the extrinsic stimuli through the implemented reward system based on the collected GreenScore. "By offering citizens a personal benefit in the real world, we have a good tool to reach our target group (citizens with an inherent disposition towards proper waste behavior) and motivate them to change their behavior. We also contribute to sustainable development when, for example, people use their points for free public transport instead of driving their car." (ID 6).

Third, the experts stated: "through the implemented challenges, we can contribute to the education of citizens who, for various reasons such as a different culture or lack of public waste bins in their home country, have not had a relationship with the proper disposal of waste in public areas." Therefore, our prototype provides a decentralized solution for citizen waste-education which addresses the general awareness for littering behavior and proper waste disposal.

5. Discussion and conclusion

We contribute to the calls for research on new ways to use IS for environmental protection and reduction of environmental pollution in cities (e.g, Castro Lundin et al., 2017; Helmefalk & Rosenlund, 2020; van der Aalst et al., 2023). Our SWA prototype provides an entry point for cities and developers to design SWAs engaging citizens to reduce their littering thereby effectively improve urban cleanliness and sustainable development in cities. We offer theoretical and empirical grounded design guidelines in theoretically and empirically derived DRs, DPs and DFs highlighting the importance of citizens' behavior change to effectively contribute to the sustainable development of cities.

We agree with other research that smart bins provide the basis for SWAs to engage citizens in correct waste disposal (Aguiar-Castillo et al., 2019; Delnevo et al., 2021). Additionally, we concur on the point that utilizing gamification in SWAs can have a positive effect on the user's littering behavior by implementing design elements that enhance extrinsic motivation (Aguiar-Castillo et al., 2019; Bitrián Arcas et al., 2021). Building on these considerations, we extend the current state of research by also addressing the intrinsic motivation of users to change their littering behavior. For instance, Briones et al. (2018) show user's progress in form of progress bars that fill when the user disposes waste. We appreciated the idea of showing progress to the user and extended this by utilizing a virtual environment. Thus, the user can (1) recognize the link between positive waste behavior and the behavior's environmental impact, and (2) more effectively self-reflect one's own contribution capabilities to a cleaner environment. Further, Delnevo et al. (2021) utilize badges to reward users for correct waste disposal. We extended this idea by employing the badges in the virtual environment. The intrinsic motivation is addressed as users take personal responsibility for the visualization progress with badges reinforcing desired behavior even more. Throughout our research we also collated some work related to SWAs focusing the users' learning process (Hoffmann & Pfeiffer, 2021; Santti et al., 2020). The authors employ a virtual environment to build up capabilities such as correct recycling techniques, but only partially connect their applications to real-world actions. We differ from these approaches in that we are not focusing learning. We assume that, in the context of littering, citizens do know the correct behavior, but face awareness lacks on appropriate waste disposal or have inherent disposition towards engaging in such behavior we aim to address by employing motivation mechanisms that address both problems.

Our outcome yields several theoretical contributions. First, we contribute to literature on persuasive IS design by providing a step toward a design theory for SWAs that enhances the internal motivation to engage in litter disposal (Aguiar-Castillo et al., 2019; Schöbel et al., 2020). Gamification is mostly employed using DPs targeting extrinsic motivation (such as rewarding) to influence the user's motivation (e.g., Anschütz et al., 2022; Rapp et al., 2019; Schöbel et al., 2020). In contrast, studies show that intrinsic motivating design elements have a greater impact on behavior change (Ryan & Deci, 2000; Schöbel et al., 2020). This problem is currently being discussed in recent research and solutions sought by recent gamification scholars. Exemplary avenues focus on personalizing gamification (Tondello et al., 2016), or achieving a deeper understanding of psychological affects (Rapp et al., 2019; Schöbel et al., 2020). To this ongoing research, we aim to contribute by proposing DPs that inherently incorporate gamification and persuasion to enhance the user's intrinsic motivation.

As with any study, our approach has limitations. During our empirical research, we conducted four workshops involving a group of interdisciplinary experts from one city. These data may have been enriched with additional interviews or contrasted with insights from different cities. Additionally, our literature analysis focused on SWAs used to change littering behavior. Research from other city fields of action, which in a broader sense can contribute to the effective reduction of environmental pollution through behavioral change (such as smart mobility, e.g., Anschütz et al., 2022), was not considered, but might be interesting for future researchers. From a more theoretical perspective, the question arises whether the used motivational elements have a sufficiently high potential to motivate litterers to change their behavior. We plan a survey on the exact motivational offers that can motivate citizens to change their waste behavior as a point of our further research. Further, we plan to conduct a real-world case study to ensure the prototype's effectiveness in addressing the previous outlined problems and the citizens motivation to change their waste behavior based on the provided motivation offerings.

Furthermore, we see a high potential in the combination of the app and a rewarding-system that is not limited to the digital environment but can also be used in

the physical world. In addition, future lines of research could be expanded to include emerging technologies such as natural language processing that could enhance learning, for example by providing individualized and timely feedback. This could provide a customized experience for a variety of citizens who may have different motivations and preferences.

6. References

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